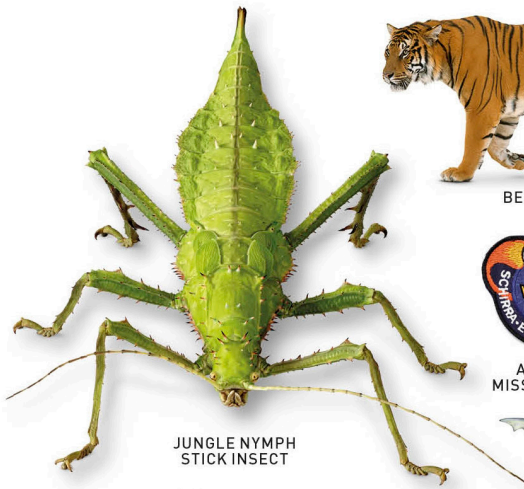




S M I T H S O N I A N



JUNGLE NYMPH  
STICK INSECT



BENGAL TIGER



RASPBERRY



APOLLO 7  
MISSION BADGE



SOCCER BALL



SUIT OF  
ARMOR



FIRE ENGINE



CATTLEHEART  
SWALLOWTAIL



COCKER  
SPANIEL



TUTANKHAMUN



ROMAN  
SHIELD



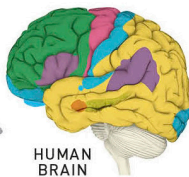
ABRAHAM  
LINCOLN



SATURN



DUSKY SHARK



HUMAN  
BRAIN



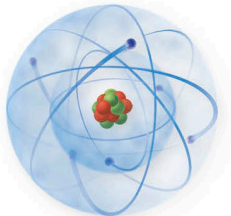
SULFUR



RED LAND CRAB



ATLANTIC  
PUFFIN



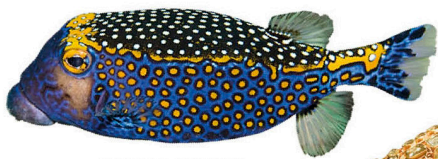
ATOM



TOKAY

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SPOTTED BOXFISH



OTTOMAN  
DAGGER



GUAVA



BUFFY  
FISH OWL



EGYPTIAN  
BEAD COLLAR



PEACOCK  
FEATHER



CONFEDERATE  
DRUM



VIOLIN



FERRARI  
SUPERCAR



MORAY  
EEL



WEEVIL



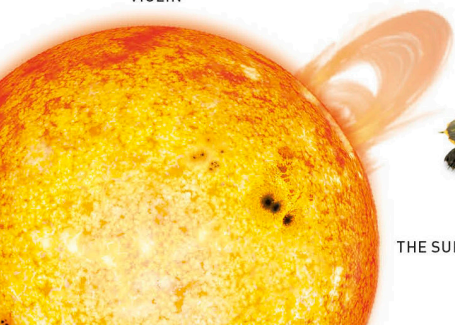
TRACK  
BIKE



ZEBRA



GREEN-YELLOW  
TOURMALINE



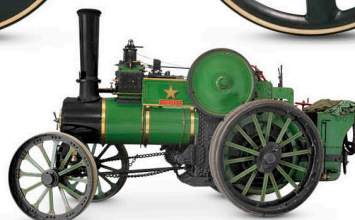
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NORTHERN  
RED-BELLIED  
TURTLE



FRENCH HORN



STEAM-POWERED  
TRACTOR



TRITON'S  
TRUMPET  
SHELL



WOOLLY  
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Smithsonian

Established in 1846, the Smithsonian is the world's largest museum and research complex,  
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It includes 19 museums and galleries and the National Zoological Park. The total number of artifacts,  
works of art, and specimens in the Smithsonian's collection is estimated at 156 million.

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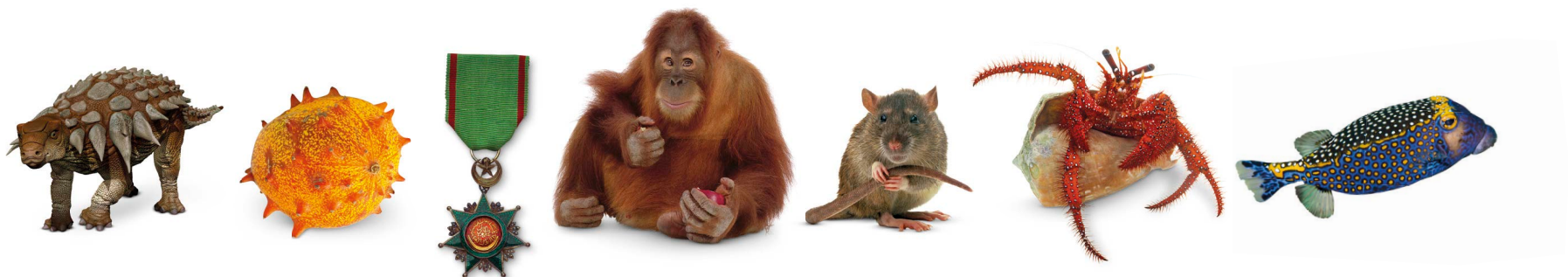
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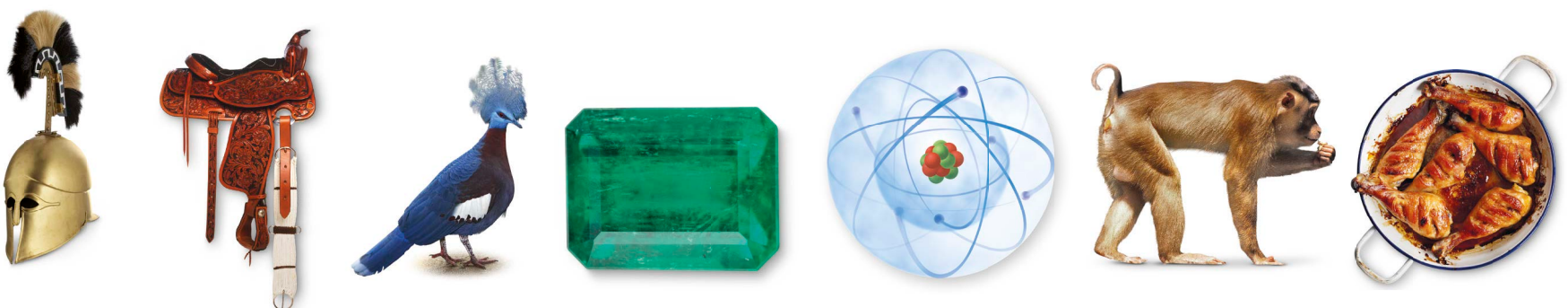
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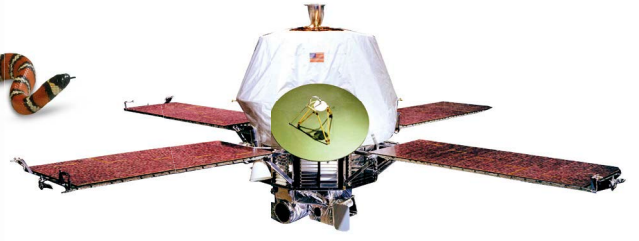
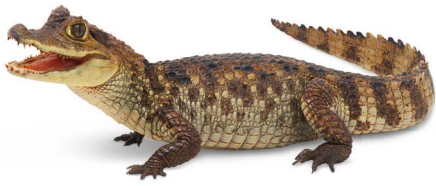
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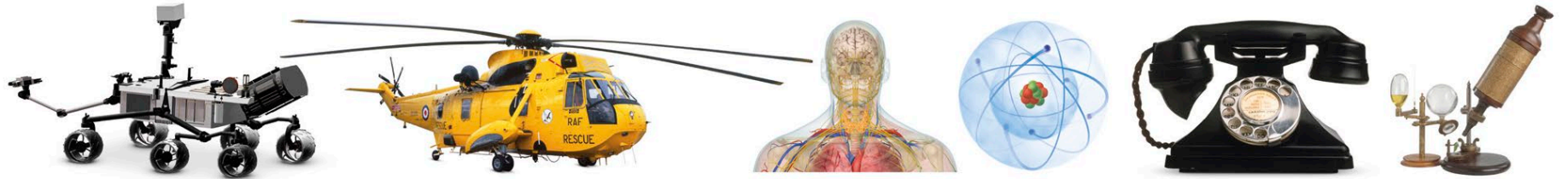
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# Science and technology





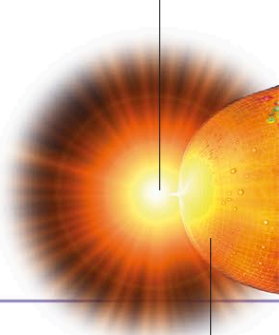
# The Universe

The Universe is everything that exists—all of space, matter, energy, and time. It is a huge wide-open space with billions of galaxies, each containing billions of stars, and yet it is at least 99.99 percent empty space. It has been expanding constantly since its beginning 13.8 billion years ago, when it exploded into life with the Big Bang.

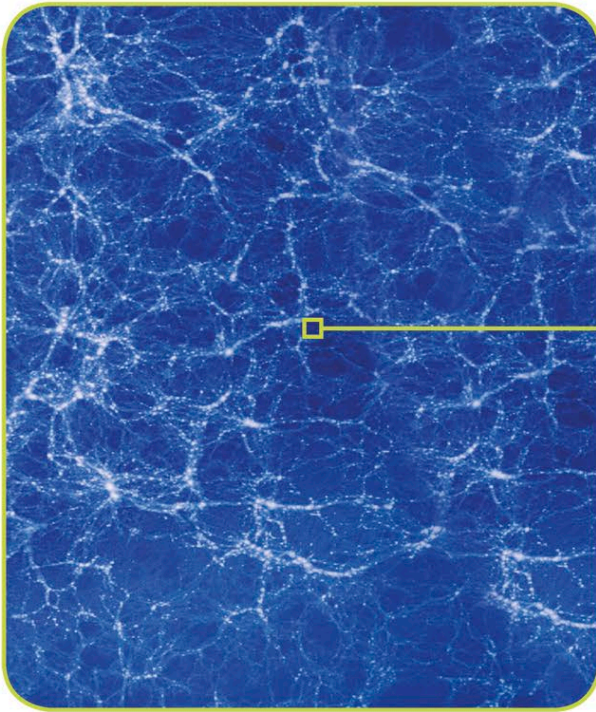
## THE BIG BANG

Before the Big Bang, the entire Universe was inside a bubble that was smaller than a piece of dust. It was extremely hot and dense, and it suddenly exploded. In less than a second, the Universe became bigger than a galaxy. It kept on growing and cooling, and pure energy became matter. During the billions of years that followed, stars, planets, and galaxies formed to create the Universe as we know it.

The Universe begins, 13.8 billion years ago

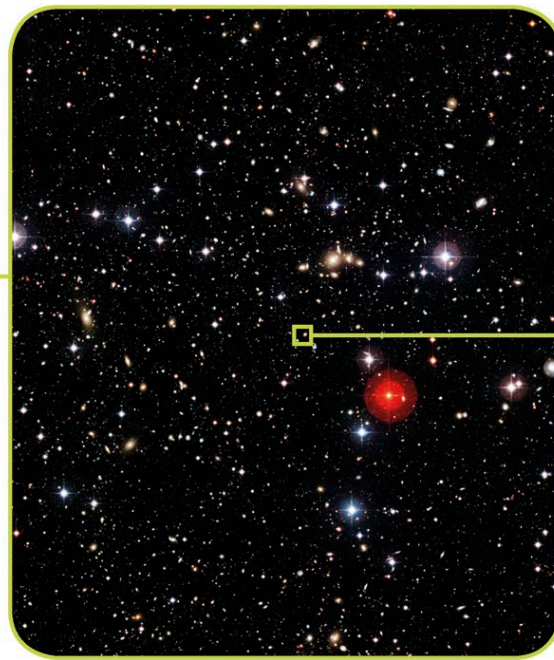


Energy turns into matter



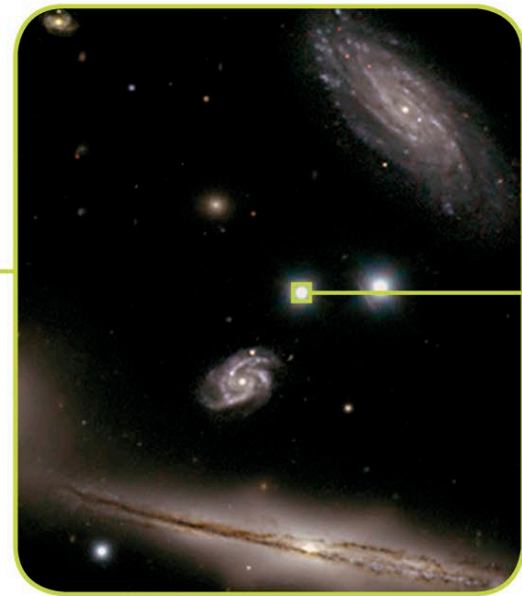
### UNIVERSE

The Universe is ever-expanding. It is full of dark energy, dark matter, and matter such as superclusters of galaxies.



### SUPERCLUSTER

Superclusters are one of the largest known structures in the Universe, made up of galaxy clusters.



### LOCAL GROUP

The Local Group is a cluster of about 50 galaxies inside the Virgo Supercluster, which includes the Milky Way.

## GALAXIES

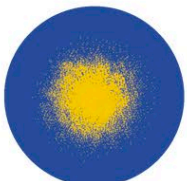
Galaxies are huge groups of stars, and they can be seen in the night sky using a telescope. They come in different shapes, and most of them are thought to have a massive black hole at their center.



SPIRAL



BARRED SPIRAL



ELLIPTICAL



IRREGULAR

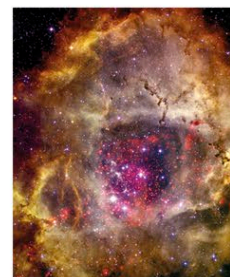
**OUR GALAXY—THE MILKY WAY—IS A BARRED SPIRAL GALAXY WITH FIVE FULL OR PARTIAL ARMS.**

## NEBULAE

Many nebulae are the “nurseries” of the Universe—they are huge clouds of gas and dust in which stars form. They may be trillions of miles wide and can have amazing shapes.



TARANTULA NEBULA



ROSETTE NEBULA



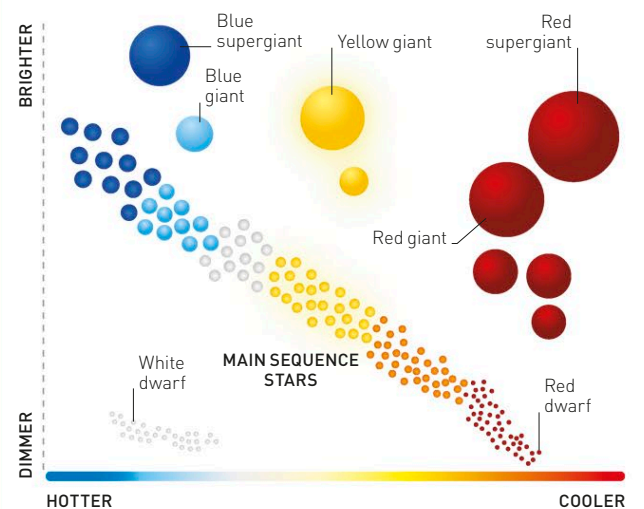
EAGLE NEBULA



N90

## STARS

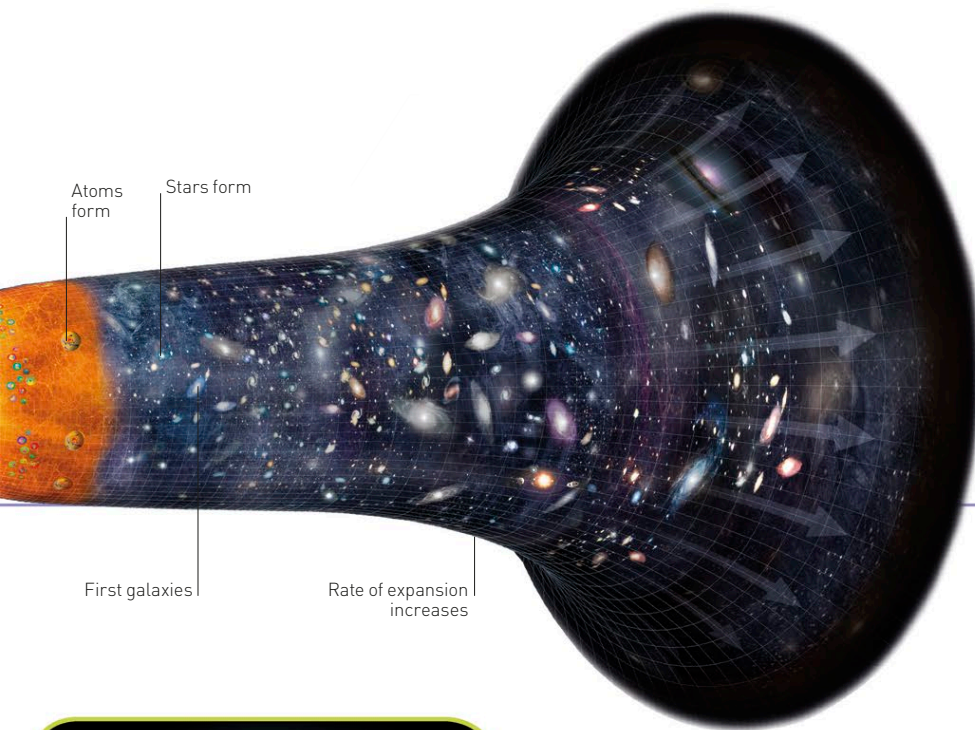
Stars are classified into different types depending on their temperature and brightness. Scientists use the Hertzsprung-Russell graph (shown below) to compare the size, temperature, and brightness of different types of star.



### STAR TYPES

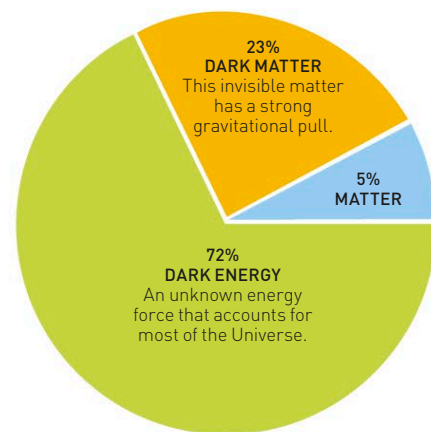
Most of the stars, including our Sun, are found along a part of the graph called the main sequence. As they age, these become giants or supergiants, and then dwarfs or supernovas.





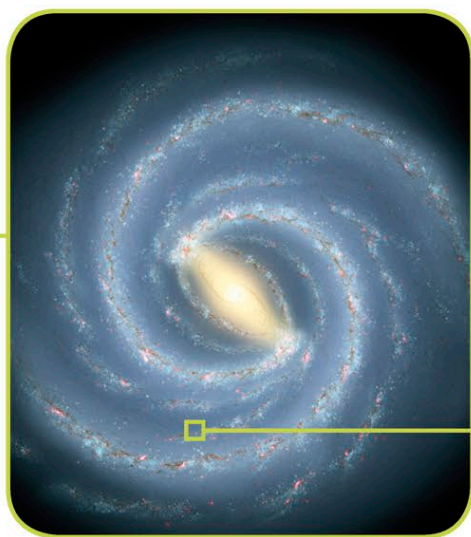
## WHAT MAKES UP THE UNIVERSE?

The Universe contains matter and energy. Matter is generally physical “stuff” that can be seen, like the planets, but galaxies also contain invisible matter called “dark matter.” This does not give off light or heat and can be detected only by the effects of its gravity on visible objects. Between and beyond both types of matter is “dark energy,” a mysterious thing that scientists know almost nothing about.



## THE SCALE OF THE UNIVERSE

The Universe is so vast that it is hard to appreciate its size. This series of pictures “zooms in” on the Universe to show how our Solar System and planet relate to the rest of the Universe. Space is so huge that astronomers use the speed of light to measure distances. One light-year is the distance light travels in a year, which is approximately 6 trillion miles (nearly 10 trillion km).



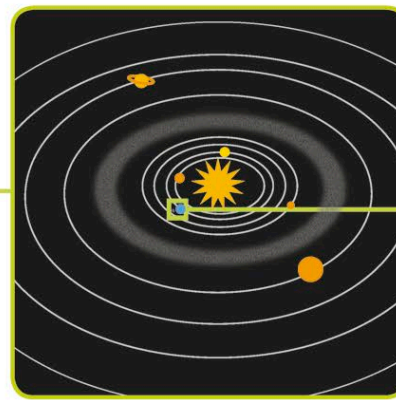
### MILKY WAY GALAXY

The Milky Way has a spiral shape and holds around 200 billion stars within its gravitational pull.



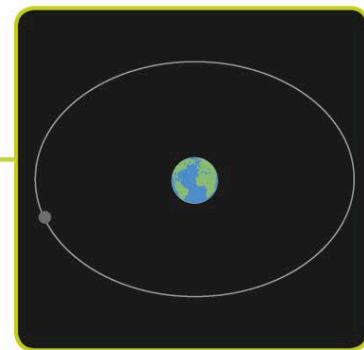
### STELLAR NEIGHBORHOOD

Our Solar System is on one of the Milky Way's spiral arms, 27,000 light-years from the galaxy's center.



### SOLAR SYSTEM

The Sun sits at the center of our Solar System, and eight major planets orbit it.



### EARTH AND MOON

Earth is one of the planets orbiting the Sun, and the Moon orbits Earth.

## BLACK HOLES

A black hole is a region of space where matter has collapsed in on itself. This means there is nothing to be seen, but astronomers know, black holes exist because they have such a strong gravitational pull that nothing can escape them—not even light.



ARTIST'S IDEA OF A BLACK HOLE

## DWARF PLANETS

Dwarf planets, like major planets, have enough self-gravity to make them form into a round shape, but they are smaller and orbit the Sun with many similar small objects. Pluto was once listed as a major planet, but now it is classed as a dwarf planet.



PLUTO

## COMETS

Comets are small bodies made of ice and dust orbiting the Sun. As they get near the Sun, the ice evaporates in the warmth. Jets of gas and dust create a vast cloud that stretches out into long tails.



COMET

## PLANETS

Planets are large, spherical objects that orbit a star. In our Solar System, there are eight major planets: Mercury, Venus, Earth, Mars, Jupiter, Saturn, Uranus, and Neptune. Planets outside our Solar System are known as exoplanets.



EARTH

## MOONS

A moon is a rocky or icy body that orbits a planet. Some planets have many moons, but Earth has only one. Moons are also known as natural satellites.



EARTH'S MOON

## ASTEROIDS

Asteroids are small rocky bodies that orbit the Sun. There are millions of them in space, and they are mainly made of materials that were left over from the formation of planets.



EROS, A NAMED ASTEROID





## THE SUN

The Sun is the hottest and largest object in our Solar System. Its fiery surface bathes the planets around it in light, and its gravity shapes their orbits. The Sun is now about halfway through its life. In about 5 billion years, it will turn into a red giant before puffing its outer layers into space, leaving behind only a ghostly cloud called a planetary nebula.

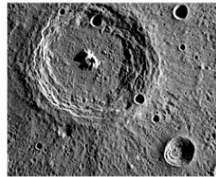
**THE SUN IS SO HUGE  
THAT EARTH COULD  
FIT INSIDE IT 1  
MILLION TIMES.**

# The planets

Around 4.6 billion years ago, a great cloud of dust and gas formed into the Sun. The parts that were not used began to form into clumps, which grew into planets. The four planets closest to the Sun formed mainly from rock. The four giant outer planets formed mainly from ice and gases.

## MERCURY

Mercury is the nearest planet to the Sun and the smallest in the Solar System—it is about as wide as the Atlantic Ocean. Mercury is a rocky world that has no atmosphere or water.



**BRAHMS CRATER**  
Mercury is covered in craters made by debris crashing into its surface.

### MERCURY

#### ROCKY PLANET

**DISTANCE FROM THE SUN:** 36.0 million miles  
(57.9 million km)

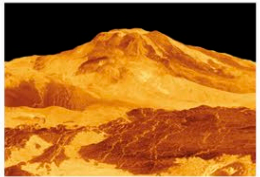
**DIAMETER:** 3,032 miles  
(4,879 km)

**TIME TAKEN TO ORBIT THE SUN:** 87.9 Earth days

**NUMBER OF MOONS:** 0

## VENUS

Venus is the second planet from the Sun. It is about the same size as Earth and is made from similar materials, but its atmosphere is made of carbon dioxide—the gas that we breathe out.



**MAAT MONS**  
Venus has more than 1,600 volcanoes, the highest of which is Maat Mons.

### VENUS

#### ROCKY PLANET

**DISTANCE FROM THE SUN:** 67.3 million miles  
(108.2 million km)

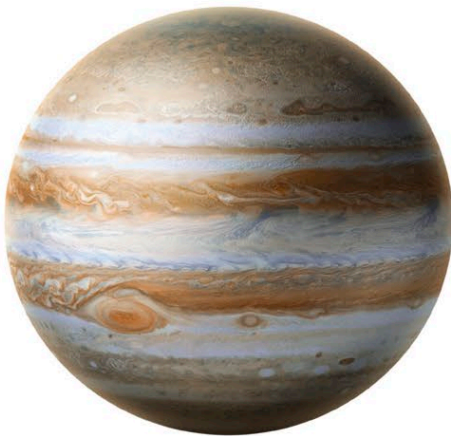
**DIAMETER:** 7,521 miles  
(12,104 km)

**TIME TAKEN TO ORBIT THE SUN:** 224.7 Earth days

**NUMBER OF MOONS:** 0

## JUPITER

Jupiter is the largest planet in the Solar System—it could hold around 1,300 Earths. It is mainly made of liquefied hydrogen gas and is encircled by clouds of colorful gases, swept around by fierce winds.



**GREAT RED SPOT**  
This is a giant storm several times bigger than Earth. It has been raging for 300 years.

### JUPITER

#### GAS GIANT

**DISTANCE FROM THE SUN:** 483.8 million miles  
(778.6 million km)

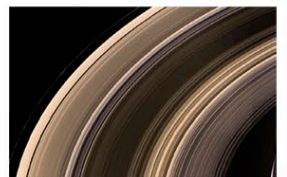
**DIAMETER:** 88,846 miles  
(142,984 km)

**TIME TAKEN TO ORBIT THE SUN:** 11.86 Earth years

**NUMBER OF MOONS:** 79

## SATURN

The second-largest planet in the Solar System, Saturn is not dense—it would float in a planetary-sized bathtub. It is surrounded by a system of rings that extend thousands of miles from the planet but in some places are only about 30 ft (10 m) thick.



**RINGS OF SATURN**  
Saturn's rings are made of chunks of ice.

### SATURN

#### GAS GIANT

**DISTANCE FROM THE SUN:** 890.8 million miles  
(1,433.5 million km)

**DIAMETER:** 74,898 miles  
(120,536 km)

**TIME TAKEN TO ORBIT THE SUN:** 29.43 Earth years

**NUMBER OF MOONS:** 82



## DISTANCE FROM THE SUN

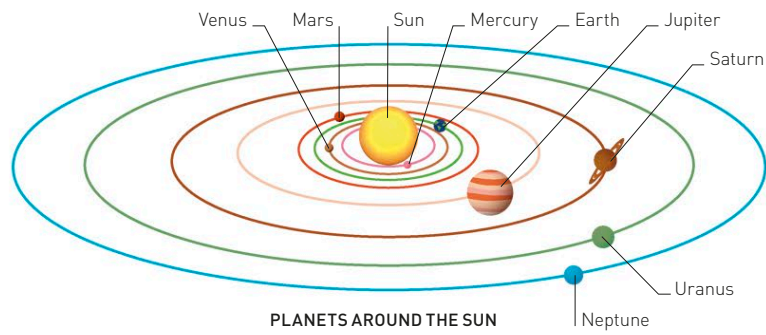
The distances between the planets are huge, becoming bigger as we move out through the Solar System. If the Sun were the size of a grapefruit, Neptune would be 9 miles (14.5 km) away.





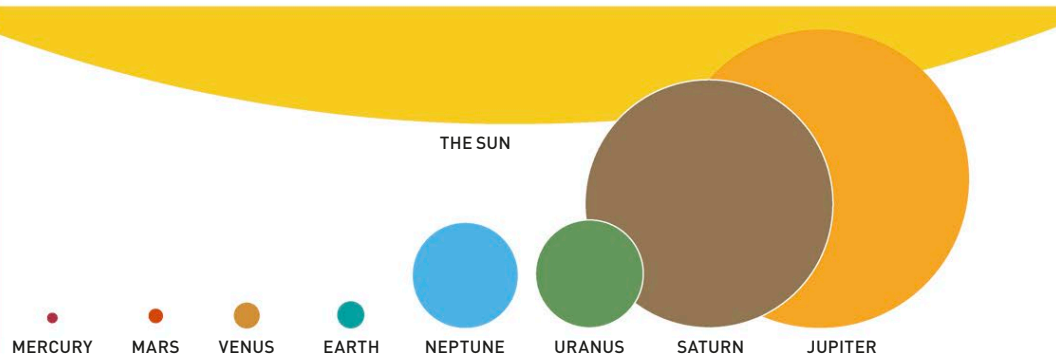
## ORBITS

The planets are all trapped in the Solar System by the Sun's gravity. They travel around the Sun counterclockwise in elliptical (oval) orbits. This means they are closer to the Sun at some points in their orbits than others. The planets near the Sun orbit faster than those farther away.



## PLANET SIZES

The four rocky planets nearest to the Sun are much smaller than the giants. The Sun dwarfs them all but is itself much smaller than many other stars in the Universe.



## EARTH

Earth moves around the Sun at 18.6 miles per second (30 km per second) and takes just over 365 days to orbit it completely. It is the only planet known to have life on it.



**HIMALAYAS**  
This mountain range was formed on Earth around 70 million years ago.

### EARTH

#### ROCKY PLANET

**DISTANCE FROM THE SUN:**  
93.0 million miles  
(149.6 million km)

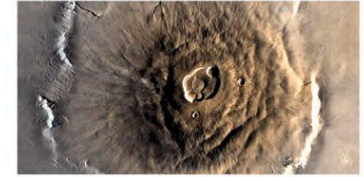
**DIAMETER:** 7,926 miles  
(12,756 km)

**TIME TAKEN TO ORBIT THE SUN:** 365.25 Earth days

**NUMBER OF MOONS:** 1

## MARS

The planet Mars is red, because its surface is covered in iron-rich dust and rock. It is about half the size of Earth and has both the highest mountain and the deepest valley of any planet in the Solar System.



**OLYMPUS MONS**  
This mountain on Mars is about three times as tall as Earth's Mount Everest. It is an extinct volcano.

### MARS

#### ROCKY PLANET

**DISTANCE FROM THE SUN:**  
141.6 million miles  
(227.9 million km)

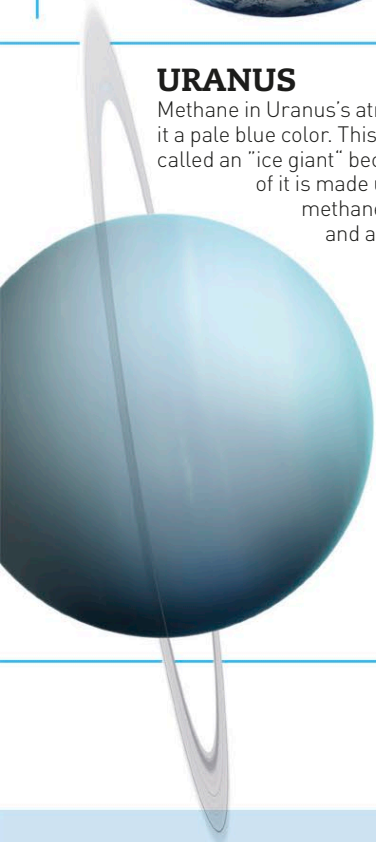
**DIAMETER:** 4,220 miles  
(6,792 km)

**TIME TAKEN TO ORBIT THE SUN:** 687 Earth days

**NUMBER OF MOONS:** 2

## URANUS

Methane in Uranus's atmosphere gives it a pale blue color. This planet is often called an "ice giant" because 80 percent of it is made up of frozen methane, water, and ammonia.



**RINGS**  
Uranus has very faint rings compared to the gas giants.

### URANUS

#### ICE GIANT

**DISTANCE FROM THE SUN:**  
1.78 billion miles (2.87 billion km)

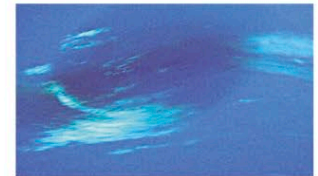
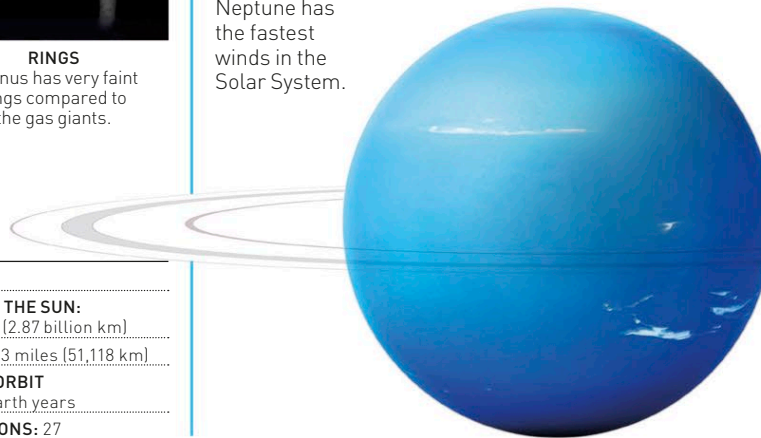
**DIAMETER:** 31,763 miles (51,118 km)

**TIME TAKEN TO ORBIT THE SUN:** 83.8 Earth years

**NUMBER OF MOONS:** 27

## NEPTUNE

Neptune is the farthest planet from the Sun, so it gets little sunlight to warm its atmosphere. Its vivid blue color is due to methane and an unknown compound. Neptune has the fastest winds in the Solar System.



**GREAT DARK SPOT**  
This storm, which has now dispersed, was large enough to contain Earth and moved at 750 mph (1,200 kph).

### NEPTUNE

#### ICE GIANT

**DISTANCE FROM THE SUN:**  
2.79 billion miles (4.50 billion km)

**DIAMETER:** 30,775 miles (49,528 km)

**TIME TAKEN TO ORBIT THE SUN:** 163.7 Earth years

**NUMBER OF MOONS:** 14

URANUS



1,864 million miles (3,000 million km)

NEPTUNE



2,796 million miles (4,500 million km)

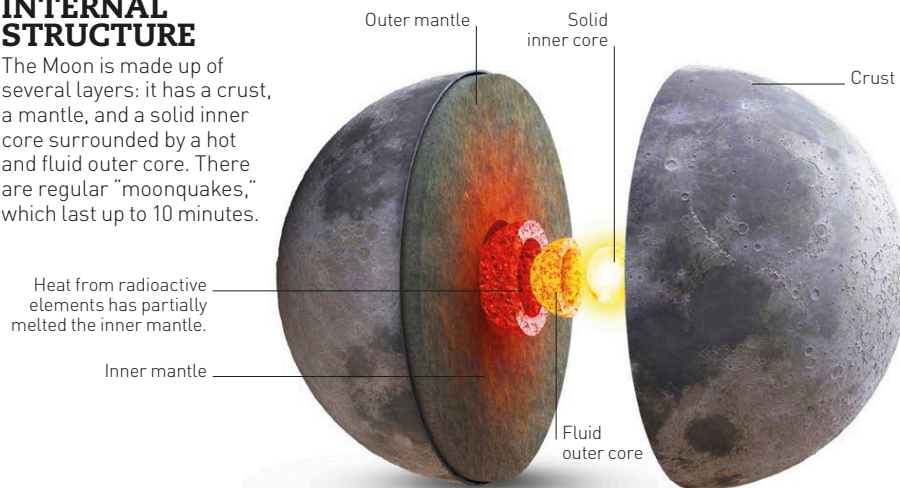


# The Moon

Always in orbit around Earth, the Moon is Earth's only natural satellite. It provides Earth with light during the night, though it has no light of its own—it merely reflects the Sun's light. It is the closest object to Earth in space, and we can see its cratered surface even with the naked eye.

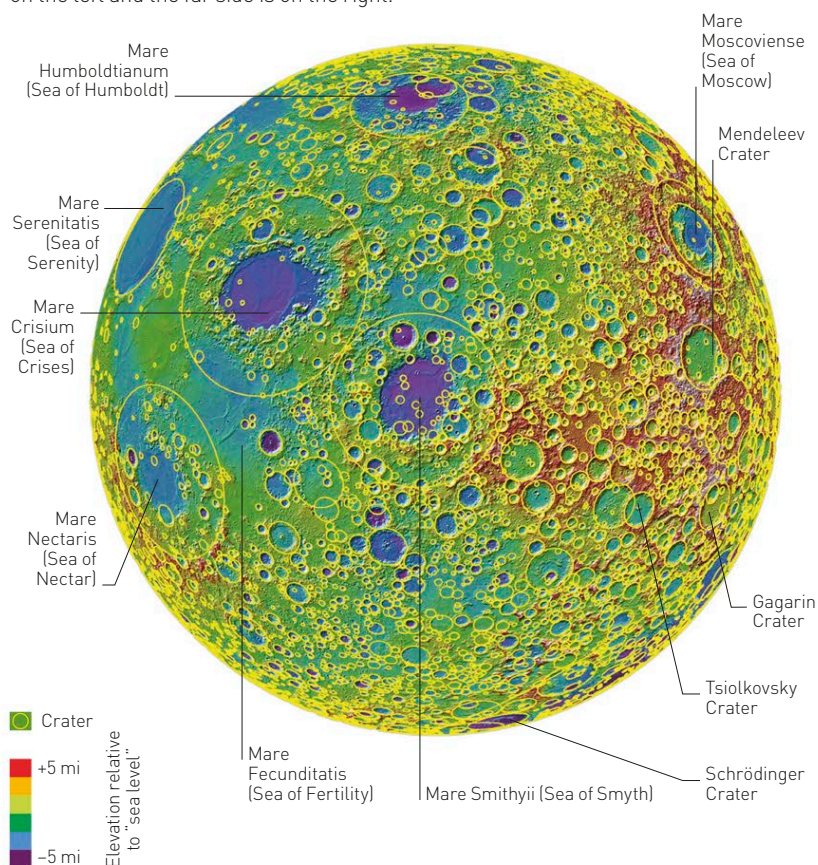
## INTERNAL STRUCTURE

The Moon is made up of several layers: it has a crust, a mantle, and a solid inner core surrounded by a hot and fluid outer core. There are regular "moonquakes," which last up to 10 minutes.



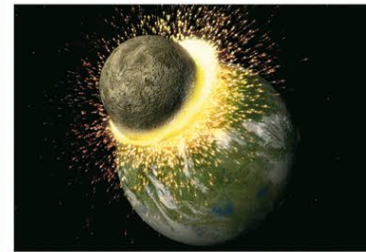
## CRATERS

The Moon is rocky and pockmarked with craters formed by asteroids crashing into its surface billions of years ago. The biggest craters are called "maria," or seas. They are very flat because they were filled with volcanic lava that welled up from inside the Moon and then solidified. In this Moon map, the near side is on the left and the far side is on the right.



## HOW THE MOON FORMED

There are many theories about how the Moon came into existence. Scientists think the most likely explanation is that something collided with Earth, sending debris into space that eventually formed the Moon.



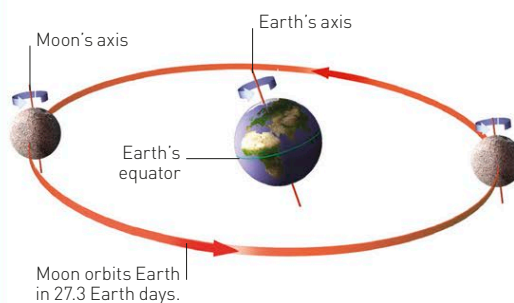
**1 IMPACT**  
A giant astronomical object hit the primitive molten Earth. The object was absorbed, but debris shot into space.



**2 MOON FORMATION**  
Earth's gravity pulled the debris into orbit, and the fragments collided and clumped together, forming the Moon.

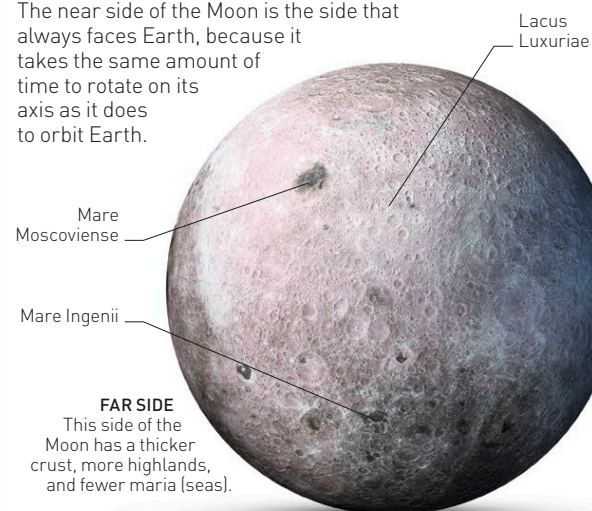
## ORBITING EARTH

The Moon takes 27.3 days to orbit Earth and the same amount of time to spin on its axis. We see some, all, or none of the Moon, depending on how much of its sunlit side faces Earth.



## FAR SIDE AND NEAR SIDE

The near side of the Moon is the side that always faces Earth, because it takes the same amount of time to rotate on its axis as it does to orbit Earth.



### FAR SIDE

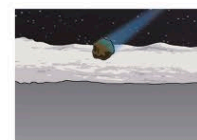
This side of the Moon has a thicker crust, more highlands, and fewer maria (seas).

### NEAR SIDE

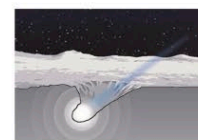
The near side is divided into two areas: the Lunar Highlands and maria.

## HOW CRATERS FORM

When the Moon was young, it was bombarded by asteroids—rocky pieces left over from the planet-making process. They blasted away the Moon's surface, forming craters—circular hollows about 10–15 times the size of the impacting asteroid.



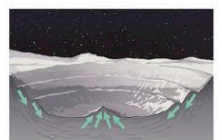
**1 INCOMING SPACE ROCK**  
There is no atmosphere to protect the Moon from flying objects.



**2 INITIAL IMPACT**  
The object strikes the ground faster than the speed of sound, breaking the crust.



**3 SHOCK WAVE**  
On impact, the object melts and vaporizes, spewing hot rock vapor over a huge area.



**4 CRATER**  
Some of the rock vapor (ejecta flow) settles in and around the large hole that is the crater.



## PHASES OF THE MOON

Over a month, the Moon seems to change shape. Although half of the Moon is always bathed in sunlight, most of the time, depending on where the Moon is in its orbit around Earth, only part of the sunlit area is visible from Earth. In the dark night sky, we do not see the unlit part of the Moon.



**WAXING CRESCENT**  
Only a thin sliver of the sunlit part of the Moon is seen from Earth.



**FIRST QUARTER**  
The sunlit portion increases to show half of the Moon's hemisphere lit up.



**WAXING GIBBOUS**  
The sunlit part increases—now more than half of the Moon is visible in the sky.



**FULL MOON**  
A full side of the Moon is now visible. This is halfway through the lunar month.



**WANING GIBBOUS**  
Turning away from Earth again, the lit-up section of the Moon begins to decrease.



**LAST QUARTER**  
Rising only around midnight, this half-lit Moon is brightest at dawn.



**WANING CRESCENT**  
This marks the near completion of the Moon's orbit around Earth.



**NEW MOON**  
The lit half of the Moon is completely hidden from Earth at this point.



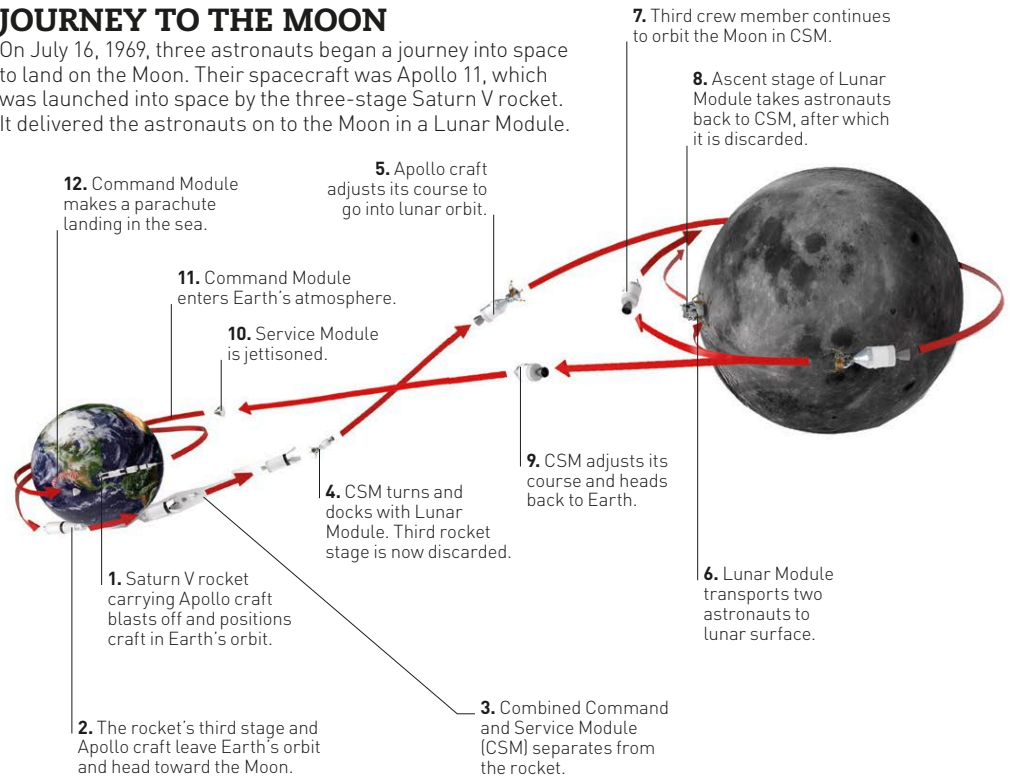
Darker areas are "maria"—smooth, low-lying areas (like seas without water).

The Lunar Highlands are hilly regions with lots of craters.

**WE ALWAYS SEE THE SAME FACE OF THE MOON FROM EARTH—IT IS KNOWN AS THE "NEAR SIDE" OF THE MOON.**

## JOURNEY TO THE MOON

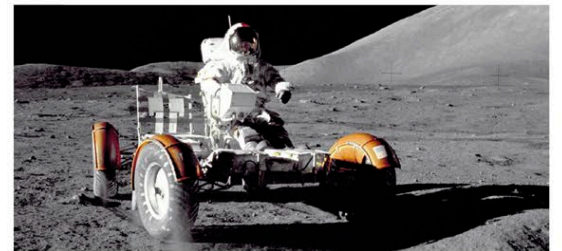
On July 16, 1969, three astronauts began a journey into space to land on the Moon. Their spacecraft was Apollo 11, which was launched into space by the three-stage Saturn V rocket. It delivered the astronauts on to the Moon in a Lunar Module.



## MOON LANDING

In 1972, the crew of Apollo 17 landed on the Moon and stayed there for three days. They completed three successful excursions to examine craters and the Taurus Mountains.

ASTRONAUT EUGENE CERNAN ON THE LUNAR ROVING VEHICLE, 1972, DURING LAST MOON MISSION



## TRUE OR FALSE?

People have had theories about the Moon since they first looked up at the skies in ancient times. Modern science has helped us work out which Moon myths are true and which are false.



**ALIENS INHABIT THE MOON**  
Samples of the Moon taken by astronauts show no trace of life, past or present.



**YOU WEIGH LESS ON THE MOON**  
Your normal weight is Earth's force of gravity on you. The Moon's gravity is less than Earth's, so on the Moon, you would weigh less.



**THE MOON IS DRIFTING AWAY FROM EARTH**  
The Moon is moving away from us by 1.5 in (3.8 cm) per year.



**THE MOON HAS A DARK SIDE**  
The Moon spins on its axis, so every part of it is exposed to the Sun at some point during rotation.



**FULL MOON CAUSES LUNACY**  
Research by scientists has proved there is no link between madness and the full moon.



**THE MOON CAUSES THE OCEAN TIDES**  
The Moon's gravity does cause the tides of waters on Earth.

## MOON MISSIONS

In the second half of the 20th century, there was a "Space Race" between the US and the Soviet Union (USSR) to launch crafts, satellites, and people into space. In 1959, the USSR landed a space probe on the Moon, and in 1969, the US landed people on the Moon. Since then, other countries have sent spacecraft to find out more about the Moon.

**THE LAST TIME A HUMAN LANDED ON THE MOON WAS IN 1972.**

	SPACE AGENCY	SUCCESSFUL MISSIONS
	NASA (USA)	27
	RFSA (USSR/RUSSIA)	23
	CNSA (CHINA)	7
	JAXA (JAPAN)	2
	ISRO (INDIA)	2
	ESA (EUROPE)	1



# Space exploration

Early in the 20th century, rockets were invented that were powerful enough to blast away from Earth. By the century's end, thousands of spacecraft and hundreds of people had entered space. Sending human explorers to Mars is one of the great ambitions for the 21st century.

## APOLLO MISSION BADGES

The US space program is run by NASA (National Aeronautics and Space Administration), and it creates a mission patch, or badge, for every space mission. The badges include elements that represent different parts of the mission: its purpose, the name of the space vehicle, and its official number.



APOLLO 1



APOLLO 7



APOLLO 8



APOLLO 9



APOLLO 10



APOLLO 11



APOLLO 12



APOLLO 13



APOLLO 14



APOLLO 15



APOLLO 16



APOLLO 17

## THE SPACE AGE

In 1957, the Soviet Union (USSR) launched into Earth orbit a polished aluminum ball containing a temperature control system, batteries, and a radio transmitter. This was the beginning of the Space Age.

**1959** The USSR launches Luna 2, which crashes on the Moon, becoming the first human-made object to reach the lunar surface.

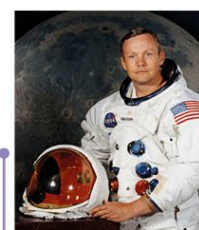


Yuri Gagarin

**1961** Soviet cosmonaut Yuri Gagarin becomes the first human in space.

**1965** Soviet cosmonaut Alexei Leonov becomes the first person to perform a spacewalk.

**1969** The US's Neil Armstrong and Buzz Aldrin become the first humans to walk on the Moon.



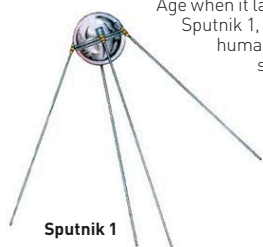
Neil Armstrong

**1973** NASA's Pioneer 10 becomes the first spacecraft to travel beyond the Asteroid Belt and fly past Jupiter.

**1981** NASA launches Columbia, the first "space shuttle," or reusable spacecraft.

1950

**1957** The Soviet Union marks the start of the Space Age when it launches Sputnik 1, the first human-made satellite.



Sputnik 1

**1958** The US launches Explorer 1, its first satellite.

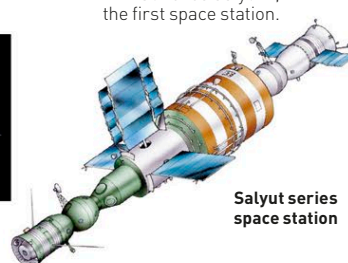
Rocket carrying Explorer 1

**1965** NASA's Mariner 4 becomes the first spacecraft to fly by Mars.



Mariner 4

**1971** The Soviet Union launches Salyut 1, the first space station.



Salyut series space station

**1973** NASA launches its first space station, Skylab.



Skylab

**1977** NASA launches Voyager 1 and 2. Over the next few years, they send images and scientific data from Jupiter and Saturn.



Voyager 1

## MISSIONS TO SPACE

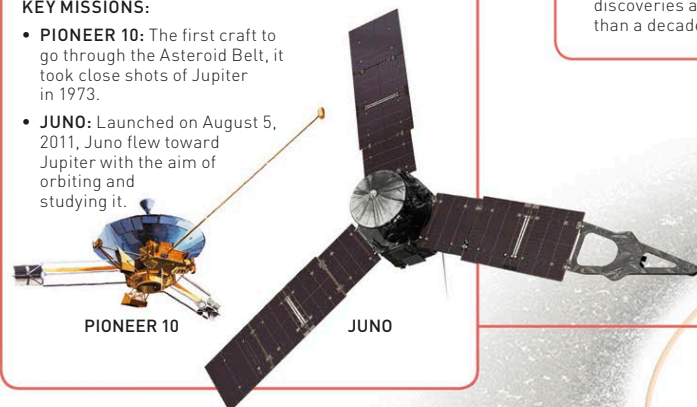
Space missions have landed people on the Moon and rovers on Mars. They have sampled the atmosphere of Jupiter and explored Saturn, Mercury, and even the Asteroid Belt. These missions help us understand the Solar System and our own planet.

### MISSIONS TO JUPITER

NUMBER OF MISSIONS: 9

#### KEY MISSIONS:

- PIONEER 10:** The first craft to go through the Asteroid Belt, it took close shots of Jupiter in 1973.
- JUNO:** Launched on August 5, 2011, Juno flew toward Jupiter with the aim of orbiting and studying it.



PIONEER 10

JUNO

### MISSIONS TO ASTEROID BELT

NUMBER OF MISSIONS: 13

#### KEY MISSIONS:

- DAWN:** This spacecraft was launched in 2007 to study two bodies in the Asteroid Belt: Vesta and Ceres. It spent a year orbiting Vesta before moving on to Ceres.
- ROSETTA:** A mission to a comet that photographed asteroids Steins and Lutetia in 2008 and 2010.



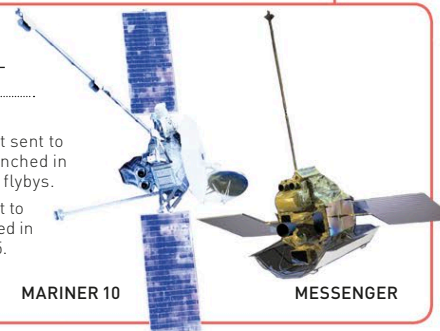
ROSETTA

### MISSIONS TO MERCURY

NUMBER OF MISSIONS: 2

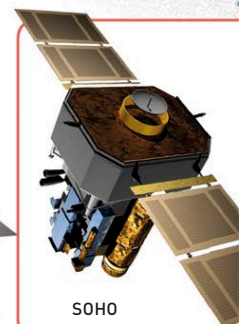
#### KEY MISSIONS:

- MARINER 10:** The first craft sent to study Mercury, this was launched in 1973 and did three Mercury flybys.
- MESSENGER:** The first craft to orbit Mercury, it was launched in 2004 and operated until 2015.



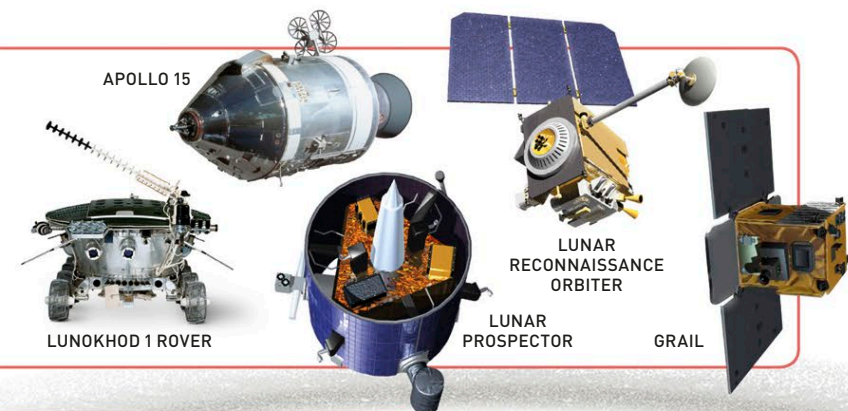
MARINER 10

MESSENGER



SOHO



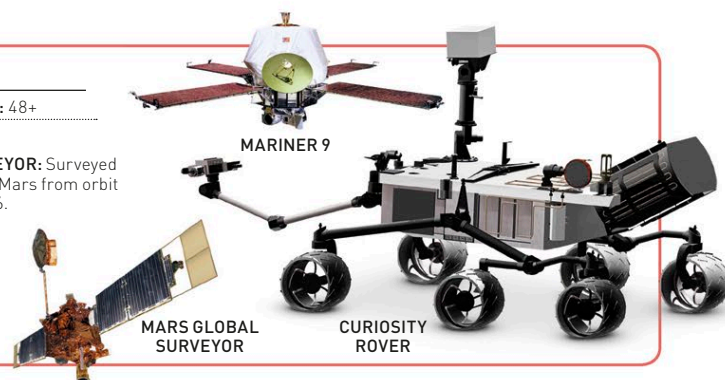


## MISSIONS TO MARS

NUMBER OF MISSIONS: 48+

### KEY MISSIONS:

- **MARS GLOBAL SURVEYOR:** Surveyed and mapped details of Mars from orbit between 1996 and 2006.
- **CURIOSITY:** This robotic science laboratory on wheels has made many important discoveries since landing in 2012.



## MISSION TO KUIPER BELT

NUMBER OF MISSIONS: 1

### KEY MISSION:

- **NEW HORIZONS:** Launched in 2006, it returned close-up images of Pluto and its moons in 2015, then flew on to explore more of the small icy worlds in the Kuiper Belt.

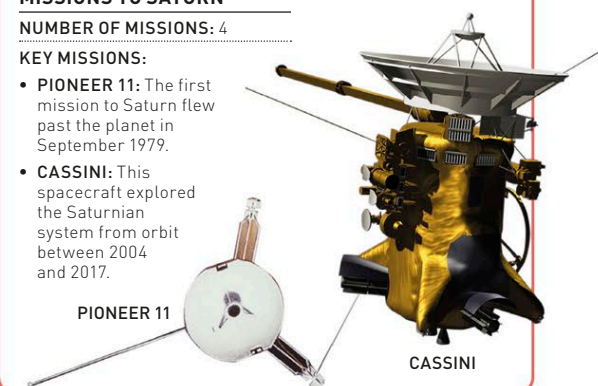


## MISSIONS TO SATURN

NUMBER OF MISSIONS: 4

### KEY MISSIONS:

- **PIONEER 11:** The first mission to Saturn flew past the planet in September 1979.
- **CASSINI:** This spacecraft explored the Saturnian system from orbit between 2004 and 2017.



PIONEER 11

CASSINI

## MISSION TO URANUS AND NEPTUNE

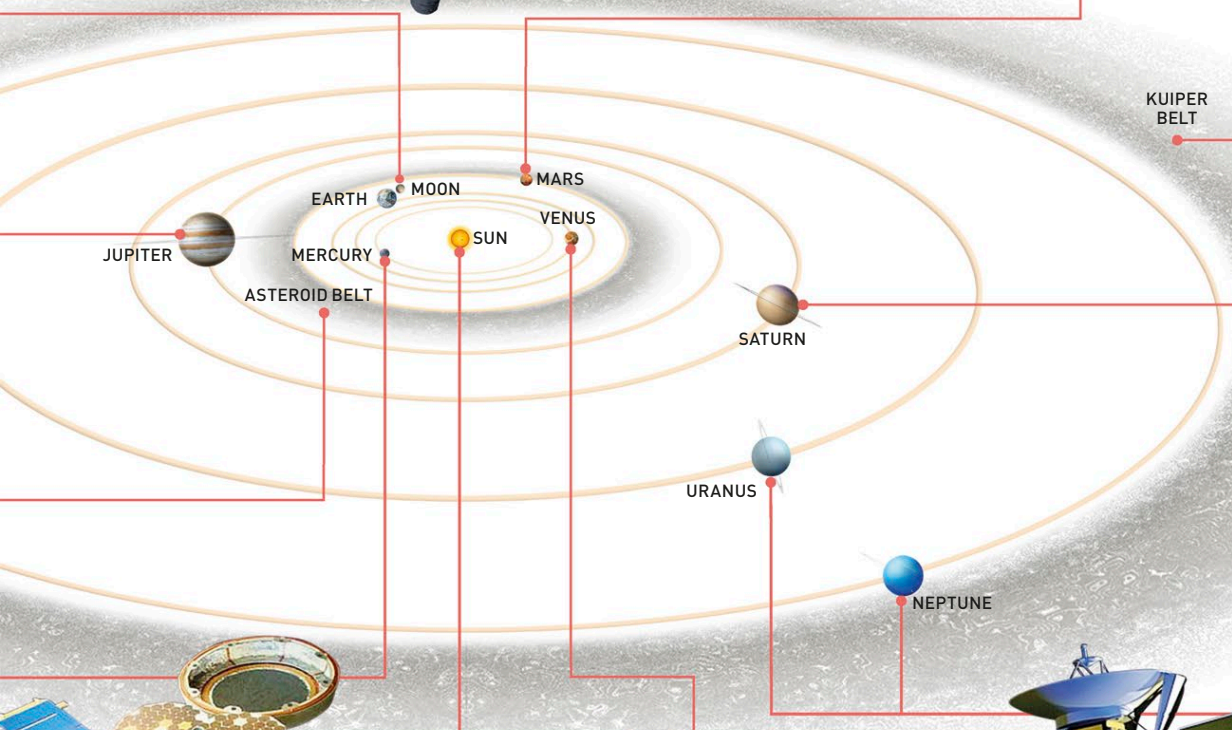
NUMBER OF MISSIONS: 1

### KEY MISSION:

- **VOYAGER 2:** This achieved the first flyby of Uranus and Neptune. In 2007, it entered the heliosheath, the outer shell of particles around our Sun. Voyager 2 reached interstellar space (space between stars) in November 2018.



VOYAGER 2

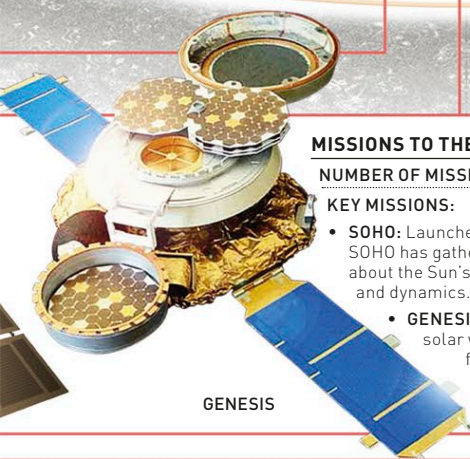


## MISSIONS TO THE SUN

NUMBER OF MISSIONS: 19

### KEY MISSIONS:

- **SOHO:** Launched in 1995, SOHO has gathered information about the Sun's structure and dynamics.
- **GENESIS:** Collected solar wind material for investigation in 2004.



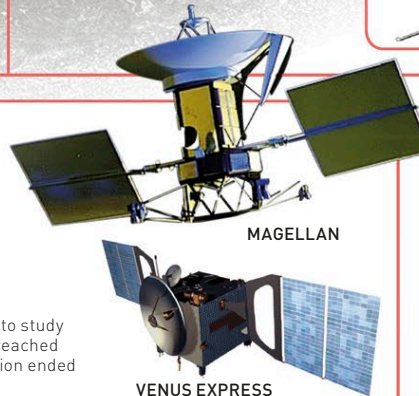
GENESIS

## MISSIONS TO VENUS

NUMBER OF MISSIONS: 40+

### KEY MISSIONS:

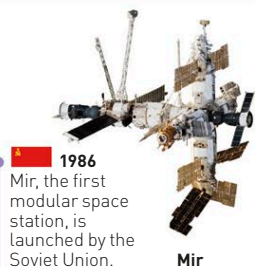
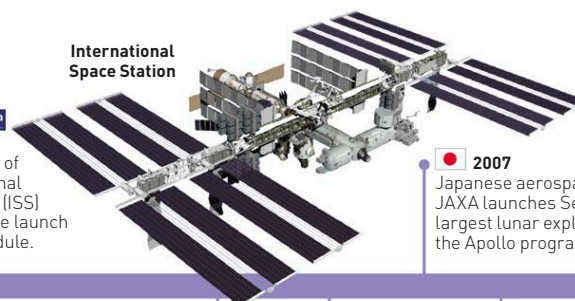
- **MAGELLAN:** Sent on a radar mapping mission from 1989 to 1994.
- **VENUS EXPRESS:** Sent to study Venus's atmosphere, it reached Venus in 2006. The mission ended in 2014.



MAGELLAN

VENUS EXPRESS

## International Space Station



Mir

**1986**  
Mir, the first modular space station, is launched by the Soviet Union.



**1998**  
The assembly of the International Space Station (ISS) begins with the launch of its first module.



**1990**  
NASA launches the Hubble Space Telescope into Earth orbit using a space shuttle.



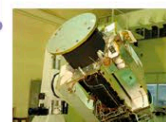
**2003**  
The European Space Agency (ESA) launches Mars Express—its first visit to another planet in the Solar System.



**2005**  
The European Huygens probe of the Cassini-Huygens mission lands on Saturn's moon, Titan. It is the first landing on another planet's moon.



**2008**  
The Indian Space Research Organisation (ISRO) sends its first mission, Chandrayaan-1, to the Moon.



The Chandrayaan-1 spacecraft



**2011**  
Tiangong-1, China's first space station, is launched.



**2014**  
The European Philae probe is the first human-made object to land on a comet.



**2015**  
NASA's New Horizons becomes the first mission to reach a Kuiper Belt object, when it encounters Pluto.



**2018**  
Japan's Hayabusa2 releases HIBOU, the first rover to operate on the surface of an asteroid (Ryugu).

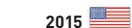


**2019**  
China's Chang'e 4 spacecraft makes the first soft landing on the far side of the Moon.

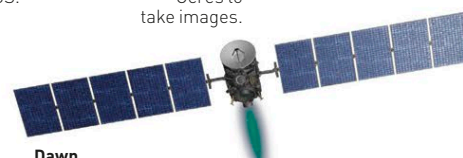


Hubble Space Telescope

**2012**  
Dragon, the first commercial craft, carries cargo to and from the ISS.



**2015**  
NASA's Dawn mission orbits dwarf planet Ceres to take images.



Dawn

**2020**  
The Crew Dragon craft takes two astronauts to the ISS, where it docks on its own.

2025



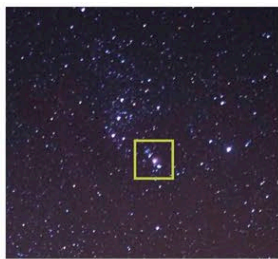
# Stargazing

Astronomy is the branch of science that is dedicated to studying stars, planets, and all the celestial bodies that surround Earth. It seeks to explain where we came from and the beginning of the Universe itself.

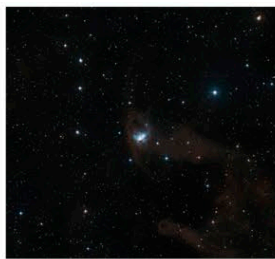
## LOOKING AT THE SKY

Binoculars are a great way to start looking at the night sky, because they reveal up to 10 times as much detail as the naked eye and are easy to use. Telescopes provide even greater detail.

**MERCURY, VENUS, MARS, JUPITER, AND SATURN CAN BE SEEN WITH THE NAKED EYE.**



NAKED-EYE VIEW OF THE ORION NEBULA



BINOCULAR VIEW OF THE ORION NEBULA



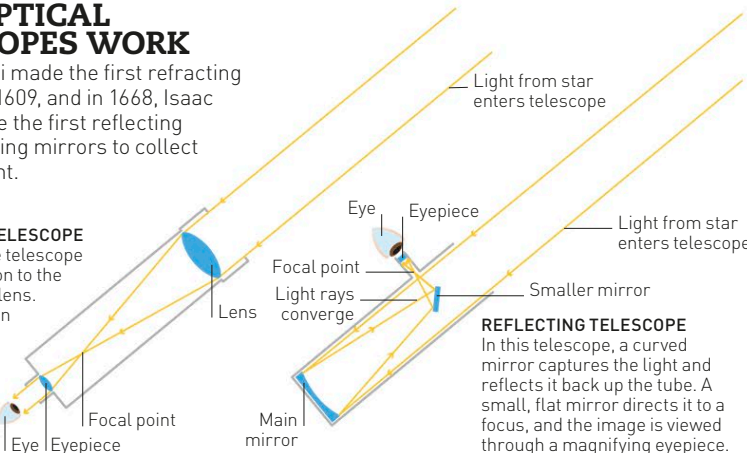
TELESCOPE VIEW OF THE ORION NEBULA

## HOW OPTICAL TELESCOPES WORK

Galileo Galilei made the first refracting telescope in 1609, and in 1668, Isaac Newton made the first reflecting telescope, using mirrors to collect and focus light.

### REFRACTING TELESCOPE

Light enters the telescope and is focused on to the focal point by a lens. An eyepiece then magnifies the focused light into an image, which is seen by your eye.



### REFLECTING TELESCOPE

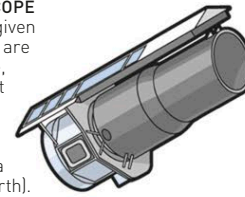
In this telescope, a curved mirror captures the light and reflects it back up the tube. A small, flat mirror directs it to a focus, and the image is viewed through a magnifying eyepiece.

## PICTURING SPACE

Astronomers learn about space using telescopes. These telescopes are each designed to pick up one particular type of electromagnetic radiation from space and use that radiation to create an image. The pictures on the right here show the Crab Nebula imaged by different types of telescope.

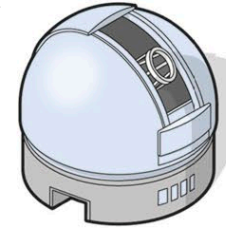
### INFRARED TELESCOPE

These detect heat given off by objects. They are often used in space, where they are kept cold and far from Earth (so that they do not pick up confusing heat data from objects on Earth).



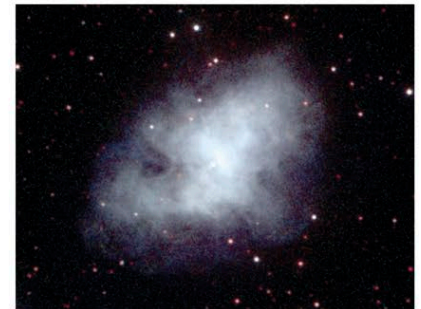
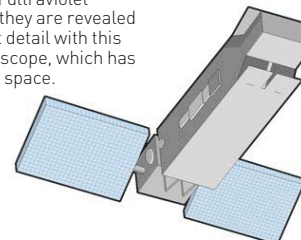
### OPTICAL TELESCOPE

These use lenses and mirrors to capture light from distant objects. Reflecting and refracting telescopes are forms of optical telescope.



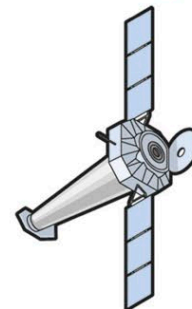
### ULTRAVIOLET TELESCOPE

Hot and active objects in the cosmos give off large amounts of ultraviolet energy, so they are revealed in the most detail with this kind of telescope, which has to be put in space.



### X-RAY TELESCOPE

These telescopes capture high-energy rays from extremely hot objects. X-rays from celestial objects are blocked by Earth's atmosphere, so these telescopes are sent into space.



## TIMELINE

Since ancient times, people have recorded astronomical observations. As science advances, we are still trying to discover the great mysteries of the Universe.

**c.330 BCE**  
Greek philosophers begin to believe that Earth is a sphere.

Greek philosopher Aristotle

**240 BCE**  
Eratosthenes, a Greek astronomer, estimates Earth's circumference.

**c.150 CE**  
Claudius Ptolemy says that Earth sits at the center of the cosmos. Belief in the Ptolemaic system continues for the next 1,400 years.

Ptolemy

**1543 CE**  
Polish astronomer Nicolaus Copernicus publishes his revolutionary model of the Solar System, putting the stationary Sun at the center.

Copernicus's Solar System

**1633**  
The Catholic Church puts Italian astronomer Galileo Galilei on trial for teaching Copernicus's heliocentric (Sun-center) theory.

Galileo Galilei

## 2500 BCE

**c.2500 BCE**  
Stonehenge is built. Its huge stones mark the rising and setting points of the Sun at the solstices.

Stonehenge

**c.700 BCE**  
Babylonians predict regular patterns of Sun and Moon eclipses.

Aristarchus's calculations

**c.280 BCE**  
Ancient Greek astronomer Aristarchus calculates the size of the Sun and Moon and their distances from Earth.

**240 BCE**  
The first certain appearance of Halley's Comet is described in the Chinese *Records of the Grand Historian*.

Halley's Comet

**1054 CE**  
Chinese astronomers observe a supernova that is visible in the daytime. The matter blasted outward by it remains observable as the Crab Nebula.

**1609**  
German mathematician Johannes Kepler calculates that the planets follow noncircular, elliptical orbits.

Elliptical orbit

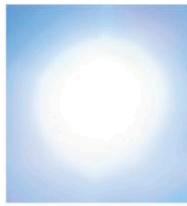
**1687**  
English scientist Isaac Newton discovers that gravity keeps the Moon in orbit around Earth and the planets in orbit around the Sun.

Isaac Newton



## VIEW FROM EARTH

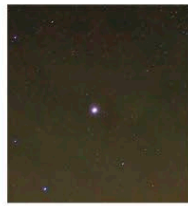
It is impossible to tell how large a star or planet is just from its size in the sky. The Sun's diameter is 400 times that of the Moon, but it is also about 400 times farther away.



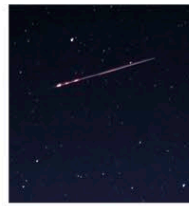
SUN



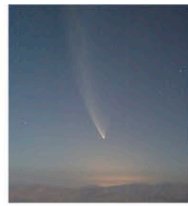
MOON



JUPITER



METEOR



COMET



POLARIS



THE PLEIADES

## LIGHTS IN THE SKY

Sometimes we can see lights in the sky, such as the Northern Lights, caused by something happening in Earth's atmosphere.



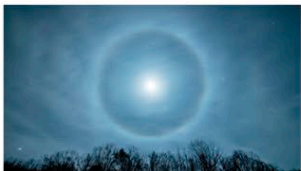
### NORTHERN LIGHTS

Also known as the aurora borealis, this light display is caused by particles from the Sun hitting Earth's magnetic field.



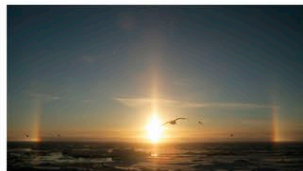
### SOUTHERN LIGHTS

Also known as the aurora australis, this is similar to the northern lights but takes place above Earth's southern hemisphere.



### MOON HALO

A halo around the Moon is caused by moonlight passing through ice crystals in high clouds.



### SUNDOG

Patches of sunlight appear at either side of the Sun. They are caused by sunlight passing through ice crystals in clouds.

## LIFE OUT THERE

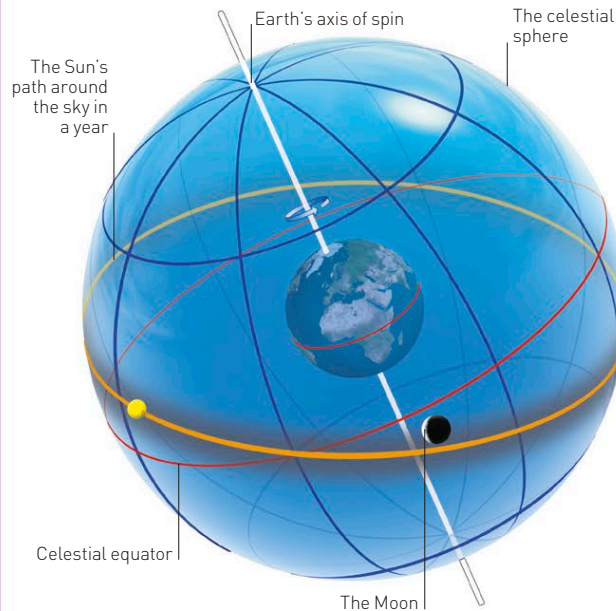
Since 1960, astronomers have used radio telescopes for SETI—the Search for Extraterrestrial Intelligence. They have looked for radio signals that might be coming from intelligent beings beyond Earth but so far have not discovered any.



ALLEN TELESCOPE ARRAY, CALIFORNIA

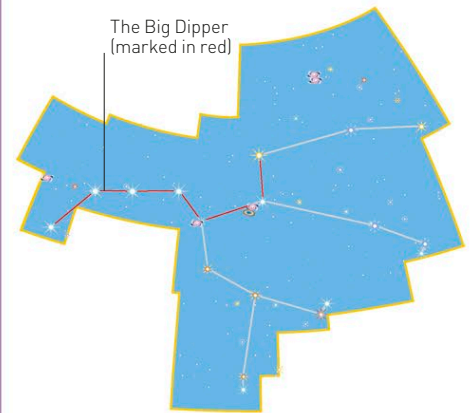
## THE CELESTIAL SPHERE

The celestial sphere is an imaginary sphere around Earth. Any sky object can be mapped on to this sphere. Because Earth rotates, the celestial sphere appears to rotate. Like Earth, it has north and south poles and is divided into two hemispheres by an equator.



## CONSTELLATIONS

Stargazers in ancient times named groups of stars after mythical beings and animals. These star patterns are called constellations, and we still use them today to map the stars. There are 88 constellations in total. However, which ones you can see depends on when you look and where you are on Earth.

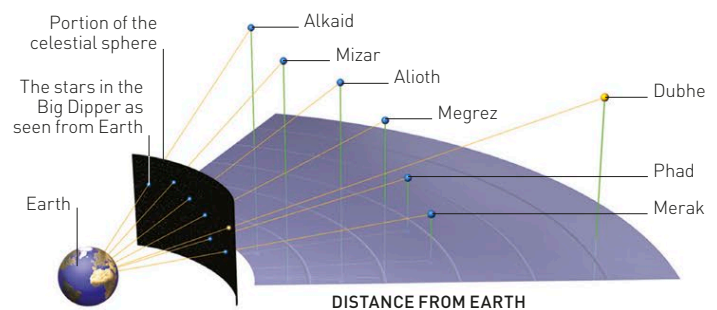


### URSA MAJOR

This constellation is also known as the Great Bear. It contains an asterism (smaller group of stars) known as the Big Dipper, or the Plow.

## LINE OF SIGHT

Wherever you stand on Earth, you can see a portion of the celestial sphere. Although stars in a constellation look as if they belong together, in reality, they are not close to each other in space. For example, the nearest star to Earth in the Big Dipper (Mizar) is only two-thirds the distance of the farthest.



Uranus

1781

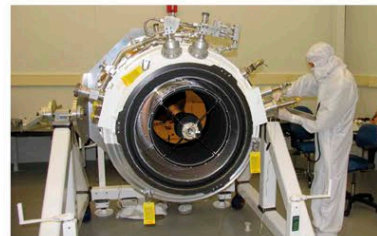
German-born astronomer William Herschel discovers Uranus, a planet beyond Saturn, doubling the size of the known Solar System.

1933

American physicist Karl Jansky records the first radio-wave signals from space, which he concludes are from the Milky Way.

1992

Astronomers discover the first extra-solar planets (exoplanets).



Infrared Astronomical Satellite

2006

The International Astronomical Union defines the properties of a "planet" and in doing so demotes Pluto from a planet to a dwarf planet.



Ceres

1801

Italian astronomer Giuseppe Piazzi comes across a rocky body orbiting between Mars and Jupiter. Named Ceres, this is the largest object in the Asteroid Belt and is classified as a dwarf planet.

1843

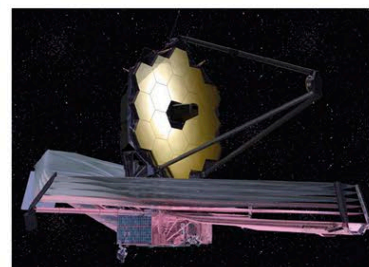
German amateur astronomer Samuel Heinrich Schwabe observes that sunspots (areas of lower temperature) follow regular cycles.



Sunspots

1922

American astronomer Edwin Hubble works out that there are more galaxies in the Universe than the Milky Way, and that they are moving apart—the Universe is expanding.



James Webb Space Telescope

2021

The James Webb Space Telescope (JWST) is an infrared space observatory scheduled to launch in March 2021. It is a successor to the Hubble Space Telescope and will offer the clearest images ever seen of objects in space.

2025



# Northern skies

If you live north of the equator, you live in the northern hemisphere. On a dark and cloudless night, you can see a mass of glittering stars. If you know what to look for, you can pick out individual stars, constellations, and other wonders of the night sky.

THE NAMES FOR MOST OF THE CONSTELLATIONS IN THE NORTHERN SKIES COME FROM THE ANCIENT GREEKS.

KEY			
This map shows stars that are visible to the naked eye. Magnitude marks how bright a star is—the lower the number, the brighter the star.			
Yellow star	Red star	Magnitude brighter than 0.0	Magnitude brighter than 3.0
Orange star	White star	Magnitude brighter than 1.0	Magnitude brighter than 4.0
Blue star		Magnitude brighter than 2.0	Magnitude brighter than 5.0

## THINGS TO LOOK FOR

Individual stars, star clusters, and whole galaxies can be seen with binoculars or a small telescope. Here are some key sights to look out for in the northern skies.



DUMBBELL NEBULA

This is a “planetary” nebula, which is actually a shell of glowing gas thrown off by a dying star at the center. It is in the constellation of Vulpecula.



STAR CLUSTER M13

This is the finest globular (globe-shaped) cluster in the northern skies. It lies in the constellation Hercules.



HYADES STAR CLUSTER

This star cluster makes up the face of the bull in the constellation Taurus. The bright orange star Aldebaran, which marks the eye of Taurus, is not in the Hyades cluster and is only half as far away.



ANDROMEDA GALAXY

This spiral galaxy in the constellation Andromeda is about 2.5 million light-years away and the most distant object visible to the naked eye.



PLEIADES STAR CLUSTER

This cluster in Taurus is also known as the Seven Sisters, because seven of its blue stars are visible to the naked eye.



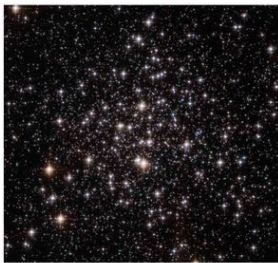
DOUBLE CLUSTER IN PERSEUS

These twin star clusters in the constellation Perseus each contain thousands of stars and are 7,500 light-years away.



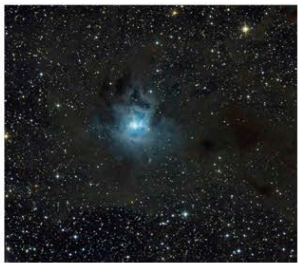
ORION NEBULA

This nebula marks the position of the “sword” below the “belt” of Orion in the Orion constellation.



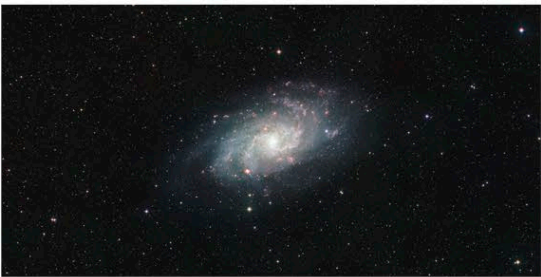
M71 STAR CLUSTER

This loosely packed star cluster is on the edge of our galaxy. It sits in the Sagitta constellation.



IRIS NEBULA

This ghostly blue nebula is in the constellation of Cepheus. At its heart is a cluster of stars.



TRIANGULUM GALAXY

About one-third the size of our Milky Way Galaxy, this neighboring spiral galaxy lies 2.7 million light-years away in the small constellation Triangulum.



CRAB NEBULA

This is the remains of a supernova (an exploding star). It is found in Taurus, near the southerly “bull horn.”



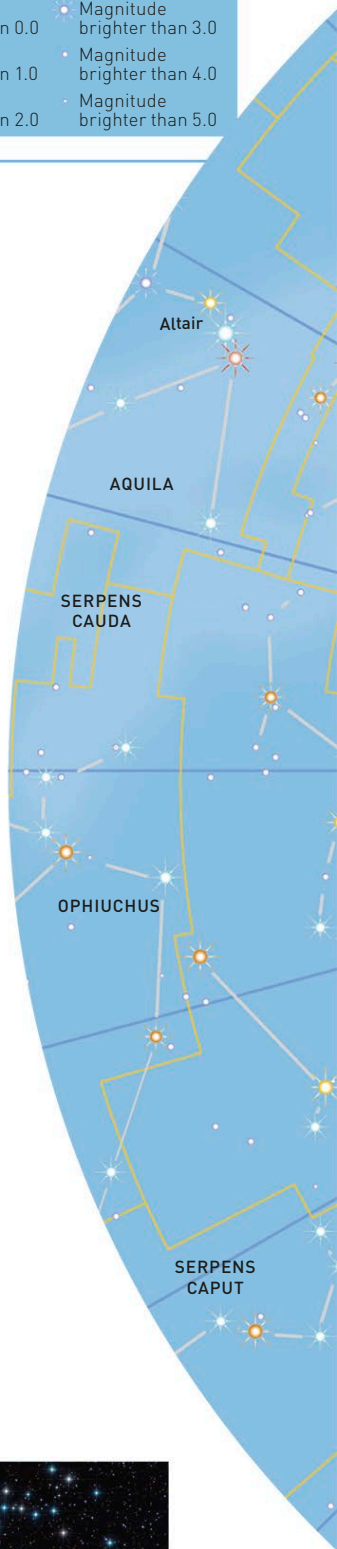
M15 STAR CLUSTER

This globular cluster is in Pegasus, northwest of Epsilon Pegasi, the constellation’s brightest star.



BEEHIVE CLUSTER

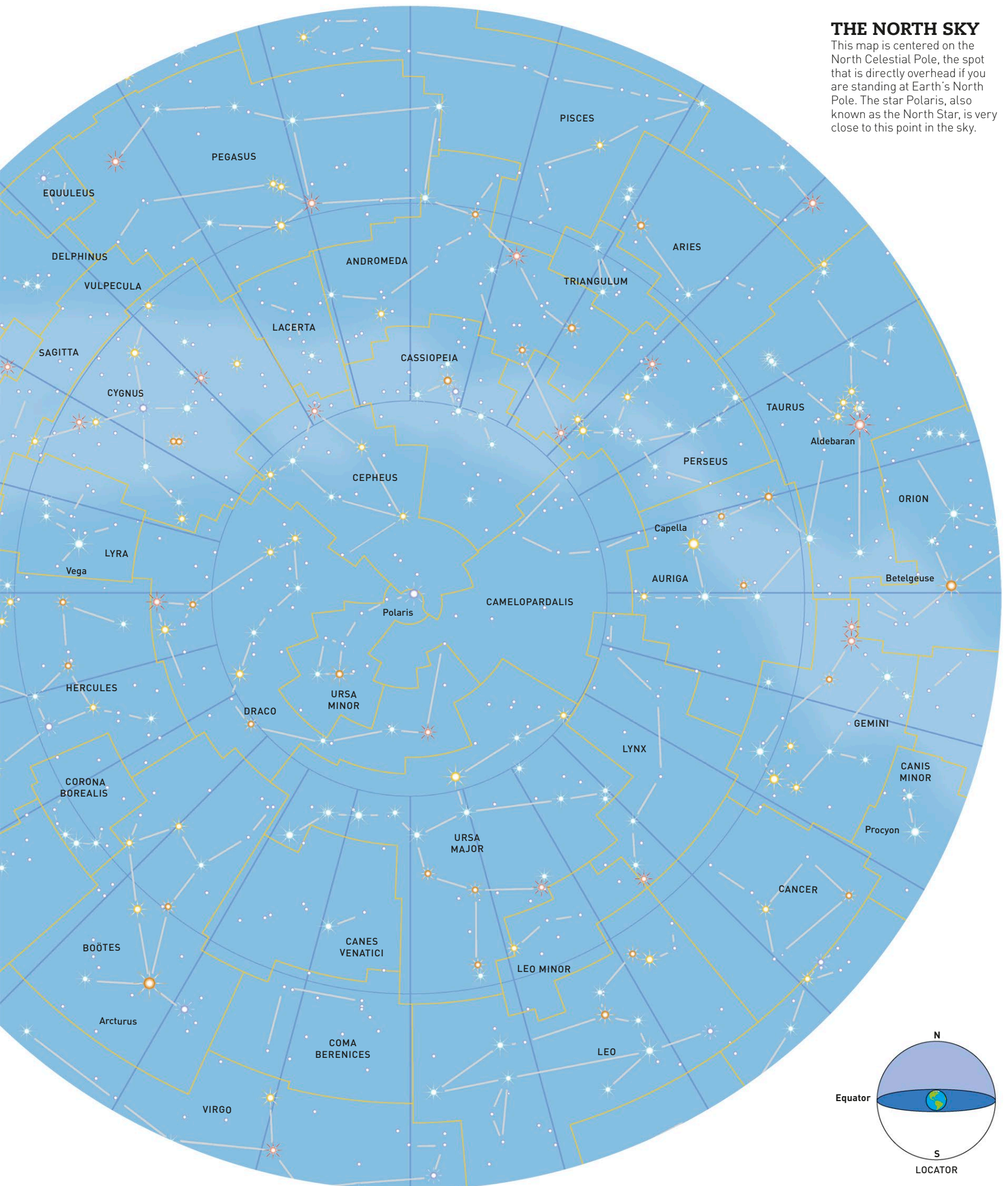
This swarm of stars in the constellation of Cancer is about three times the diameter of the Moon.





## THE NORTH SKY

This map is centered on the North Celestial Pole, the spot that is directly overhead if you are standing at Earth's North Pole. The star Polaris, also known as the North Star, is very close to this point in the sky.





# Southern skies

If you live south of the equator, you live in the southern hemisphere. On a clear night, the southern skies give a fantastic view of the Milky Way, bright star clusters, constellations, colorful nebulae—and even whole galaxies.

OMEGA CENTAURI IS  
THE LARGEST STAR CLUSTER  
IN OUR GALAXY,  
CONTAINING AROUND  
10 MILLION STARS.

KEY			
This map shows stars that are visible to the naked eye. Magnitude marks how bright a star is—the lower the number, the brighter the star.	Yellow star	Magnitude brighter than 0.0	Magnitude brighter than 3.0
	Red star	Magnitude brighter than 1.0	Magnitude brighter than 4.0
	Orange star	Magnitude brighter than 2.0	Magnitude brighter than 5.0
	White star		
	Blue star		

## THINGS TO LOOK FOR

The southern skies contain many night-sky objects that are not visible from the northern hemisphere, including the Magellanic clouds and the bright star cluster known as the Jewel Box.



CARINA NEBULA

This complex cloud of glowing gas in the Milky Way is the brightest nebula in sky. It contains some of the most massive stars known.



OMEGA CENTAURI CLUSTER

This is the largest and brightest globular cluster visible from Earth—it appears as a fuzzy star to the naked eye. It is in the center of the constellation Centaurus.



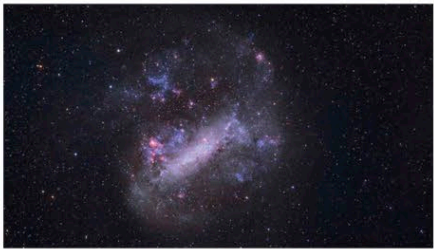
M7 STAR CLUSTER

This star cluster near the end of the scorpion's tail in the constellation Scorpius is easily visible to the naked eye. It is about 1,000 light-years away.



THE JEWEL BOX CLUSTER

This cluster in the constellation Crux has stars of contrasting colors, including a red supergiant and brilliant blue giants.



LARGE MAGELLANIC CLOUD

This small galaxy orbits our own galaxy, the Milky Way. It sits in the constellation Dorado, though part of it is in the constellation Mensa.



EAGLE NEBULA

This glowing cloud of gas in the constellation Serpens contains a cluster of bright young stars. New stars are being created inside the nebula.



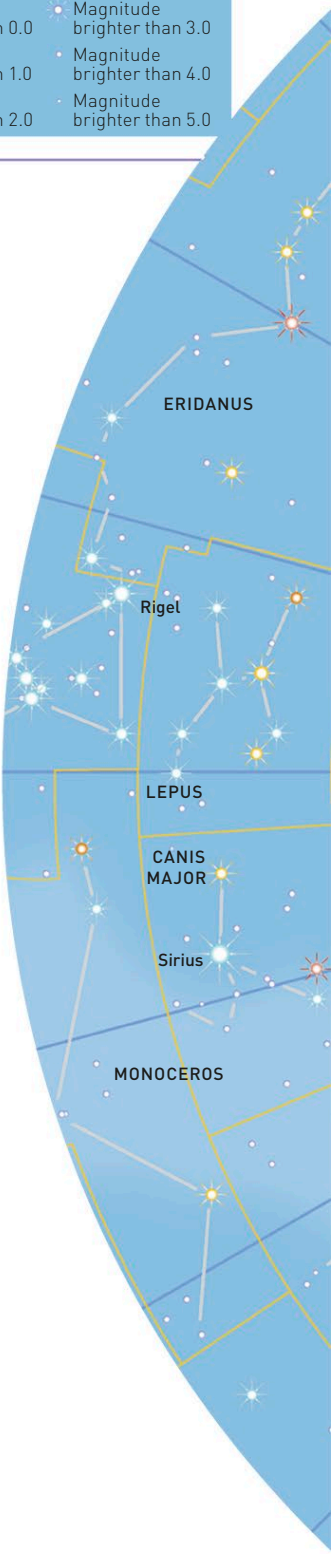
47 TUCANAEE GLOBULAR CLUSTER

This huge star cluster is around 16,700 light-years from Earth in the constellation of Tucana. It contains several million stars but looks like a single hazy star to the naked eye.



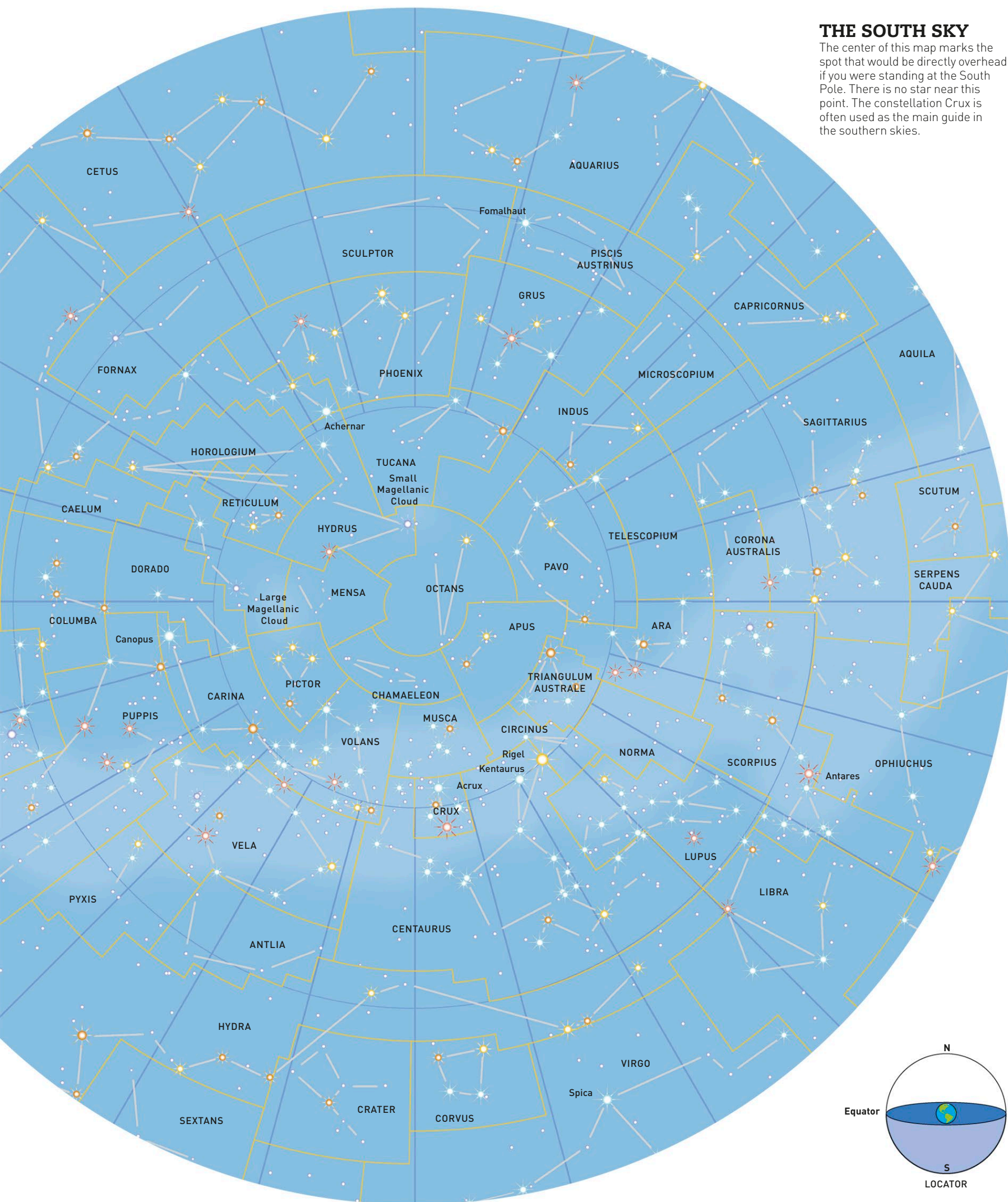
THE SOUTHERN CROSS

Crux, the Southern Cross, is the most famous of all southern constellations. It is pictured on the flags of several countries. The dark nebula next to it is called the Coalsack.





The center of this map marks the spot that would be directly overhead if you were standing at the South Pole. There is no star near this point. The constellation Crux is often used as the main guide in the southern skies.



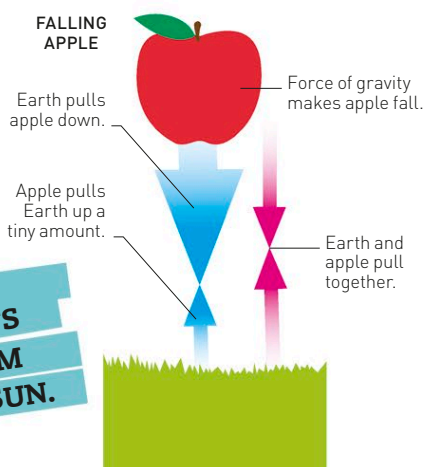


# Physics

How do forces, such as gravity and magnetism, affect matter—the stuff all around us? And how does energy make that possible? The answers to these questions are found in physics. Physicists try to unravel the rules of the Universe to explain why the world works as it does.

## GRAVITY

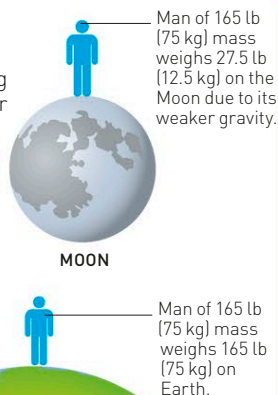
Gravity is the force that keeps us held fast on the planet, even while Earth spins at up to 1,037 mph (1,670 kph). Gravity pulls together all matter, but larger things with more mass have more gravitational force.



**GRAVITY KEEPS EARTH AND THE OTHER PLANETS IN THE SOLAR SYSTEM ORBITING AROUND THE SUN.**

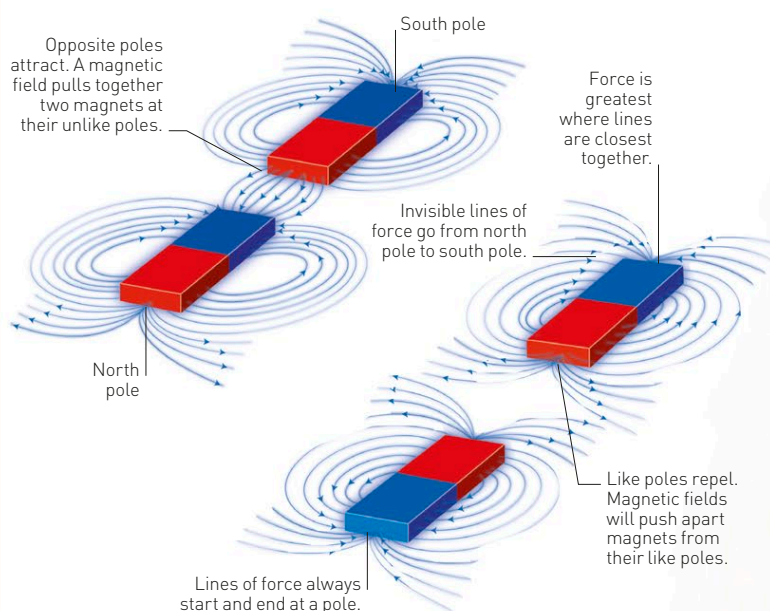
## MASS AND WEIGHT

The mass of something is the amount of matter it contains, and mass always stays the same wherever the object is. But weight changes depending on where an object is, because weight is determined by gravity, which varies from place to place.



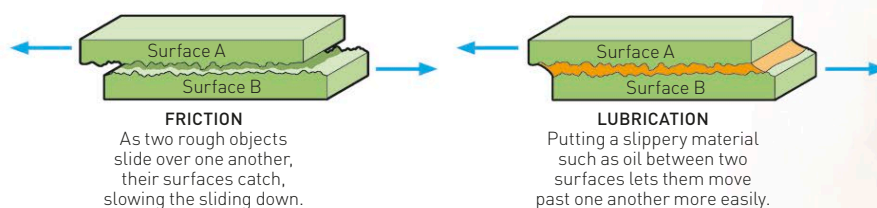
## MAGNETISM

Magnetism is a powerful invisible force that is created by electric currents. Magnetic objects have the power to attract other magnetic objects or push them away, depending on how their ends (poles) are lined up.



## FRICTION

This force occurs when one object is dragged over the surface of another object. The rougher a surface is, the more friction it produces. Even smooth surfaces have tiny bumps that will produce some friction.



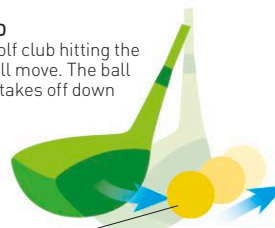
## FORCE

A force is something that pushes or pulls objects—whenever something moves, it has been moved by a force. Forces can change the speed of an object, alter its direction, or change its shape.

### CHANGING SPEED

The force of the golf club hitting the ball makes the ball move. The ball gains energy and takes off down the golf course.

The harder the ball is hit, the more force is used, and the farther it travels.



### CHANGING DIRECTION

When a force is applied to a moving object like a tennis ball, it can move it in a different direction.

Ball moves in one direction toward the racket.

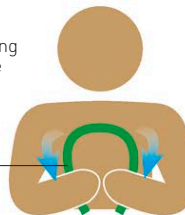
Hitting the ball with the racket applies force, changing the ball's direction.



### CHANGING SHAPE

A force may cause something to change shape if the force is strong enough and the atoms inside the object cannot resist it.

Bending a bar rearranges the atoms inside it, altering its shape.



## LAWS OF MOTION

All motion is caused by forces pushing and pulling. The scientist Isaac Newton described three laws of motion. The first says that all things will stay still or move at a steady speed unless a force acts on them. The second says that when a force acts on something, it makes it accelerate (increase speed). The third says that when a force operates on something (action), there is always an opposing and equal force (reaction).

### FIRST LAW

Before take-off, the forces acting on the rocket are balanced, so it stays still on the launchpad.

### SECOND LAW

The main engines and booster rockets create a huge downward force that accelerates the rocket upward.

### THIRD LAW

The exhaust gas firing down (the action) makes the rocket shoot up (the reaction). The rocket does not push against the air: it moves up because of the force of the exhaust blasting down.





## TYPES OF ENERGY

There are many different kinds of energy, and most of them can be converted into other forms. For example, when you burn coal, it changes the chemical energy stored in the coal into heat energy.



**POTENTIAL ENERGY**  
Energy that is stored and yet to be released.



**KINETIC ENERGY**  
The energy objects have because they are moving.



**ELECTRICAL ENERGY**  
The energy carried by electricity as it flows down a wire, for example.



**LIGHT ENERGY**  
Energy carried in electromagnetic waves.



**CHEMICAL ENERGY**  
Released by a reaction between different chemicals.



**NUCLEAR ENERGY**  
Generated by atoms splitting apart or joining together.



**SOUND ENERGY**  
Energy we can hear, made when things vibrate.



**HEAT ENERGY**  
Energy stored or moved by molecules jiggling around.

## HEAT

Heat is a form of energy, so when you heat something, you are increasing its stored energy. Objects store heat by jostling molecules or atoms inside them. Even large, cold objects can have heat energy.

**HEAT IS USUALLY ON THE MOVE—IT TRAVELS AROUND, SO COLD THINGS GET HOT AND HOT THINGS GET COLD.**



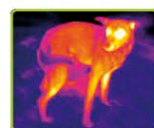
**ICEBERGS**  
Icebergs are freezing cold, but they still have some heat energy.

## ELECTROMAGNETIC SPECTRUM

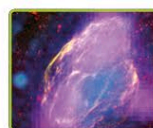
The Sun's heat and light is carried to Earth by electromagnetic waves. These are just part of a spectrum that includes radio waves, microwaves, and X-rays. All waves travel at the speed of light, but they vary in wavelength, frequency, and energy.



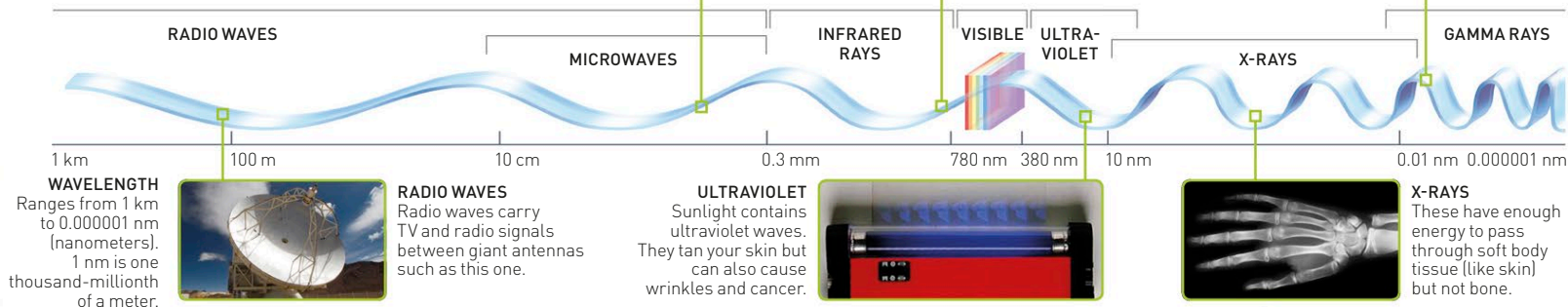
**MICROWAVES**  
Microwaves can be used to cook food.



**INFRARED RAYS**  
Infrared radiation is a kind of "hot light." It shows up on thermal (heat-sensitive) cameras.

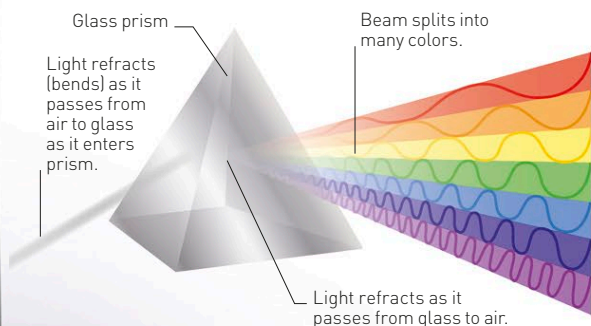


**GAMMA RAYS**  
These are made when atoms split apart in nuclear explosions.



## LIGHT AND COLORS

The light from the Sun looks white, but it is actually made up of lots of different colors. If you shine light through a prism (transparent wedge of glass), the whole spectrum of colors appears.



## SOUND

Sound is another form of energy that travels in waves. Louder sounds make bigger waves, while high-pitched sounds make waves that vibrate faster. The various noises we hear are produced by sound waves of different shapes and sizes.



**TUNING FORK**  
A tuning fork makes one simple, regular, up-and-down sound wave pattern called a "sine" wave. Each fork produces only one note.



**VIOLIN**  
When you play a violin, the strings vibrate, setting the air moving inside the hollow wooden case. A violin's sound wave is a sharp and spiky wave.

Complex, even sound wave

**FLUTE**  
A flute produces sound when you blow into it, making waves inside the pipe. The sound waves are similar to a sine wave.



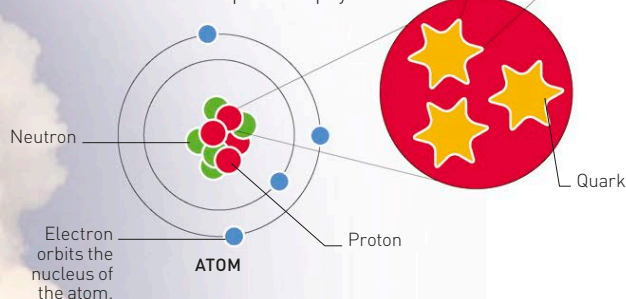
**CYMBAL**  
Percussion instruments make sounds when you hit them. Their sound waves are more like a short burst of random noise (white noise) than a precise wave.

A bigger cymbal vibrates a greater volume of air, so it sounds louder.



## TINY SCIENCE

Our whole planet and all its people are made of atoms. The nucleus of an atom consists of protons and neutrons, and these are made of even smaller things called quarks. It is unclear what those are made of, but some scientists think that they may be vibrations of matter or energy, which scientists refer to as "strings." This science is known as quantum physics.



## GREAT PHYSICISTS

In the last 400 years, physicists have invented theories that underpin much of what we know about our Universe.

### ISAAC NEWTON (1643–1727)

Newton devised the laws of gravity and motion.

### ERNEST RUTHERFORD (1871–1937)

Rutherford proved that the atom was not solid but had electrically charged electrons orbiting a nucleus.

### ALBERT EINSTEIN (1879–1955)

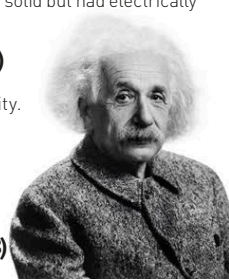
Einstein discovered many things, but he is most famous for his theory of relativity.

### CECILIA PAYNE-GAPOSCHKIN (1900–1979)

Gaposchkin found that hydrogen is the most common element in the Universe.

### RICHARD FEYNMAN (1918–1988)

Feynman is best known for introducing the world to quantum physics.



ALBERT EINSTEIN



# Electricity

We use electricity to power all sorts of things, from factories and trains to the many small appliances in our homes. The energy it contains comes from charged electrons that whizz around inside every atom.

## ELECTRICITY IN NATURE

Electricity is not only generated in power stations—it is also found in nature, from high-energy lightning strikes to inside our own bodies. Our brains use electric signals to tell our muscles to move.



**LIGHTNING**  
A bolt releases as much energy as a power station makes in one second.



**AURORA**  
These lights in the sky are streams of electrically charged particles.



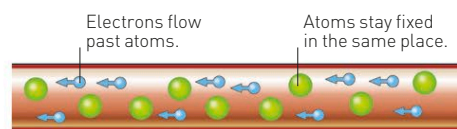
**NERVOUS SYSTEMS**  
Human nerves communicate by electric signals.



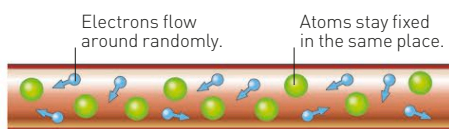
**ELECTRIC EEL**  
This eel discharges electricity in water to kill fish for food.

## ELECTRIC CURRENT

When electrons flow down wires, they carry energy from place to place. So in a flashlight, electrons move around the wire from the battery to the lamp, where their power lights up the bulb.



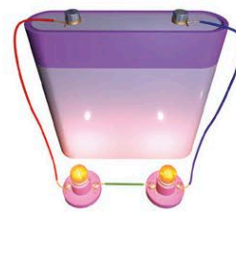
**CURRENT FLOWING**  
When the power is switched on, the electrons move along in a line, forming an electric current.



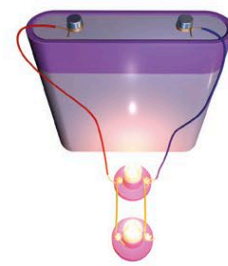
**NO CURRENT FLOWING**  
When the power is switched off, there's nothing to move the electrons in a line, so they just jerk about randomly.

## CIRCUITS

The path that electrons travel along is called a "circuit." A circuit carries power from a power source (such as a wall socket) to something that needs electricity to run (such as a lamp). There are two types of circuit.



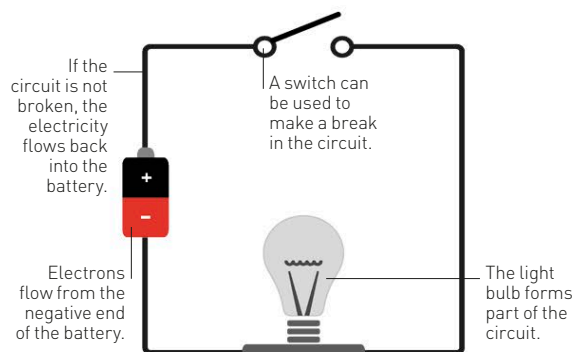
**SERIES CONNECTION**  
All the power moves through each part of the circuit in a line.



**PARALLEL CONNECTION**  
The power splits into two as it reaches two lamps wired like this.

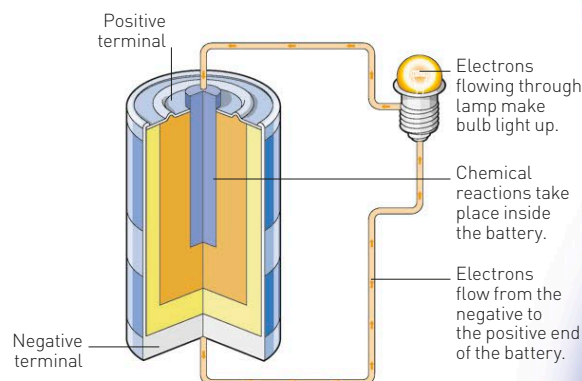
## SWITCHES

If you attach a wire to both ends of a battery and connect a light bulb to the wire at some point, the electricity would continually flow and always light the bulb. A switch is used to break the circuit, so the bulb can be switched on and off.



## BATTERIES

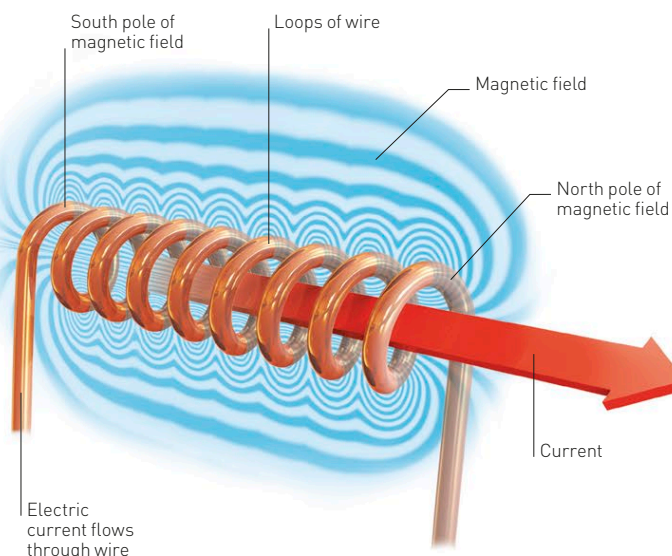
Batteries make their own electricity by using chemicals. When you connect a battery, chemical reactions take place that generate electrons.



**LIGHTNING BOLTS ARE LARGE-SCALE STATIC SHOCKS.**

## ELECTROMAGNETISM

When an electric current flows through a wire, it creates a magnetic field around it. The strength of the magnetic field can be increased by coiling the wire in loops, because that allows more current to flow through a smaller distance.



## STATIC ELECTRICITY

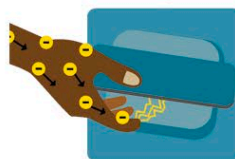
Static electricity is sometimes created when two things are rubbed together. The rubbing creates an electrical charge, which is released when it comes into contact with something else that conducts electricity.

### GETTING A SHOCK

Static shocks occur because your body builds up static when you rub against things. The static stays until you touch something metal, when it moves from you through the metal to Earth, giving you a shock.



**1 CHARGED UP**  
The electrical charge you pick up from rubbing against things is usually negative. It will stay in your body as you move around, until you touch an object such as a metal door handle.



**2 JUMPING ELECTRONS**  
When you touch a conductor, such as a metal handle, the static charge jumps from you, to the handle, to Earth. As the negatively charged electrons jump across, you feel a static shock.



## CONDUCTORS AND INSULATORS

Electricity is a flow of electrons, so materials that do not allow the flow cannot pass along electricity. These are called "insulators." Materials that do allow the flow of electricity are called "conductors." Between these two are semiconductors.

### INSULATORS

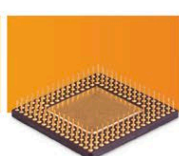


RUBBER



WOOD

### SEMICONDUCTORS



SILICON



WATER



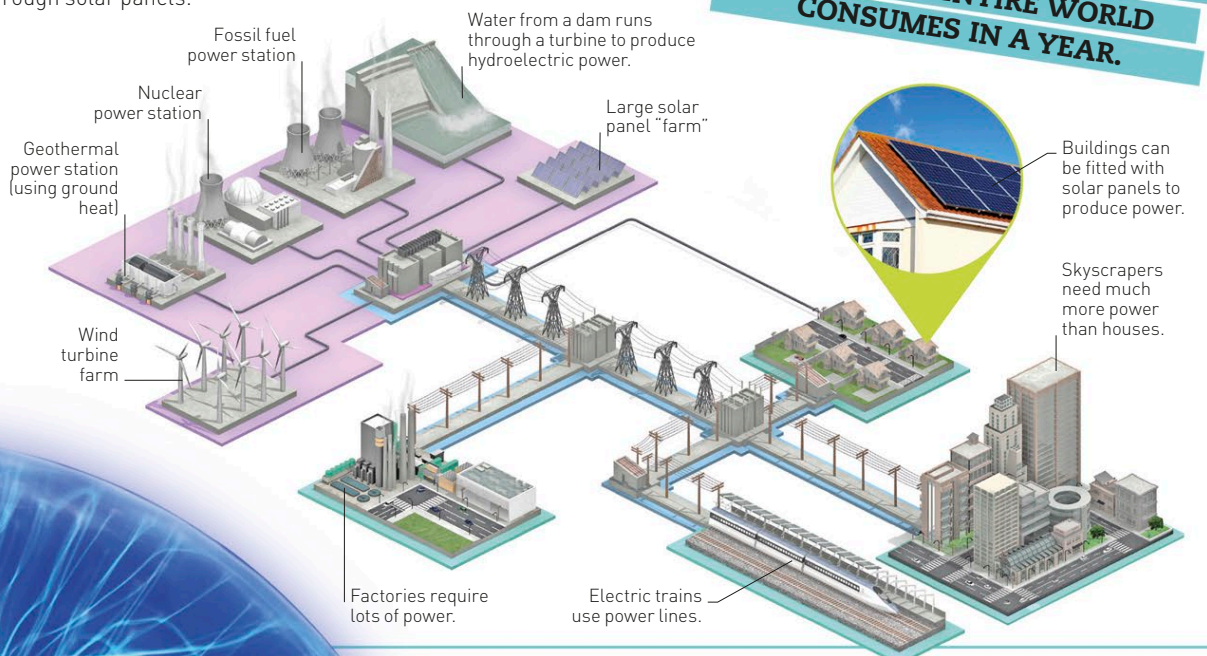
COPPER

### CONDUCTORS

## POWER TO THE HOME

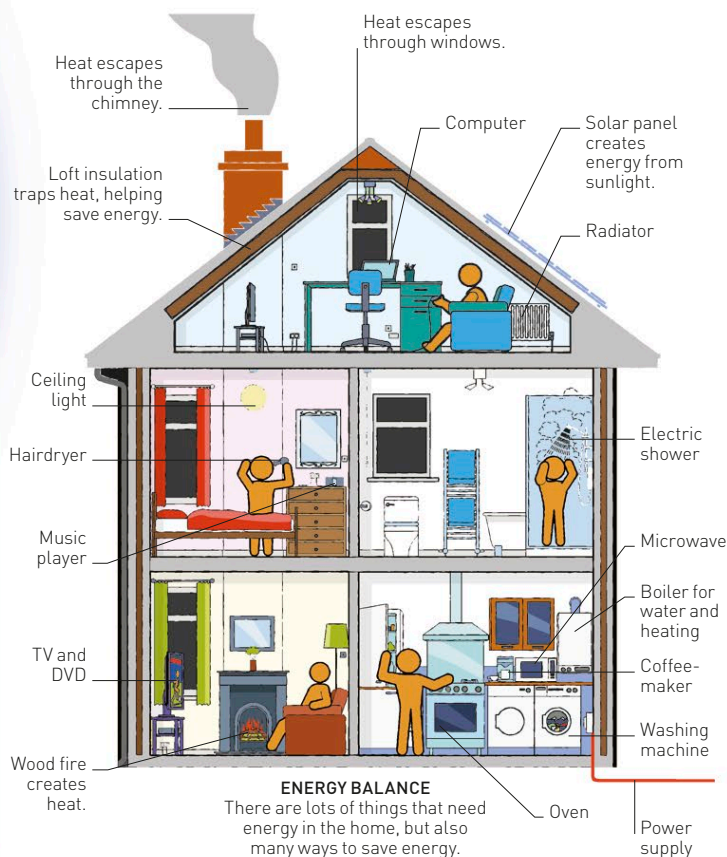
Electricity is produced for homes in several ways, such as burning coal or using nuclear power. The electricity is then fed through substations to individual houses. Some houses also produce their own power through solar panels.

**THE SUN BEAMS MORE ENERGY TO EARTH IN AN HOUR THAN THE ENTIRE WORLD CONSUMES IN A YEAR.**



## ELECTRICITY AT HOME

We use electricity at home from the moment we get up (perhaps switching on a light or using an electric toothbrush) to when we go to bed. Homes need energy for heat, light, cooking, and washing machines, as well as lots of personal items, such as hairdryers and mobile phones.



### PLASMA SPHERE

The streams of plasma here are created by the release of static electricity, which flows as a current from the center to the edge of the glass sphere.

## VOLTAGE

Voltage is a kind of force that makes electricity move through a wire. The bigger the voltage, the more current will shoot through the wire. Bigger voltages and currents deliver more electrical power, but they are also more dangerous.



### PYLONS

These hold up overhead lines that carry electricity across long distances. The largest ones use 400,000-volt cables. Cables on wooden poles use 400–11,000 volts.



### ELECTRIC TRAIN CABLES

Trains take power from cables above them or from extra rails in the track. The cables supply about 25,000 volts, but some trains use less. High-speed trains need much higher voltages than small, light trams.



### ELECTRICITY AT HOME

Voltage in the home differs from country to country, but generally lies at 110–250 volts. Factories need higher voltages because they have bigger machines.



### BATTERY CHARGERS

A laptop or phone charger needs 5–20 volts to charge its battery. Laptops need higher voltages than phones because they have bigger screens and circuits that use more energy.



### FLASHLIGHT BULBS

Bulbs for flashlights and lamps usually work with 1.5 volts. Bigger batteries store more energy and last longer.

## PIONEERS

Electricity exists naturally in the world. These people were important in finding out how to harness its power.

### BENJAMIN FRANKLIN (1706–1790)

Franklin discovered that lightning is electricity and that there are positive and negative charges.

### ALESSANDRO VOLTA (1745–1827)

A professor of experimental physics, Volta invented the first battery, called the Voltaic Pile.

### MICHAEL FARADAY (1791–1867)

Faraday discovered that if you move a magnet near wire, the wire becomes electrified. This is known as electromagnetic induction.

### THOMAS EDISON (1847–1931)

Edison built the first electric power stations and invented the light bulb, sound recorder (phonograph), and movie camera.

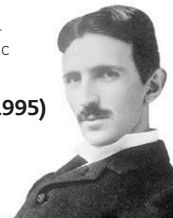
### JOSEPH JOHN THOMSON (1856–1940)

Physicist J. J. Thomson discovered the electron in 1897.

### NIKOLA TESLA (1856–1943)

Tesla discovered alternating currents, hydroelectric power, radio waves, and radar. He invented transformers, a long-distance power system, electric motors, and X-ray machines.

NIKOLA TESLA



### MÁRIA TELKES (1900–1995)

Nicknamed "the Sun Queen," Telkes was the first to design a solar-powered heating system for homes.

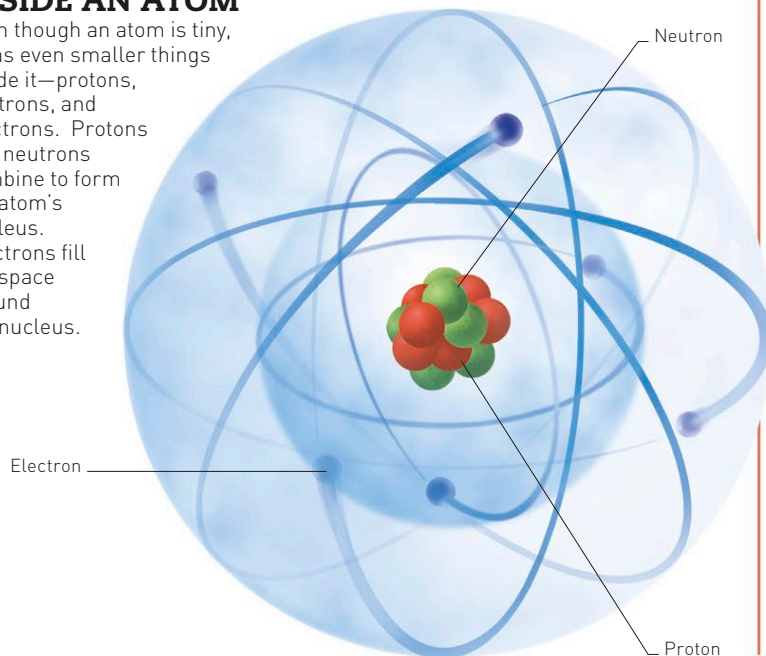


# Chemistry

Chemists dig deep. They begin with the elements that make up all matter and break them down into tiny atoms. They analyze what the atoms are, how they change state, and how they react when they mix.

## INSIDE AN ATOM

Even though an atom is tiny, it has even smaller things inside it—protons, neutrons, and electrons. Protons and neutrons combine to form the atom's nucleus. Electrons fill the space around the nucleus.



## CHEMISTRY IN ACTION

In ancient times, people used the natural materials around them, such as wood and stone, to make objects. Since then, scientists have discovered thousands of chemicals, some of which can be used to make new materials.



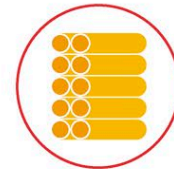
**BIOCHEMISTRY**  
This looks at chemical processes inside living things or affecting them.



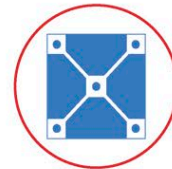
**ORGANIC CHEMISTRY**  
This branch of chemistry focuses on carbon-based compounds and their uses.



**HOUSEHOLD CHEMICALS**  
We use lots of chemicals in our homes, from the paint on our walls to the shampoo for our hair.



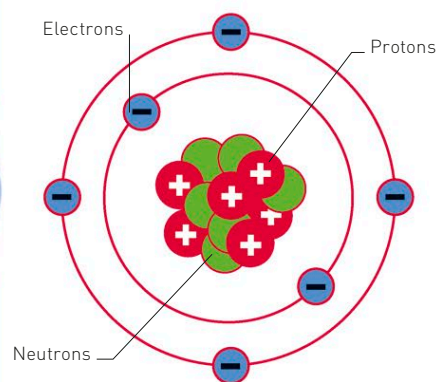
**MATERIALS SCIENCE**  
This science uses physics and chemistry to create new materials.



**ENGINEERING**  
Engineers use their knowledge of materials to design things.

## STRUCTURE OF AN ATOM

Some particles in the atom are electrically charged. The protons in the nucleus are positively charged and the electrons are negatively charged. There are always equal numbers of protons and electrons.

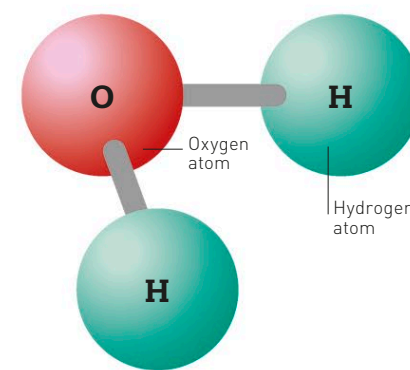


### CARBON ATOM

The number of protons inside an atom determines what kind of atom it is. For example, a carbon atom has six electrons and six protons.

## MOLECULES

Atoms of the same sort or different atoms can bond (lock together) to make molecules. A molecule can be as simple as just two atoms, as in hydrogen, or lines of thousands of atoms, as in some plastics.

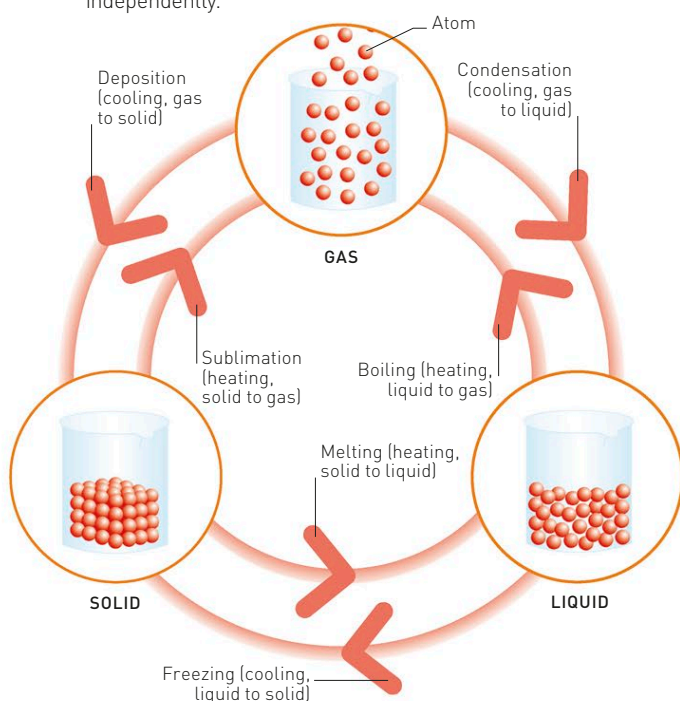


### WATER MOLECULE

A molecule of water is made up of two different kinds of atoms: two hydrogen (H) atoms and one oxygen (O) atom.

## STATES OF MATTER

All matter can change state. Water, for instance, can be a liquid, gas (steam), or solid (ice). Its state depends upon the way its atoms move around, and the state can change with a change in temperature. As a solid, its atoms lock tightly together. As a liquid, they move farther apart. As a gas, they move freely and independently.



## MIXTURES

A mixture is made when two substances are combined but no chemical reaction takes place. The ingredients are said to combine rather than to bond.



### SOLUTION

Fruit concentrate (solute) dissolves in water (the solvent) to make a drink.



### SUSPENSION

A mixture between a liquid and particles of a solid, such as water and soil.



### COARSE MIXTURE

An unevenly distributed mixture of different types of larger particles.



### ALLOY

A mixture of a metal with other elements that creates a stronger or better material.

## SEPARATING MIXTURES

The substances in a mixture are not bonded together, so they can be separated. However, the more similar the properties of each substance are to one another, the harder it is to separate them.



### FLOATING

Shaken together, these substances mix. Left for a time, they separate back out.



### MAGNETIZING

Magnetic substances will be drawn to stick to the magnet.



### CHROMATOGRAPHY

Using a substance that attracts some particles more than others separates the two.



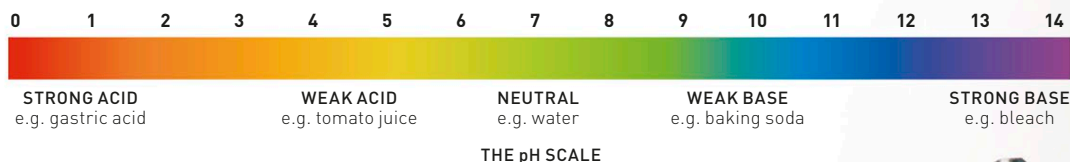
### FILTERING

Solid particles will collect on the filter during the filtration process.



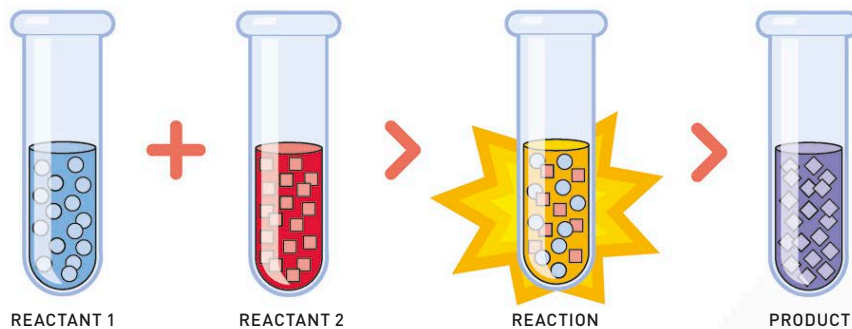
## ACIDS AND BASES

All liquids and solutions fall somewhere on the acids and bases scale, which is measured as a pH level. Those at each end of the scale are very reactive and dangerous.



## WHAT IS A CHEMICAL REACTION?

In the natural world, atoms and molecules are constantly joining together or breaking down to form new things. This can also be done in a laboratory. When scientists add one ingredient (called a reactant) to another, they create a chemical reaction. The molecules of the reactants split apart, rearrange themselves, and then form a new bond—the product of the reaction.



**SWIRLS AND FUMES**  
The product of a chemical reaction can be very different from the original reactants. This mix reacts quickly, swirling and giving off fumes.

## TYPES OF CHEMICAL REACTION

Although the product of a chemical reaction is very different from the reactants, none of the atoms are destroyed—there are the same number before as after the reaction. There are three types of chemical reaction.

**SYNTHESIS REACTION**  
Two or more reactants join together to make a new compound.



**DECOMPOSITION REACTION**  
One reactant breaks apart into two products to make two compounds.



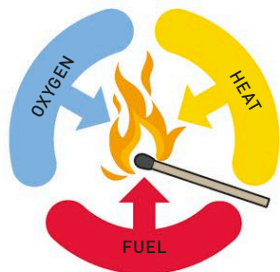
**REPLACEMENT REACTION**  
Atoms of one type swap places with those of another to make a new compound.



**GRAPHITE CAN BE CHANGED INTO DIAMOND THROUGH HEAT AND PRESSURE.**

## COMBUSTION

Car engines and power stations are powered by a chemical reaction called combustion (burning). The reactants are fuel, such as petroleum or coal, and oxygen from the air. Adding heat (setting fire to the fuel) starts the reaction.



## MATERIALS

The materials we use for making everyday objects need to have the right properties for the object's function. For example, wood is robust and good for building a chair but would be a poor choice for a frying pan, because it would catch fire.



**WOOD**  
Hard, strong, and rigid; burns readily; and is a good insulator.



### METAL

Good conductor of heat and electricity. It is strong and inflexible.



### PLASTIC

Strong, waterproof, and can be made into any shape. Good insulator.



### CERAMIC

Fragile if knocked but can withstand high temperatures.



### GLASS

Transparent and can be made into any shape. Breaks easily if thin.



### SYNTHETIC FIBER

Plastic-based fibers are strong and waterproof.



### KEVLAR®

High-strength material that withstands high impact and extreme temperatures.

## GREAT CHEMISTS

The discoveries of great chemists have contributed to human progress in everything from medicine to space travel.

### ROBERT BOYLE (1627–1691)

The author of *The Sceptical Chymist* was the first to develop rigorous scientific techniques for his experiments in the field of chemistry.

### ANTOINE LAVOISIER (1743–1794)

The first chemist to demonstrate that water is made of oxygen and hydrogen and to show that oxygen is needed for combustion.

### MARIE CURIE (1867–1934)

Two-time winner of the Nobel Prize, Curie discovered radium.

MARIE CURIE

### LINUS PAULING (1901–1994)

A prolific scientist who worked out how molecules bond together.

### DOROTHY HODGKIN (1910–1994)

A pioneer in X-ray techniques who discovered the atomic structure of penicillin.





# Periodic table

The building blocks of every single thing on Earth are pure chemical substances called elements. Put a few elements together by joining their atoms and you can get anything from a flea to a space rocket. Carbon-based elements are found in all living things, while water has just two elements—hydrogen and oxygen.

## WHAT IS THE PERIODIC TABLE?

Elements are listed in a chart called the periodic table. Each entry shows the element's name, short chemical symbol, atomic number, and atomic mass.

### ATOMIC NUMBER

An element's atomic number refers to the number of protons in the nucleus of an atom of the element. Titanium has 22.

**ATOMIC MASS**  
This is the mass of the nucleus inside an atom.

**CHEMICAL SYMBOL**  
This scientific symbol is a short version or representation of the element's name.

**NAME**  
This is the element's name. Titanium is a strong, light metal that is found in abundance in Earth's crust.

## THE PERIODIC TABLE

Elements with a similar structure sit together in the grid, which predicts how they will behave. Most of the 118 elements occur in rocks or in the atmosphere, but scientists have also built new ones by smashing smaller atoms together.

1	2	3	4	5	6	7	8	9
1 1.008 <b>H</b> Jupiter HYDROGEN	3 6.94 <b>Li</b> Watermelon tourmaline LITHIUM	4 9.012 <b>Be</b> Aquamarine BERYLLIUM						
11 22.990 <b>Na</b> Salt SODIUM	12 24.305 <b>Mg</b> Peridot MAGNESIUM							
19 39.098 <b>K</b> Banana POTASSIUM	20 40.078 <b>Ca</b> Cheese CALCIUM	21 44.956 <b>Sc</b> SCANDIUM	22 47.867 <b>Ti</b> Benitoite gemstone TITANIUM	23 50.942 <b>V</b> Vanadinite VANADIUM	24 51.996 <b>Cr</b> Chrome tap CHROMIUM	25 54.938 <b>Mn</b> Spessartine MANGANESE	26 55.845 <b>Fe</b> Iron horseshoe IRON	27 58.933 <b>Co</b> Blue glass COBALT
37 85.468 <b>Rb</b> Fireworks RUBIDIUM	38 87.62 <b>Sr</b> Strontium STRONTIUM	39 88.906 <b>Y</b> YTTRIUM	40 91.224 <b>Zr</b> Zircon stone ZIRCONIUM	41 92.906 <b>Nb</b> Rocket engine NIOBIUM	42 95.95 <b>Mo</b> Steel girder MOLYBDENUM	43 (98) <b>Tc</b> TECHNETIUM	44 101.07 <b>Ru</b> RUTHENIUM	45 102.906 <b>Rh</b> Rhodium-plated buckle RHODIUM
55 132.905 <b>Cs</b> Caesium atomic clock CAESIUM	56 137.327 <b>Ba</b> Crystals BARIUM	57-71 <b>La-Lu</b> LANTHANIDE	72 178.486 <b>Hf</b> Nuclear reactor control rod HAFNIUM	73 180.948 <b>Ta</b> Capacitor TANTALUM	74 183.84 <b>W</b> Filament in light bulb TUNGSTEN	75 186.207 <b>Re</b> Jet turbine blades RHENIUM	76 190.23 <b>Os</b> Tip of fountain pen OSMIUM	77 192.217 <b>Ir</b> Surgical needle IRIDIUM
87 (223) <b>Fr</b> FRANCIUM	88 (226) <b>Ra</b> RADIUM	89-103 <b>Ac-Lr</b> ACTINIDE	104 (267) <b>Rf</b> RUTHERFORDIUM	105 (268) <b>Db</b> DUBNIUM	106 (269) <b>Sg</b> SEABORGIUM	107 (270) <b>Bh</b> BOHRIUM	108 (269) <b>Hs</b> HASSIUM	109 (278) <b>Mt</b> MEITNERIUM
			57 138.905 <b>La</b> Monazite LANTHANUM	58 140.116 <b>Ce</b> Cerium oxide CERIUM	59 140.908 <b>Pr</b> Permanent magnet PRASEODYMIUM	60 144.242 <b>Nd</b> Earbuds NEODYMIUM	61 (145) <b>Pm</b> PROMETHIUM	62 150.36 <b>Sm</b> Samaraskite SAMARIUM
			89 (227) <b>Ac</b> ACTINIUM	90 232.038 <b>Th</b> THORIUM	91 231.036 <b>Pa</b> PROTACTINIUM	92 238.029 <b>U</b> Nuclear power plant URANIUM	93 (237) <b>Np</b> NEPTUNIUM	94 (244) <b>Pu</b> Atomic bomb PLUTONIUM

### RARE-EARTH METALS

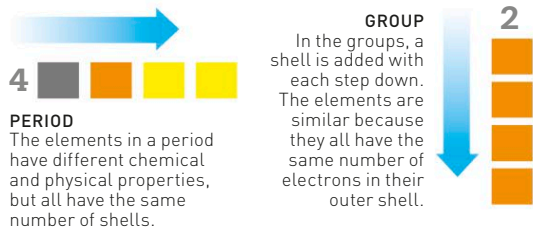
Elements with a higher number than uranium (92) rarely occur naturally. These transuranic elements are created in particle accelerators or nuclear reactors. As the lanthanides and actinides are too long to show on the main table, they are shown expanded below it.

96 PERCENT OF THE HUMAN BODY IS MADE UP OF JUST FOUR ELEMENTS: OXYGEN, CARBON, HYDROGEN, AND NITROGEN.



## READING THE TABLE

















The table has horizontal rows called periods and vertical columns called groups. Atoms get bigger and heavier toward the bottom of each group because they have more protons and more electrons in the shells (rings) around them. As you move along the rows from left to right, atoms gain protons and electrons and become more tightly packed.



**THE RUSSIAN SCIENTIST  
DMITRI MENDELEEV  
INVENTED THE MODERN  
PERIODIC TABLE IN 1869.**

## PERIODIC TABLE KEY

- Alkali metals**  
Soft reactive metals, usually in compounds.
- Alkaline earth metals**  
Very reactive metals not found as pure elements.
- Transition metals**  
Malleable, ductile metals that are good conductors.
- Rare earth metals**  
Toxic, radioactive metals, often human-made.
- Other metals**  
Malleable, ductile, solid, dense metals.
- Metalloids**  
Share properties with metals and non-metals.
- Other nonmetals**  
Poor solid conductors, brittle, with no metallic lustre, and gases.
- Halogens**  
These exist in solid, liquid, and gas forms.
- Noble gases**  
Stable gases that do not react naturally.

10		11		12		ALUMINUM		SILICON		PHOSPHORUS		SULFUR		CHLORINE		ARGON	
28 58.693		29 63.546		30 65.38		31 69.723		32 72.630		33 74.922		34 78.971		35 79.904		36 83.798	
Ni  Spoon NICKEL		Cu  Wire COPPER		Zn  Sphalerite ZINC		Ga  Solar thermal panel GALLIUM		Ge  Camera lens GERMANIUM		As  Arsenic ARSENIC		Se  SELENIUM		Br  Bromine BROMINE		Kr  Fluorescent lamp KRYPTON	
46 106.42		47 107.868		48 112.414		49 114.818		50 118.710		51 121.760		52 127.60		53 126.904		54 131.293	
Pd  Catalytic converter PALLADIUM		Ag  Silver pendant SILVER		Cd  Yellow paint CADMIUM		In  Light-emitting diode (LED) INDIUM		Sn  Tin-plated can TIN		Sb  Bullet ANTIMONY		Te  Compact Disc (CD) TELLURIUM		I  Liquid iodine IODINE		Xe  Arc lamp XENON	
78 195.084		79 196.967		80 200.592		81 204.38		82 207.2		83 208.980		84 (209)		85 (210)		86 (222)	
 Ring Pt PLATINUM		 Necklace Au GOLD		Hg  Thermometer MERCURY		Tl  Rat poison THALLIUM		Pb  Lead battery LEAD		Bi  Crystal BISMUTH		Po  POLONIUM		At  ASTATINE		Rn  RADON	
110 (281)		111 (280)		112 (285)		113 286		114 289		115 289		116 293		117 294		118 294	
Ds  DARMSTADIUM		Rg  ROENTGENIUM		Cn  COPERNICIUM		Nh  NIHONIUM		Fl  FLEROVIUM		Mc  MOSCOVIUM		Lv  LIVERMORIUM		Ts  TENNESSINE		Og  OGANESSION	
63 151.964		64 157.25		65 158.925		66 162.500		67 164.930		68 167.259		69 168.934		70 173.045		71 174.967	
Eu  Xenotime EUROPIUM		Gd  GADOLINIUM		Tb  Green fluorescent lamp TERBIUM		Dy  Fergusonite crystals DYSPROSIUM		Ho  Gadolinite HOLMIUM		Er  Fiber optic cable ERBIUM		Tm  THULIUM		Yb  Atomic clock YBBIUM		Lu  LUTETIUM	
95 (243)		96 (247)		97 (247)		98 (251)		99 (252)		100 (257)		101 (258)		102 (259)		103 (262)	
 Smoke detector Am AMERICIUM		Cm  CURIUM		Bk  BERKELIUM		Cf  CALIFORNIUM		Es  EINSTEINIUM		Fm  FERMIUM		Md  MENDELEVIUM		No  NOBELIUM		Lr  LAWRENCIUM	



# Biology

Biology is the science of all life, from microscopic bacteria that cannot be seen with the naked eye to enormous animals such as elephants and whales. It includes their form and function, origin and growth, and evolution and distribution.

## NEEDED FOR LIFE

Almost all life forms need the same essentials to survive. Few forms of life can exist without most of these basic necessities.



### WATER

All living things are made of cells, which need water to exist—most life forms are mainly made up of water.



### ENERGY SOURCE

Life forms need energy to grow and move around. Plants use sunlight to make energy. Animals get energy by eating plants or each other.



### OXYGEN

Oxygen in air or water is necessary for almost all life.



### ESSENTIAL CHEMICALS

The chemicals hydrogen, nitrogen, and carbon are essential for life. Plants get them from soil, while animals absorb them from food.



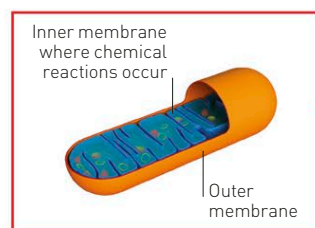
### THE RIGHT TEMPERATURE

Few living things can exist in extremely hot or cold temperatures.

**ALMOST ALL ORGANISMS  
NEED THE SAME BASIC  
ESSENTIALS IN  
ORDER TO LIVE.**

## WHAT IS A CELL?

Cells are the building blocks of life. The cells of all living things except archaea and bacteria contain a nucleus, mitochondria, and other organelles. Cells can be specialized to perform different functions—for example, we have nerve, muscle, and bone cells. The human body has around 75 trillion cells. Less complex organisms may have only one.

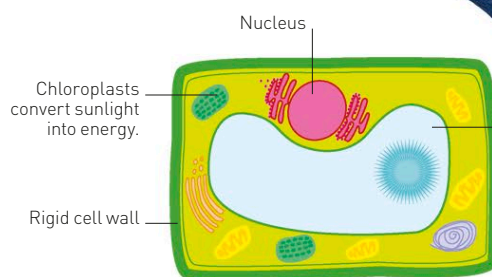


### MITOCHONDRION

This is the part of the cell that releases energy from food molecules within the body.

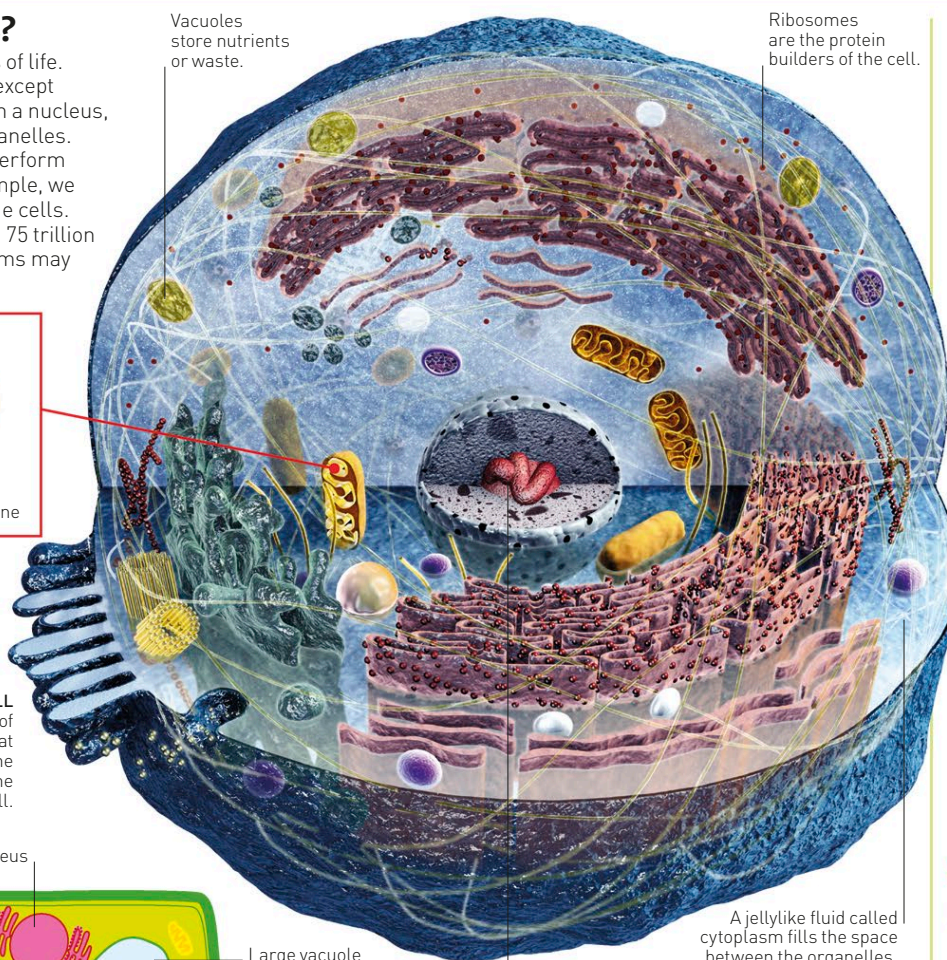
### ANIMAL CELL

An animal cell contains lots of "machines" called organelles that perform special jobs such as the mitochondrion. A cell membrane surrounds the cell.



### PLANT CELL

A plant cell has much in common with animal cells, but it also has a rigid cell wall and chloroplasts.



Vacuoles store nutrients or waste.

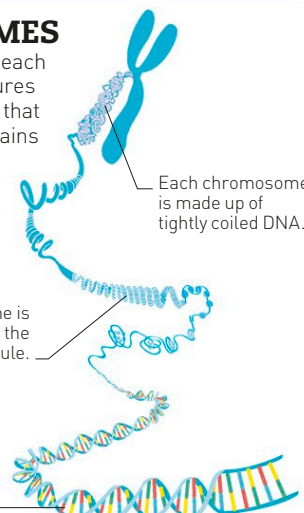
Ribosomes are the protein builders of the cell.

A jellylike fluid called cytoplasm fills the space between the organelles.

The nucleus is the cell's control center. It sends chemical instructions to other parts of the cell.

## CHROMOSOMES

Within the nucleus of each cell, there are structures called chromosomes that carry DNA. DNA contains genes that determine how an organism looks and functions. Humans have 46 chromosomes (23 pairs).



DNA is a long molecule arranged in a double-helix shape.

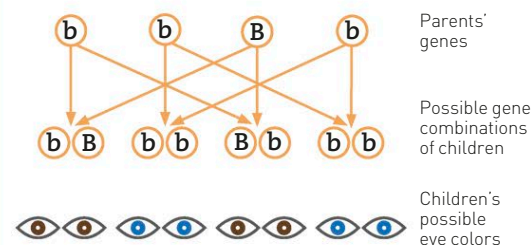
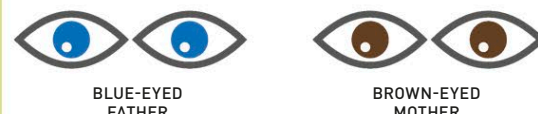
## GENES

Our genes are inherited from our parents—half from mom and half from dad—and they dictate things such as eye color. Each person has two versions of each gene, called alleles, which together make up their genotype. One allele is often dominant over another, which means that that feature is the one seen in the person.

### KEY

- b** The recessive allele. A child must have two b alleles to have blue eyes.
- B** The dominant allele—a child with one or two B alleles will have brown eyes.

Each parent carries a different combination of genes for eye color.

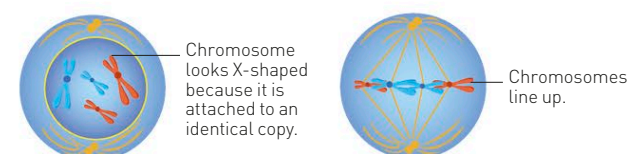


### GENETICS IN ACTION

The mother here has one recessive and one dominant allele. The father has two recessive alleles. This means it is equally likely that they have a brown- or blue-eyed child.

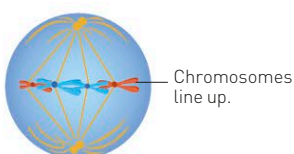
## CELL DIVISION

Organisms develop from a single cell, which divides again and again. Over the organism's lifetime, its cells are continually replaced in a process called mitosis.



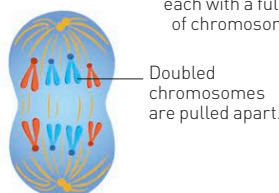
### 1 FIRST STAGE

The cell contains chromosomes that can be copied to make new identical chromosomes.



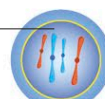
### 2 CHROMOSOMES ALIGN

The wall of the nucleus breaks down and chromosomes line up in the middle of the cell.



### 3 SEPARATION

Each doubled chromosome is pulled in half, so its two chromosomes move to opposite ends of the cell.



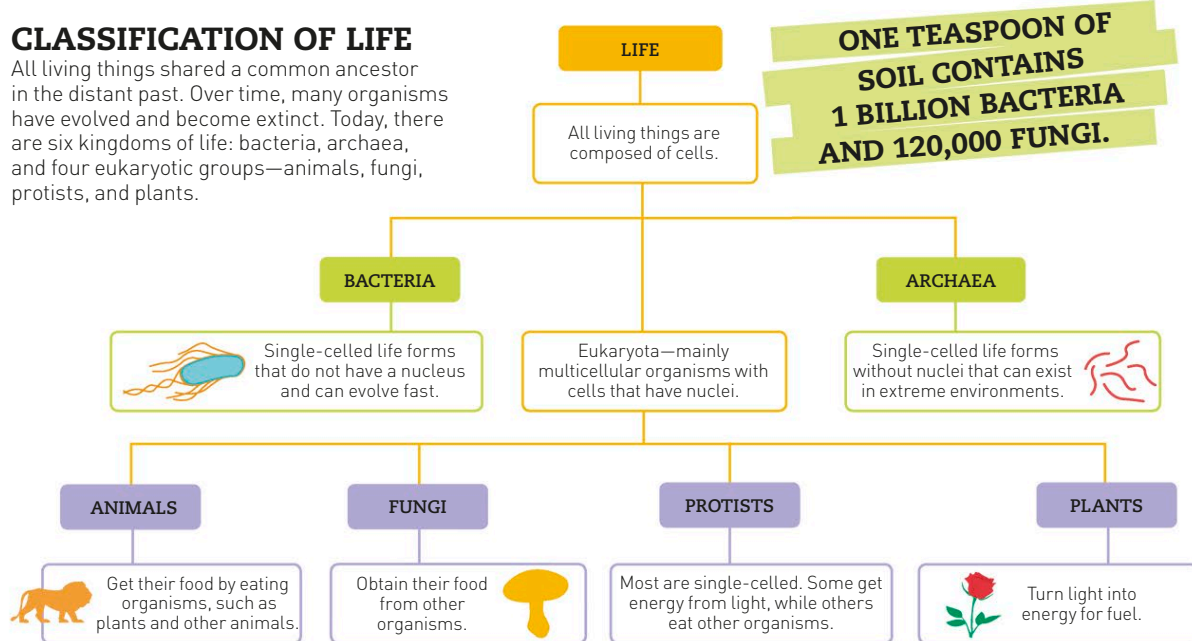
### 4 "DAUGHTER" CELLS FORM

Cell splits into two identical cells and the nuclear wall reforms.



## CLASSIFICATION OF LIFE

All living things shared a common ancestor in the distant past. Over time, many organisms have evolved and become extinct. Today, there are six kingdoms of life: bacteria, archaea, and four eukaryotic groups—animals, fungi, protists, and plants.



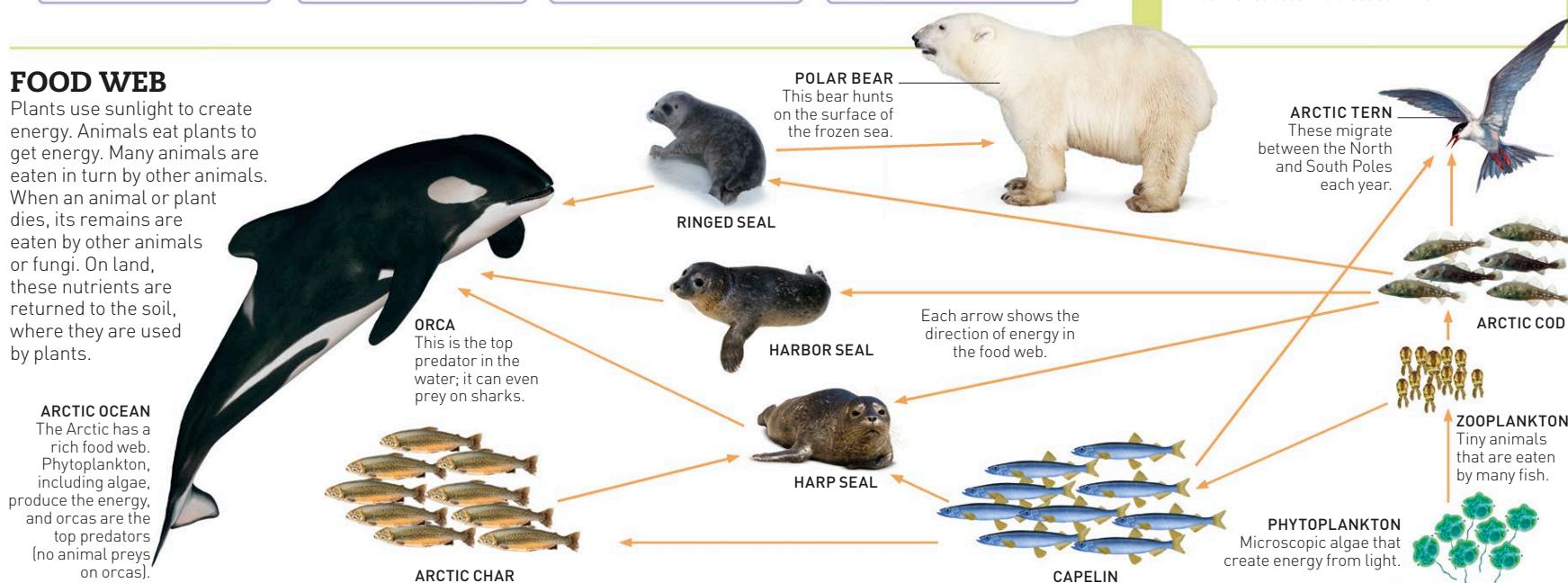
## GREAT BIOLOGISTS

Biologists study living things and their relationship to each other and the world. Their discoveries and inventions have changed the way we live.

- CHARLES DARWIN (1809–1882)**  
This British naturalist suggested the theory of evolution in his book *On the Origin of Species*.
- GREGOR MENDEL (1822–1884)**  
An Austrian scientist and monk, Mendel showed how traits are inherited.
- NETTIE STEVENS (1861–1912)**  
This American biologist explained that chromosomes inside a cell's nucleus determine whether an animal is male or female.
- LOUIS LEAKEY (1903–1972)**  
A Kenyan scientist who found evidence of early humans in Olduvai Gorge, Kenya, and suggested humans first evolved in Africa.
- FRANÇOISE BARRÉ-SINOSSI (1947–)**  
This French scientist discovered HIV, the virus that causes the disease AIDS.

## FOOD WEB

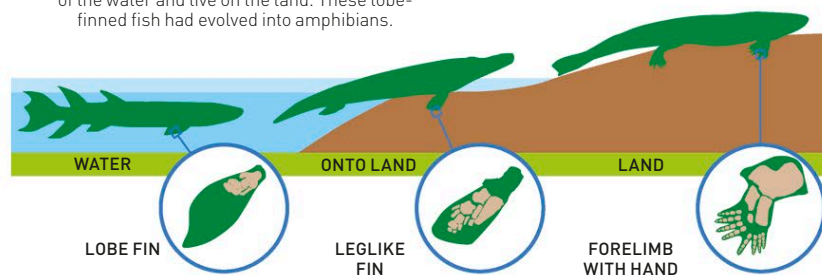
Plants use sunlight to create energy. Animals eat plants to get energy. Many animals are eaten in turn by other animals. When an animal or plant dies, its remains are eaten by other animals or fungi. On land, these nutrients are returned to the soil, where they are used by plants.



## EVOLUTION

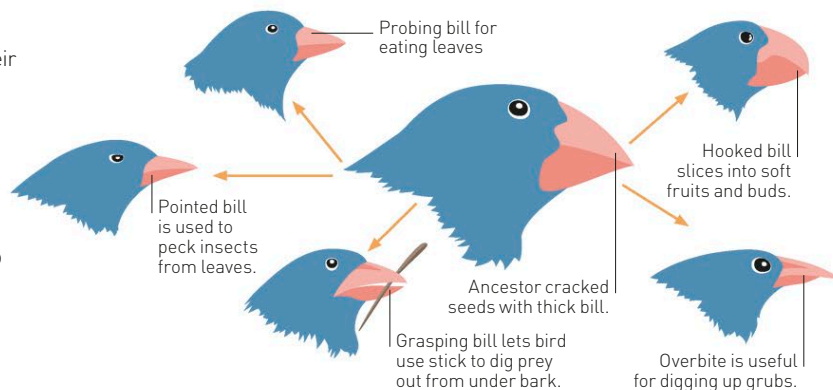
Individuals that are best suited to the environment in which they live are the ones most likely to survive and reproduce. They then pass on the genes that favor their existence to their offspring. Over time, this leads to change. This process is known as evolution by natural selection.

**FISH ON LAND**  
Over time, lobe-finned fish evolved in a way that allowed them to move out of the water and live on the land. These lobe-finned fish had evolved into amphibians.



## ADAPTATION

Animals adapt to suit their environment, and birds' beaks, or bills, are a perfect example of this. The birds pictured here have all evolved from the same ancestor, but their bills have become perfectly adapted to help them catch and eat food in different habitats.



## EXTINCTION

The dying out of a species is known as "extinction." Scientists believe that we are now undergoing the biggest wave of extinctions since most of the dinosaurs disappeared.



### GEOLOGICAL EVENTS

Meteor strikes and volcanic eruptions can cause extinctions. Most dinosaurs are thought to have been wiped out by an asteroid strike.



### HABITAT DESTRUCTION

Habitat destruction and fragmentation has led to species such as the panda being in danger of extinction.



### CLIMATE CHANGE

Only animals that suit their environments survive. *Smilodon* became extinct when the climate changed 11,000 years ago.



### HUNTED TO DEATH

Overhunting by humans can cause animals to become extinct. This happened to the easily caught dodo of Mauritius.



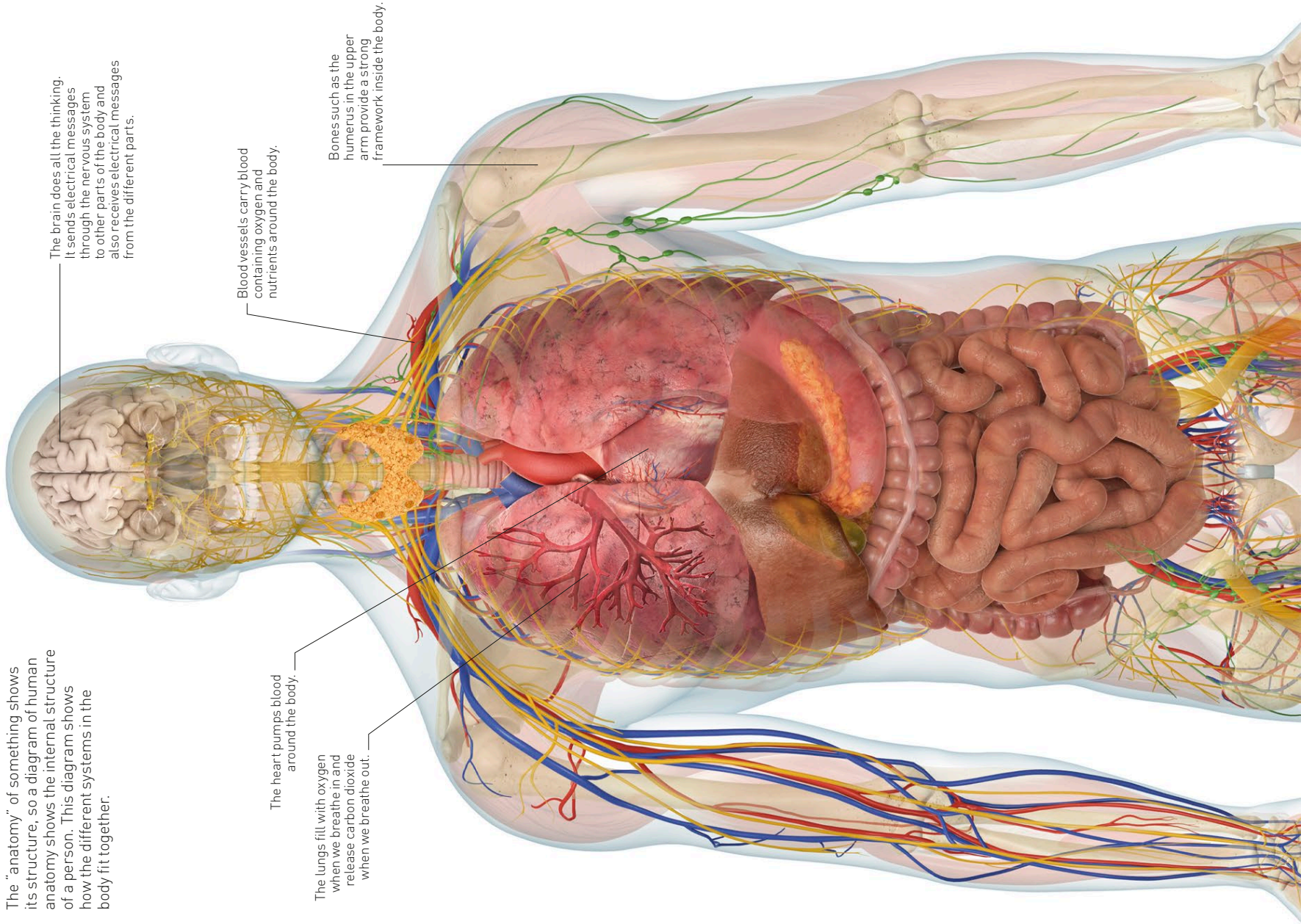
### POACHING

The tiger is threatened due to use of its body parts, such as in traditional Chinese medicine.



## HUMAN ANATOMY

The "anatomy" of something shows its structure, so a diagram of human anatomy shows the internal structure of a person. This diagram shows how the different systems in the body fit together.

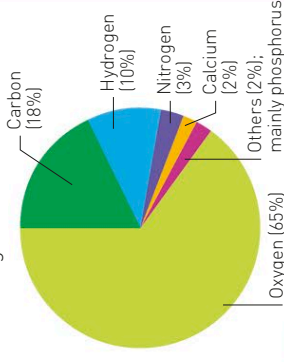


# The human body

The human body is a complex set of tissues and organs. These work together through joined-up systems that communicate with each other through electrical messages, which travel to and from the brain.

## WHAT IS THE BODY MADE OF?

More than half of the body's weight is water. The rest is made up of different kinds of tissue, from the soft tissue that lines our intestines to the hard tissue that forms our bones. Water and tissues themselves are made up of around six elements, as shown in the diagram below.

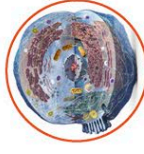


## BUILDING A BODY

Microscopes show that everything in the human body is made up of tiny cells, which are different depending on where they are and what they do. They grow in the right way for their tasks because they all contain DNA, which is like an internal instruction manual.



**DNA**  
Cells contain spirals of DNA, which tell them how to grow.



**CELL**  
There are more than 37 trillion cells in a human body.



**TISSUE**  
Cells form into tissue, such as muscle tissue.



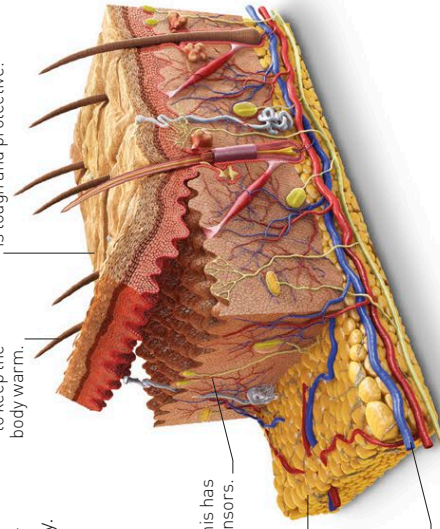
**ORGANS**  
Tissues form into organs, such as the heart (shown here).

## EVERY ELEMENT IN THE BODY COMES FROM STARDUST.

## THE SKIN

The skin is a protective layer that goes all around the body. It is tough but flexible and it is very sensitive, sending messages back to the brain. It also helps the body stay at a constant temperature.

Skin hairs rise to keep the body warm.



The dermis has touch sensors.

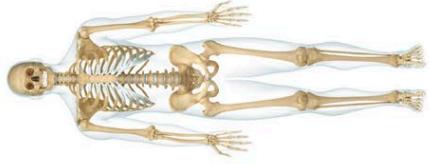
The third layer of skin is made up of fat.

Blood vessels widen to help heat escape or narrow to keep heat in the body.

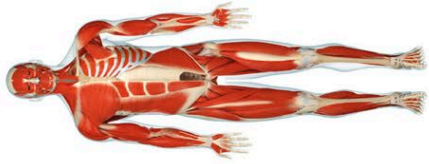


## BODY SYSTEMS

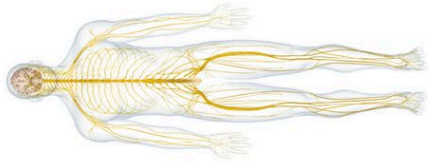
Inside the body, complex systems of tissues and organs work together to help the body perform. Each system has a particular task, such as digesting food or fighting off disease. There are 11 different systems in the body.



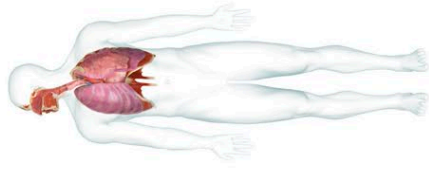
**SKELETAL**  
The bones and joints give the body its basic framework.



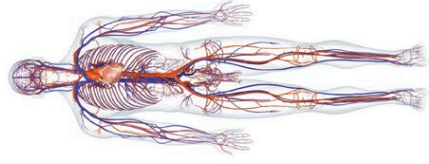
**MUSCULAR**  
The muscles allow the bones and organs of the body to move.



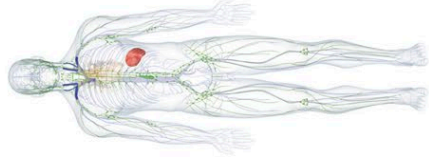
**NERVOUS**  
This is a messaging system between the brain and other parts of the body.



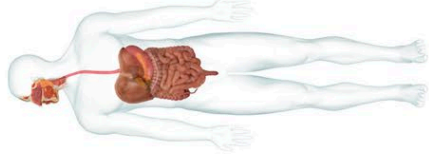
**RESPIRATORY**  
This is the system that allows us to breathe in and out.



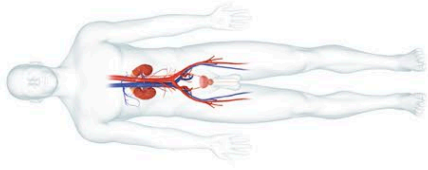
**CARDIOVASCULAR**  
Blood runs through this system, all around the body.



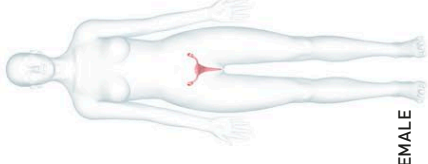
**LYMPHATIC AND IMMUNE**  
This helps us fight off disease and infection.



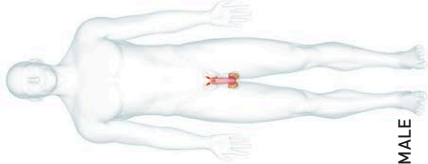
**DIGESTIVE**  
Food is broken down into vital nutrients by this system.



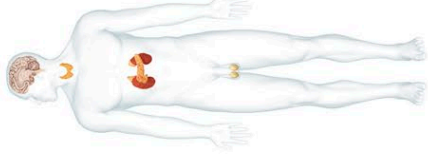
**URINARY**  
This system allows the body to filter out the waste and water it doesn't need.



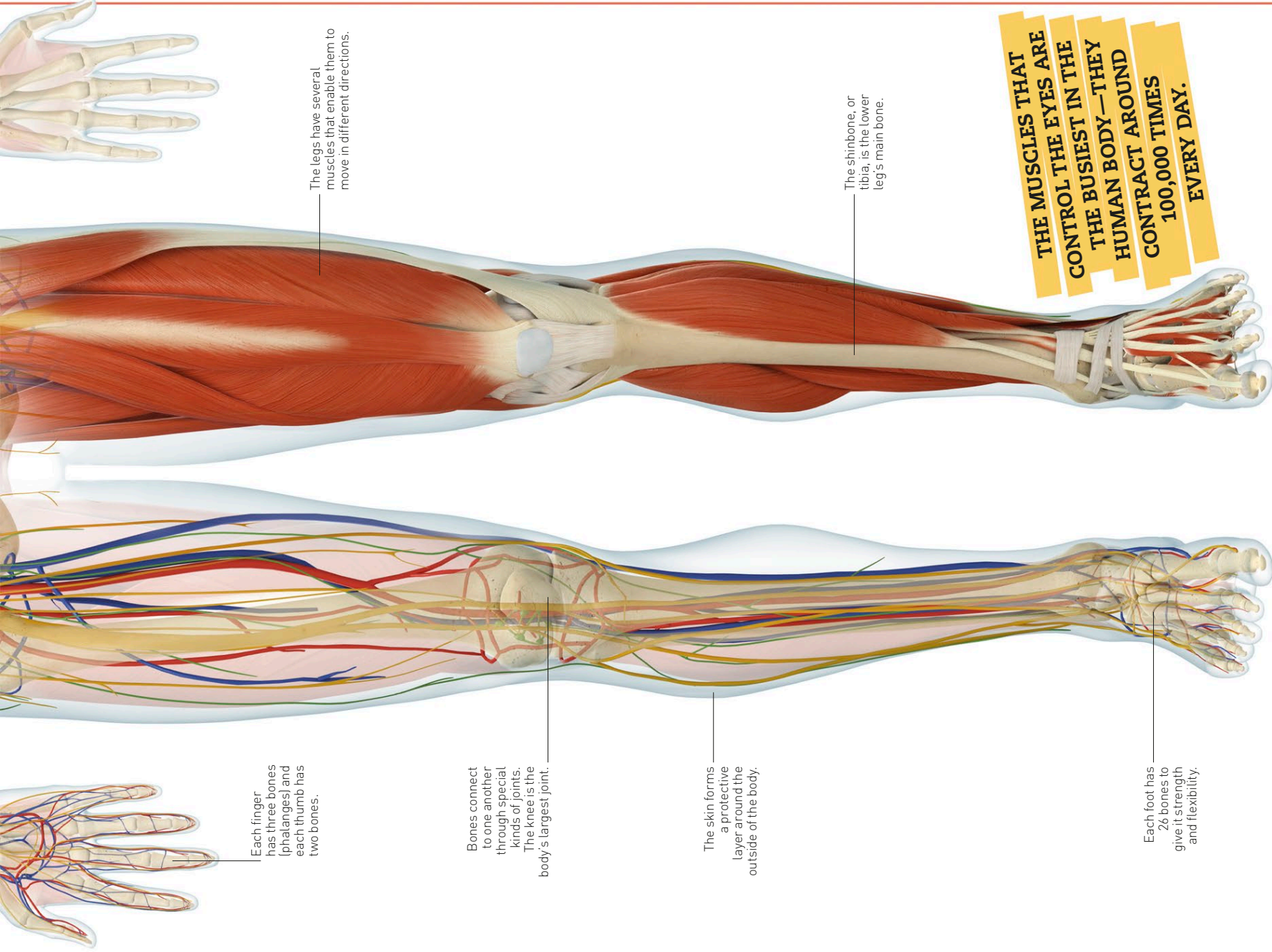
**FEMALE**



**MALE**



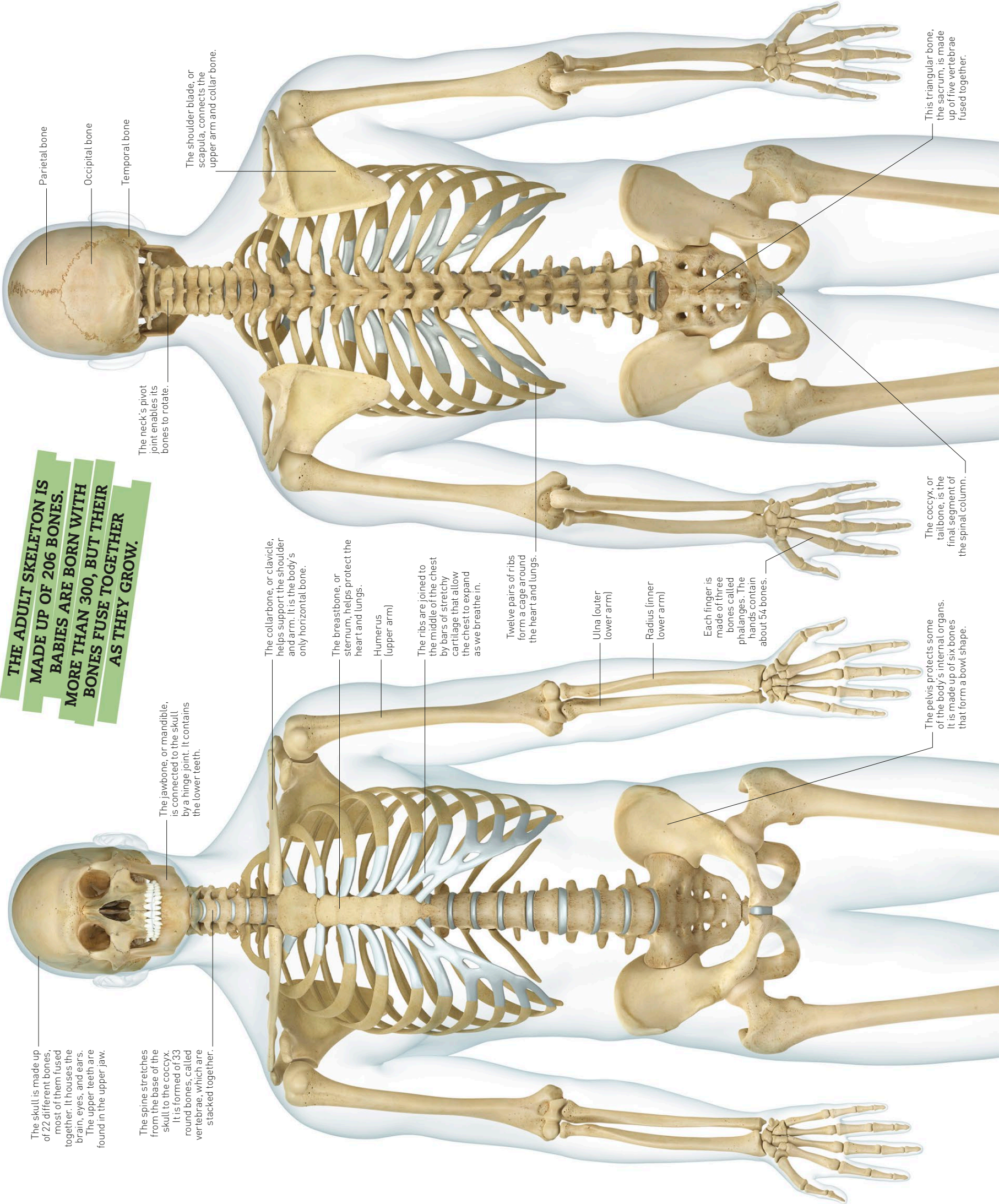
**ENDOCRINE**  
This produces chemicals called hormones, which can affect other systems.



**THE MUSCLES THAT CONTROL THE EYES ARE THE BUSIEST IN THE HUMAN BODY—THEY CONTRACT AROUND 100,000 TIMES EVERY DAY.**



**THE ADULT SKELETON IS  
MADE UP OF 206 BONES.  
BABIES ARE BORN WITH  
MORE THAN 300, BUT THEIR  
BONES FUSE TOGETHER  
AS THEY GROW.**



The skull is made up of 22 different bones, most of them fused together. It houses the brain, eyes, and ears. The upper teeth are found in the upper jaw.

The spine stretches from the base of the skull to the coccyx. It is formed of 33 round bones, called vertebrae, which are stacked together.

The jawbone, or mandible, is connected to the skull by a hinge joint. It contains the lower teeth.

The collarbone, or clavicle, helps support the shoulder and arm. It is the body's only horizontal bone.

The breastbone, or sternum, helps protect the heart and lungs.

Humerus (upper arm)

The ribs are joined to the middle of the chest by bars of stretchy cartilage that allow the chest to expand as we breathe in.

Twelve pairs of ribs form a cage around the heart and lungs.

Ulna (outer lower arm)

Radius (inner lower arm)

Each finger is made of three bones called phalanges. The hands contain about 54 bones.

The pelvis protects some of the body's internal organs. It is made up of six bones that form a bowl shape.

Parietal bone

Occipital bone

Temporal bone

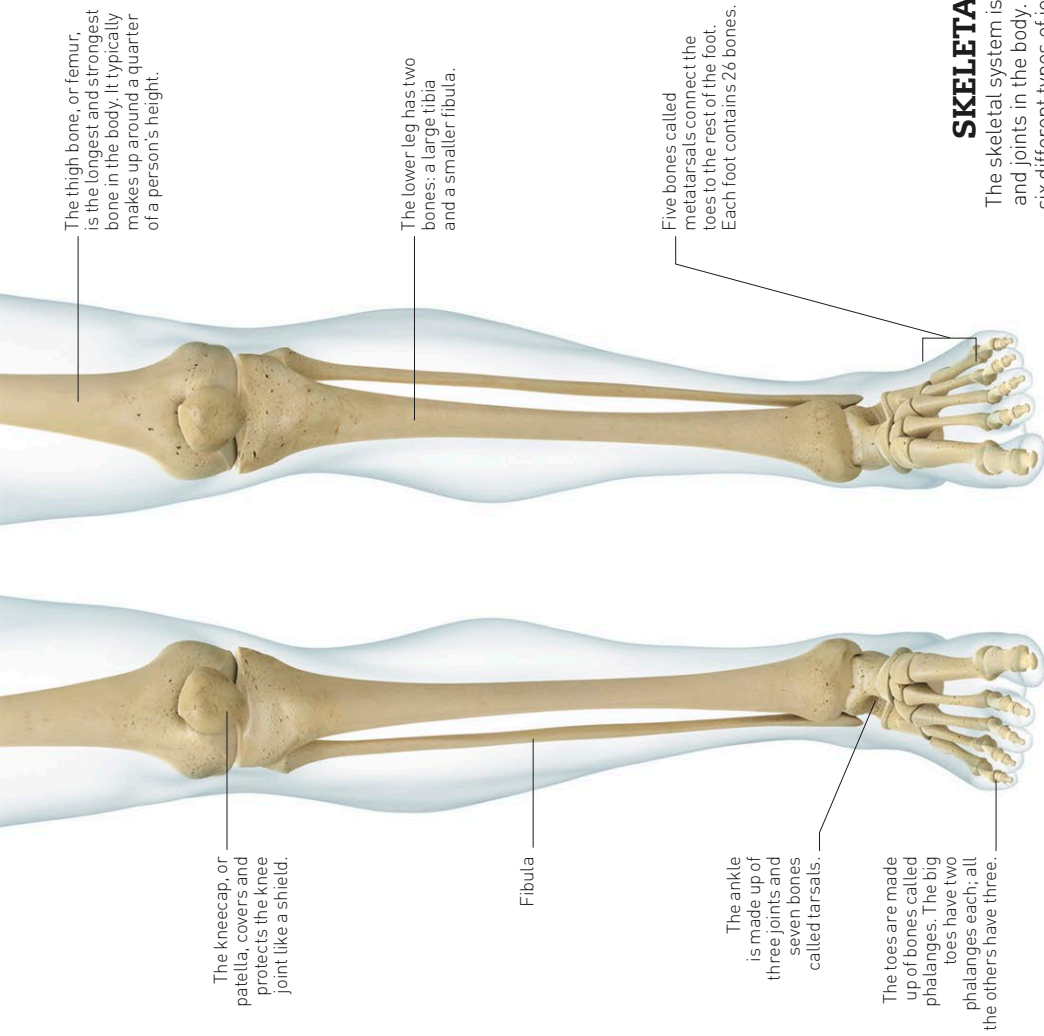
The neck's pivot joint enables its bones to rotate.

The shoulder blade, or scapula, connects the upper arm and collar bone.

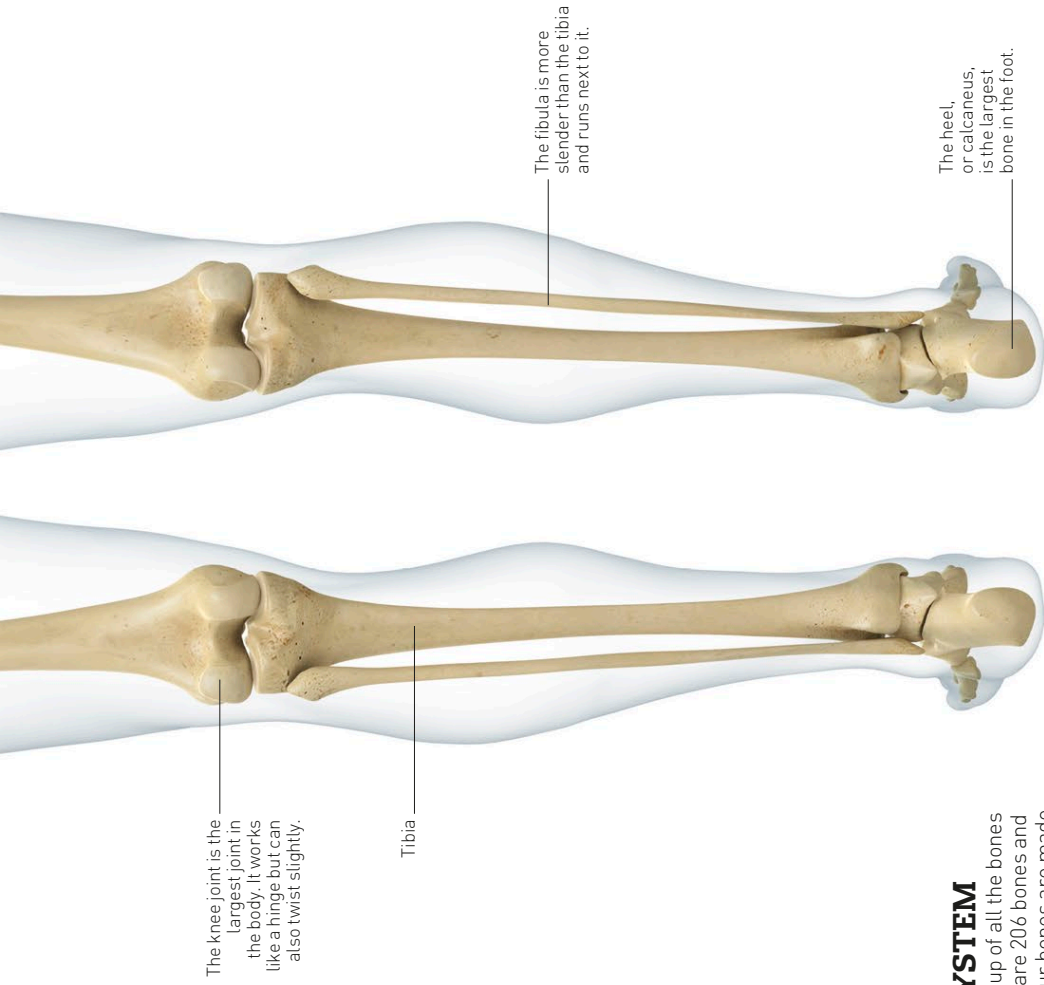
The coccyx, or tailbone, is the final segment of the spinal column.

This triangular bone, the sacrum, is made up of five vertebrae fused together.





FRONT



BACK

## SKELETAL SYSTEM

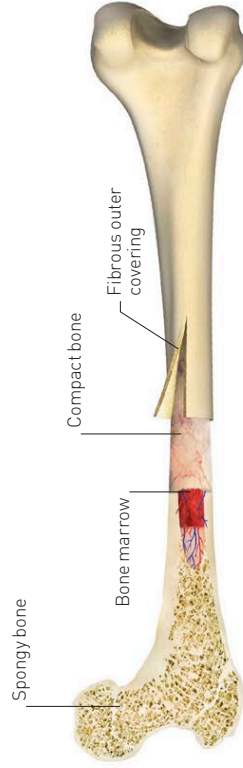
The skeletal system is made up of all the bones and joints in the body. There are 206 bones and six different types of joints. Our bones are made of living tissue, blood vessels, and nerves.

# Skeleton

The skeleton is the body's scaffolding—it gives us shape and support. It has other important functions, too. Along with muscles, it enables us to move around. It also protects our inner organs and produces red blood cells.

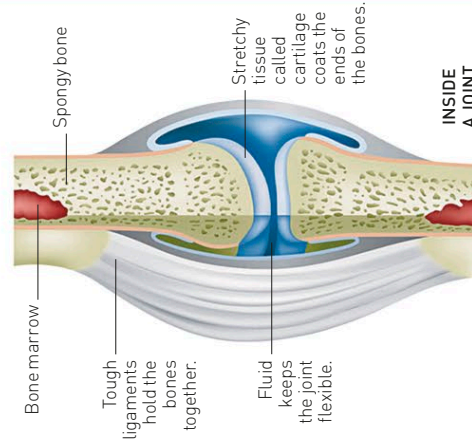
## INSIDE A BONE

Inside the solid outer bone is lighter, honeycomblike spongy bone. In big bones, the center is filled with jellylike marrow, which makes red blood cells.



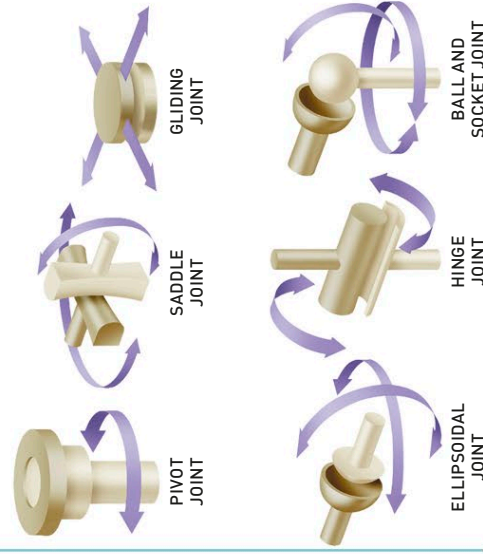
## WHAT IS A JOINT?

Where bones meet, they are held together by joints, tissues that allow them to move. Without joints, we wouldn't be able to move our bodies. The movement a joint allows depends on the shape of the bones.



## SYNOVIAL JOINTS

Synovial joints are the most common type of joints. There are six types of synovial joints, each allowing a different range of movement, depending on how the bones fit together.





ANTERIOR (FRONT)

POSTERIOR (BACK)

EACH OF THE 5 MILLION  
HAIRS ON THE HUMAN  
BODY HAS ITS OWN  
INDIVIDUAL MUSCLE.

There are 43 muscles in the face. They allow us to open and close our mouth and eyes and to make facial expressions.

The platysma tenses the neck, helping create facial expressions.

Trapezius

Pectoralis major

Pectoralis minor

The deltoid muscle in the shoulder raises the arm.

Erector spinae

Serratus anterior

Extensor compartment of the arm, containing the triceps, which straightens the elbow

Flexor compartment of the arm, containing biceps, or brachii, which bend the elbow

Intercostal muscles help lift the ribs upward and outward.

Rectus abdominus muscles, or "abs"

Flexor compartment of the forearm—these muscles flex the fingers and thumb.

Iliopsoas

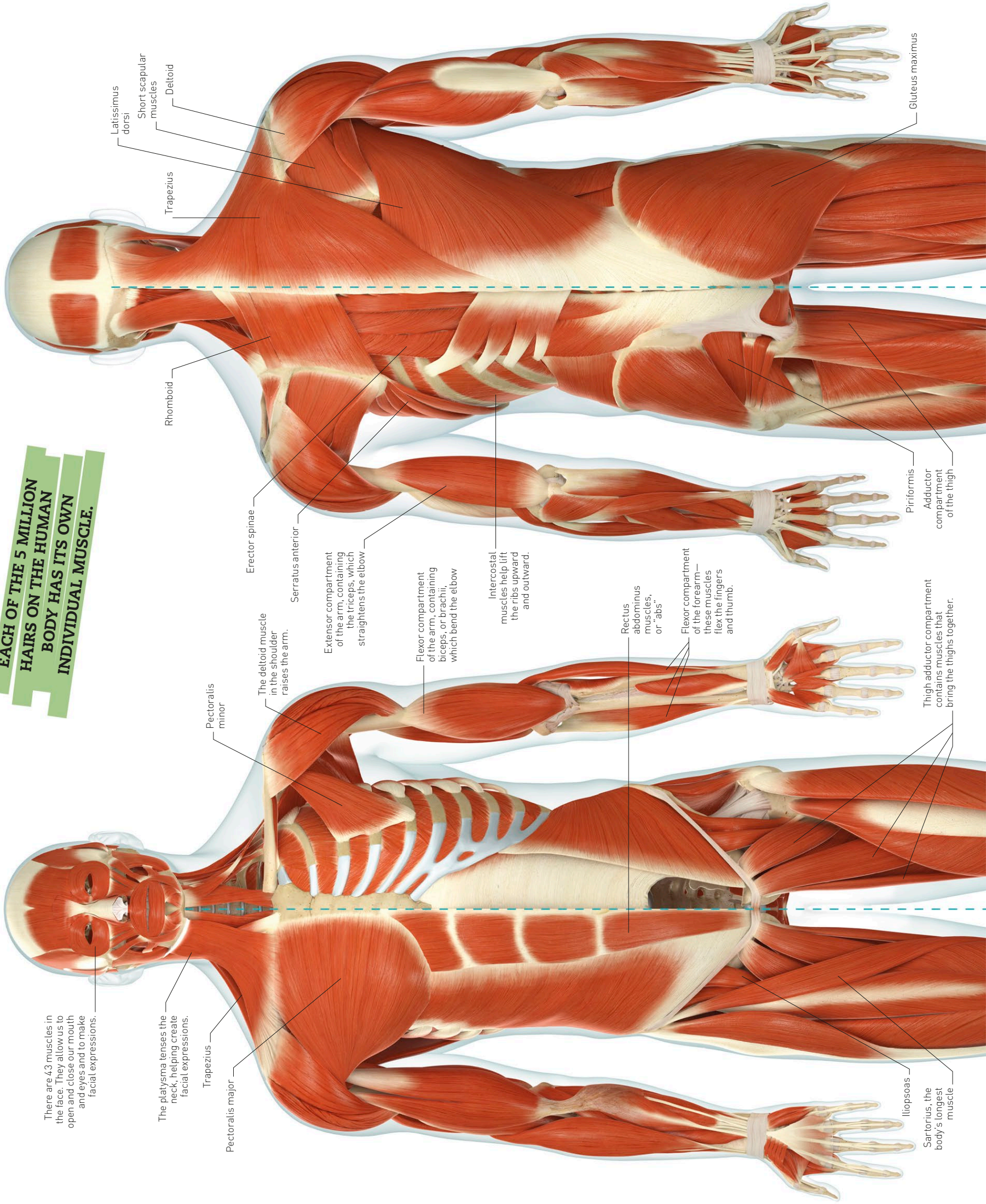
Sartorius, the body's longest muscle

Thigh adductor compartment contains muscles that bring the thighs together.

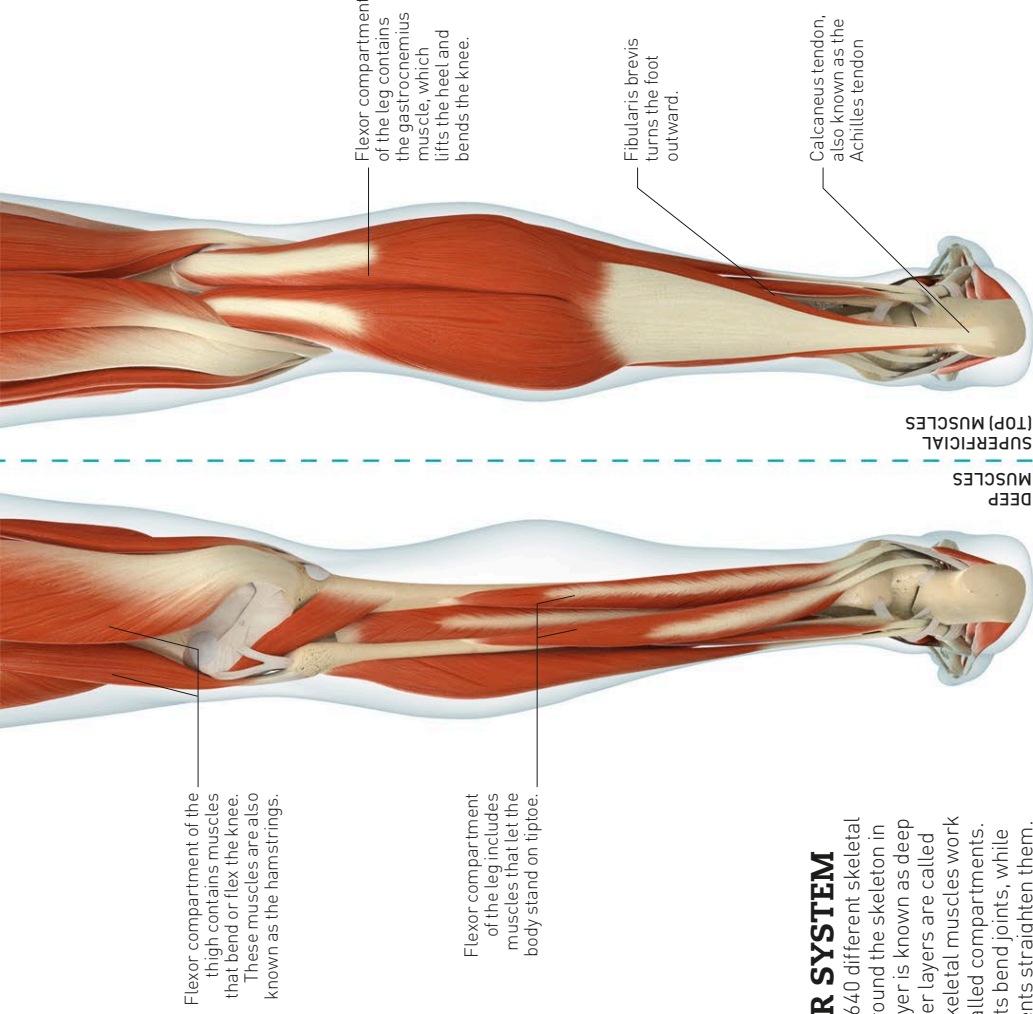
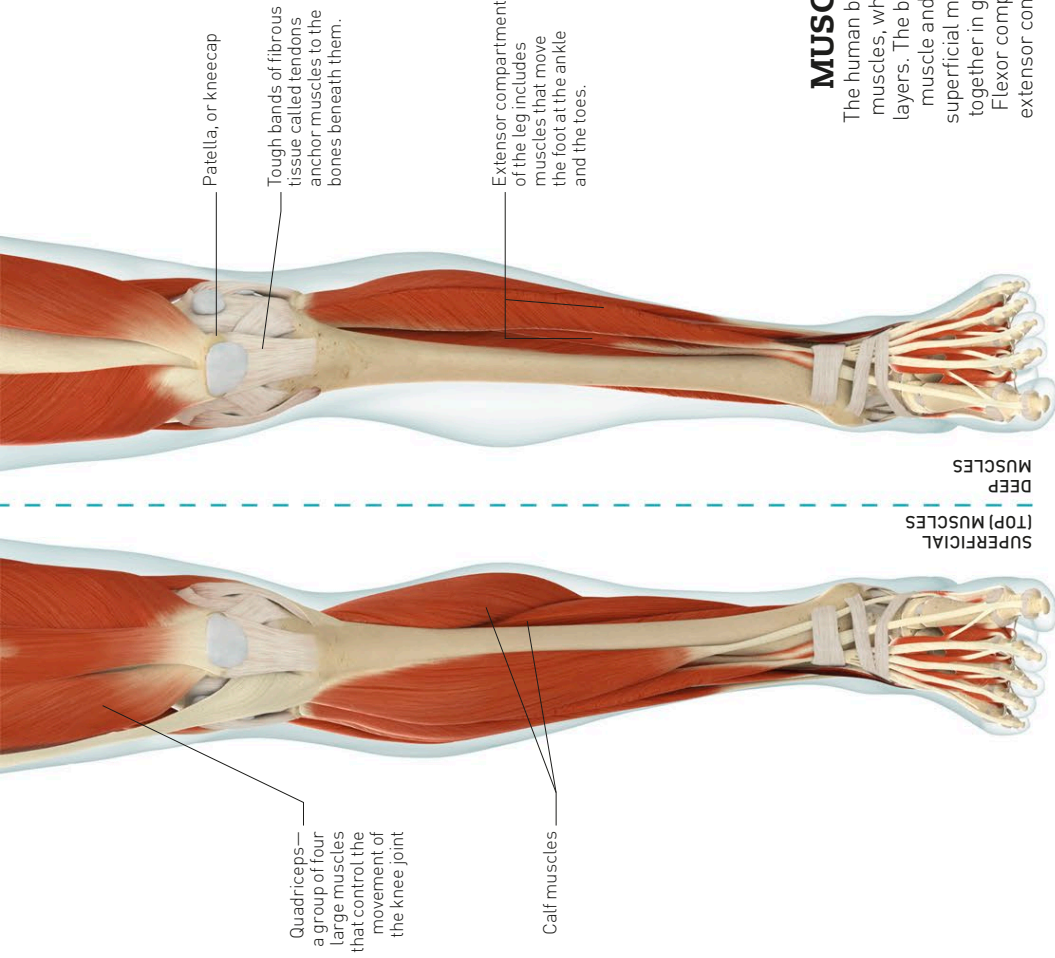
Piriformis

Adductor compartment of the thigh

Gluteus maximus





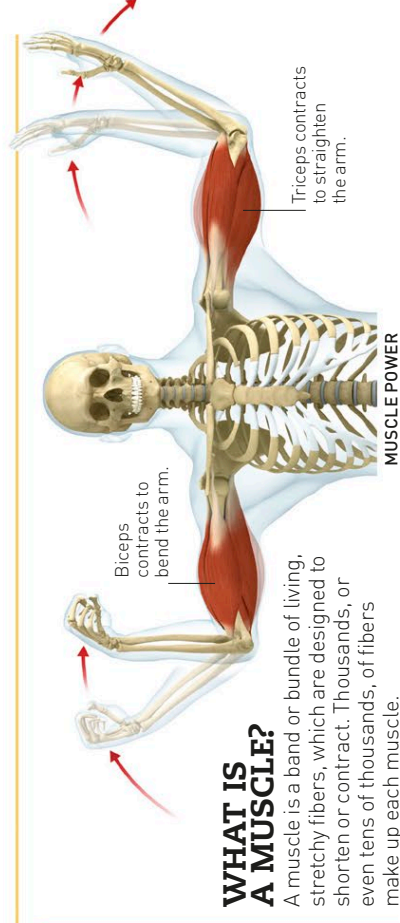


## MUSCULAR SYSTEM

The human body has 640 different skeletal muscles, which fit around the skeleton in layers. The bottom layer is known as deep muscle and the upper layers are called superficial muscle. Skeletal muscles work together in groups called compartments. Flexor compartments bend joints, while extensor compartments straighten them.

# Muscles

Every movement we make, from blinking an eye to running a race, is powered by muscles. Even the movements we are not aware of, such as the beating of our heart or the digestion of food, are actually controlled by muscles.

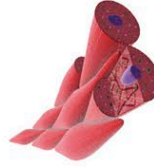


## MUSCLE TYPES

Skeletal muscles move the body's bones in response to conscious messages from the brain. Cardiac and smooth muscles work without conscious thought.



**SKELETAL MUSCLE**  
Also called striped or striated muscle, this is connected to the bones.



**SMOOTH MUSCLE**  
This muscle is found in the intestines and other organs.



**CARDIAC MUSCLE**  
Makes the heart beat by contracting rhythmically.

## MUSCLE SHAPES

There are many different shapes of skeletal muscle in our bodies. They vary in size and structure depending on their specific function.



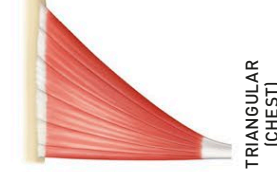
**FUSIFORM (BICEPS)**



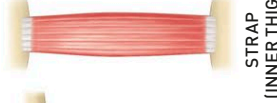
**MULTIPENNATE (SHOULDER)**



**UNIPENNATE (FINGER)**



**TRIANGULAR (CHEST)**



**STRAP (INNER THIGH)**



**CIRCULAR (MOUTH)**

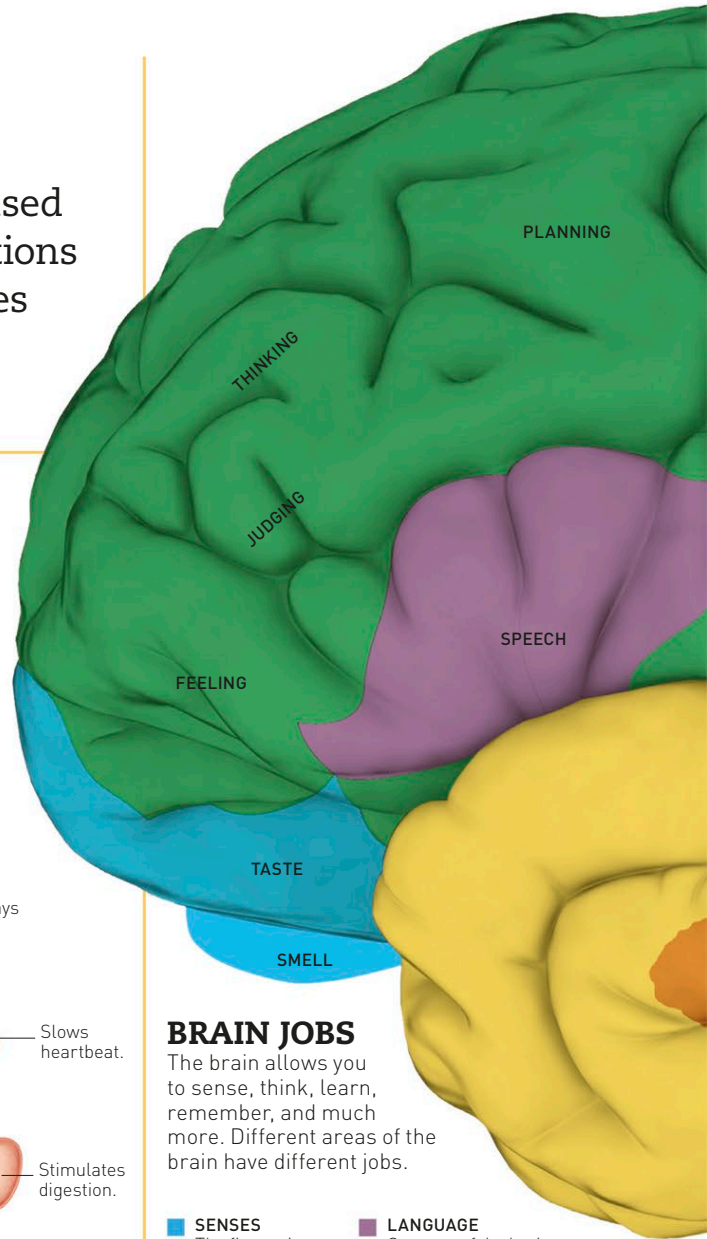
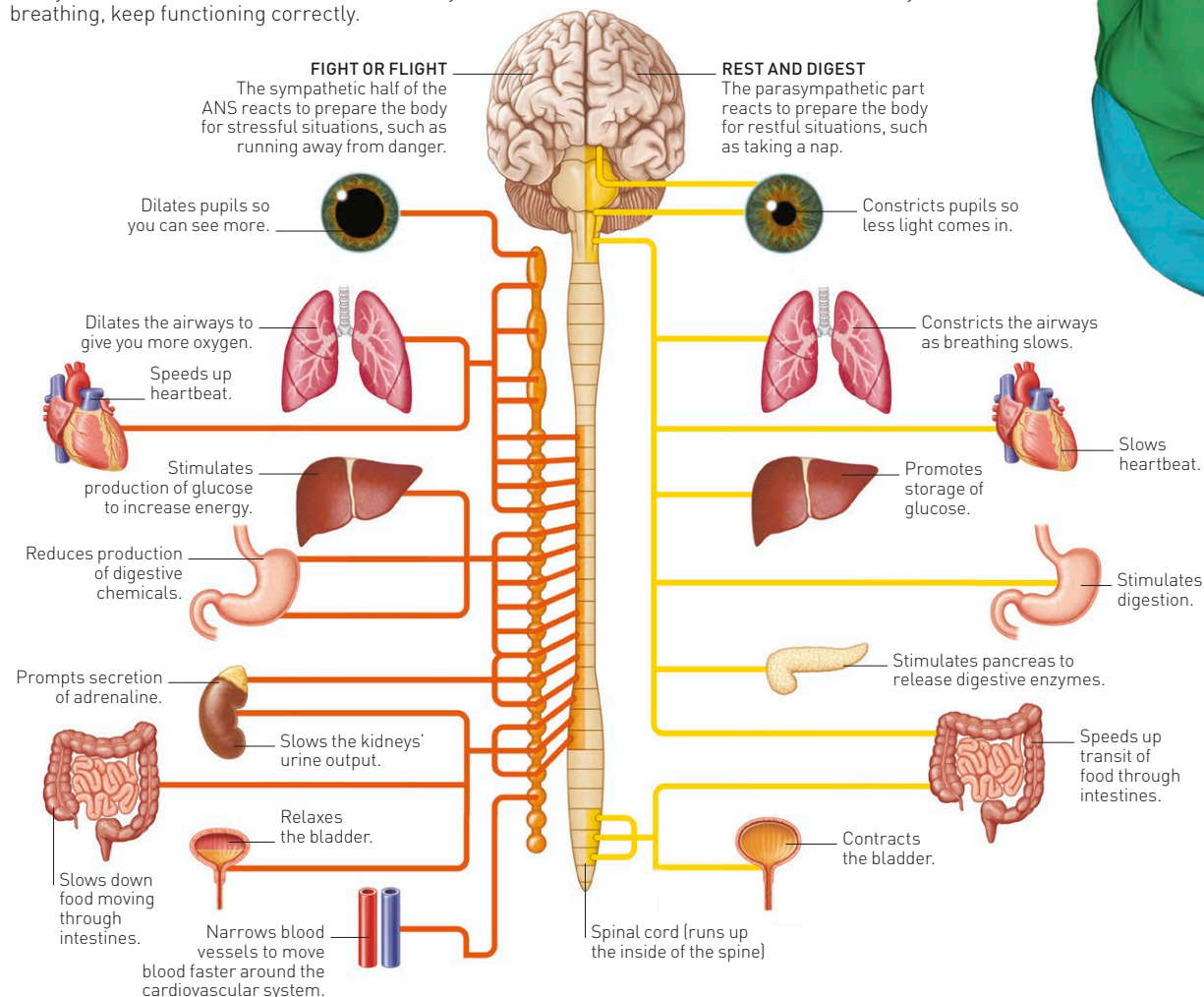


# The brain

The brain is the most complex organ in the body. Safely encased inside the skull, it controls our actions and all the body functions that keep us alive. It also monitors the world around us, stores our memories, and enables us to plan for the future.

## NERVOUS SYSTEM

The brain is linked to the rest of the body through a network of nerves, known as the nervous system. This network acts as a kind of information highway, carrying messages between the brain and the body, and back again. Part of the system, known as the autonomic nervous system (ANS), makes sure all our “automatic” body actions, such as breathing, keep functioning correctly.



## BRAIN JOBS

The brain allows you to sense, think, learn, remember, and much more. Different areas of the brain have different jobs.

### SENSES

The five main sense areas in the brain process signals from the sense organs—eyes, ears, skin, tongue, and nose.

### LANGUAGE

One part of the brain known as Broca's area controls your speech. Two other parts, known as Geschwind's territory and Wernicke's area, help you learn and understand language.

### MEMORIES

The hippocampus is where your brain makes and stores memories.

### MOVEMENT

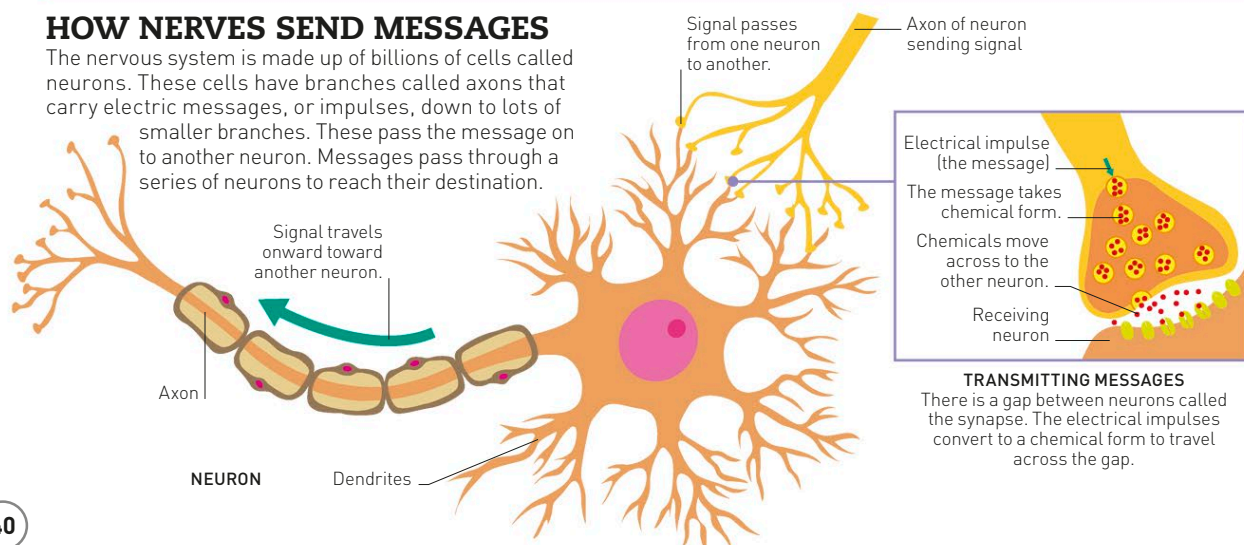
This part of the brain is called the motor cortex, and it sends signals to your muscles to tell them to move your body.

### THOUGHTS

The large area known as the prefrontal cortex processes your thoughts. It turns them into plans, judgments, and ideas, and also helps you understand other people's feelings.

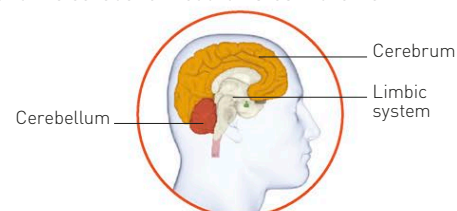
## HOW NERVES SEND MESSAGES

The nervous system is made up of billions of cells called neurons. These cells have branches called axons that carry electric messages, or impulses, down to lots of smaller branches. These pass the message on to another neuron. Messages pass through a series of neurons to reach their destination.



## BRAIN AREAS

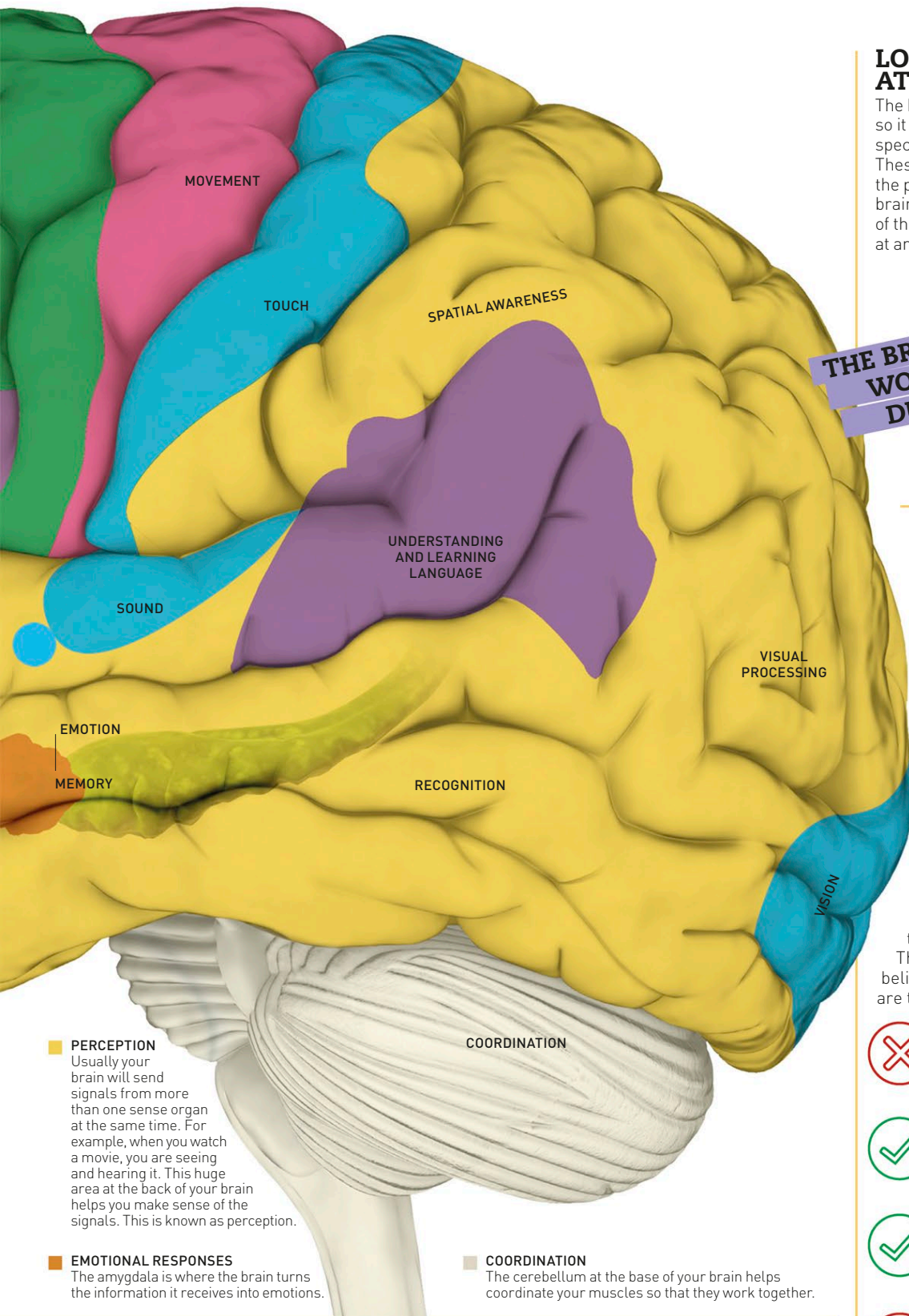
The human brain has many different parts, but it can be divided into three main areas. The large cerebrum deals with thoughts, language, and behavior; the limbic system processes emotions; and the cerebellum coordinates movement.



### HUMAN BRAIN

The human brain has lots of wrinkles, which hold all its information. If the surface of your brain was unfolded, it would be more than twice as big.





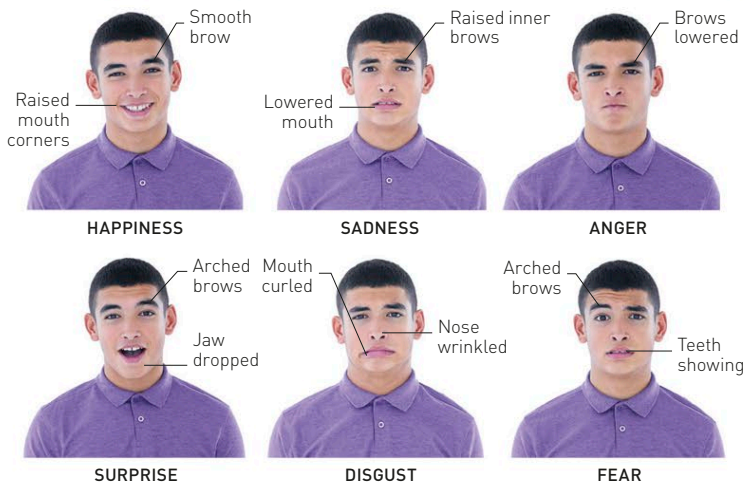
**PERCEPTION**  
Usually your brain will send signals from more than one sense organ at the same time. For example, when you watch a movie, you are seeing and hearing it. This huge area at the back of your brain helps you make sense of the signals. This is known as perception.

**EMOTIONAL RESPONSES**  
The amygdala is where the brain turns the information it receives into emotions.

**COORDINATION**  
The cerebellum at the base of your brain helps coordinate your muscles so that they work together.

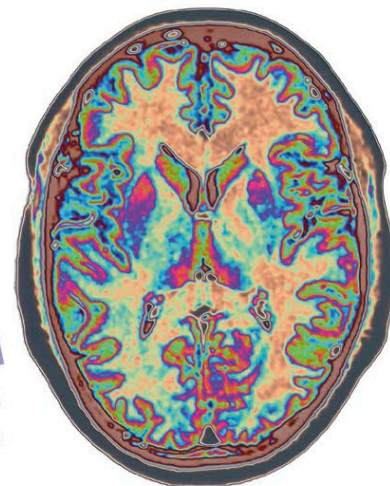
## EMOTIONS

The brain processes our feelings. As it does so, signals move through the body so that those feelings become visible to other people. There are six primary emotions, and they all show on the face in a particular way. These facial expressions are the same in everyone; a smile means the same thing whether you live in the Sahara Desert or New York City.



## LOOKING AT THE BRAIN

The brain is inside the skull, so it can only be seen using special scanning machines. These can be used to show the physical make-up of the brain or to highlight the parts of the brain that are working at any moment.



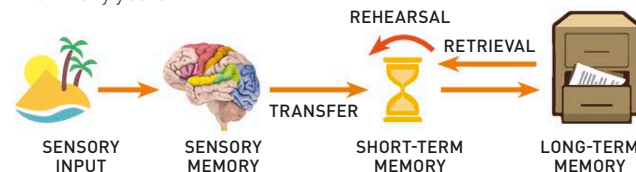
### MRI SCAN

An MRI scan uses magnetism to produce images of different sections of the brain.

**THE BRAIN IS ALWAYS WORKING, EVEN DURING SLEEP.**

## MAKING MEMORIES

The brain absorbs information from the senses, processes all of it into an image or thought, and then stores that image or thought as a memory. Memories can be short-term, such as a phone number you use once, which is held for just as long as you need it, or long-term, such as your first day at school, which you may remember for many years.



## TRUE OR FALSE?

The brain is so complex that we are only beginning to understand how it works. There are many popular beliefs about the brain—some are true and some are false.



**WE ONLY USE 10 PERCENT OF OUR BRAINS**  
The truth is that we use all of our brains to complete normal daily tasks.



**30,000 NEURONS WOULD FIT ON THE HEAD OF A PIN**  
This is true, and the brain contains around 100 billion neurons in total.



**THE BRAIN DOES NOT FEEL PAIN**  
The brain does not have pain receptors, so it cannot feel pain.



**EINSTEIN'S BRAIN WAS BIGGER THAN AVERAGE**  
Einstein's brain was a bit smaller than average. Size does not affect intelligence.

## BRAIN CONDITIONS

When parts of the brain do not function or function differently, it can affect the way that individuals make sense of the world.



### AMNESIA

This is a loss of memory due to a physical or emotional trauma.



### SYNESTHESIA

People with this disorder experience mixed-up senses. For example, some people see colors when they read or hear numbers.



### DEMENTIA

This is a set of problems, including difficulties with thinking, memory, problem-solving, and language. It usually affects older adults, and Alzheimer's is the leading cause.



### OBSESSIVE-COMPULSIVE DISORDER (OCD)

This is a disorder where people worry about things all the time and repeat actions over and over again.

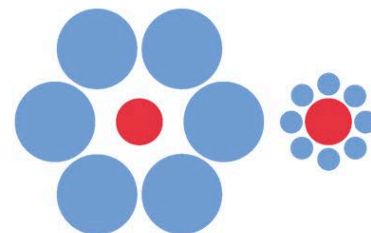
## TRICKS OF THE MIND

Sometimes you cannot believe your eyes—or more accurately, you cannot believe what your brain thinks it is seeing. The brain can be fooled.



### WHICH LINE IS LONGER?

Do you see one of these lines as longer? This is a visual illusion—the lines are both the same length.



### WHICH IS BIGGER?

The red dot on the right looks bigger, but it is not. Your brain judges it in relation to the blue dots around it.

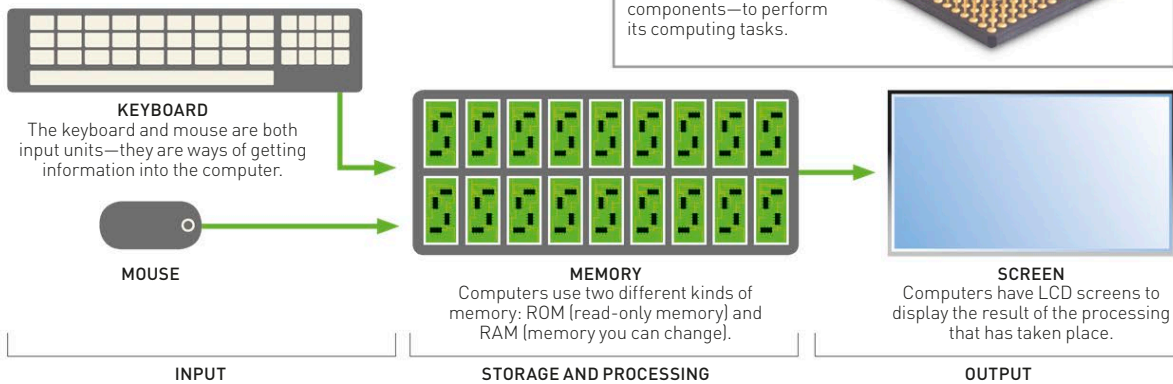


# Computers

Computers are electronic machines that we can use to do many different things, just by changing the programs they are running. Today, computers have become indispensable because they are used to run our world—from global air traffic control to personal mobile phones.

## HOW COMPUTERS WORK

Computers work by processing information: they take in information (data), store it (memory), process it in whichever way they have been programmed to do, then display the result (output).



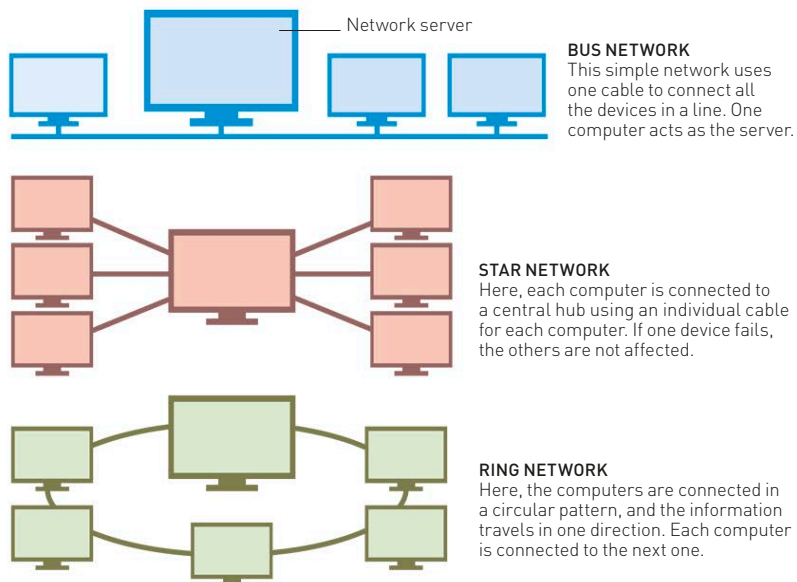
## SHRINKING SIZES

The 1949 EDSAC computer took up a whole room and was arranged over 12 racks. Today's personal computers (PCs) perform calculations millions of times faster, but they can sit easily on someone's desk or lap.

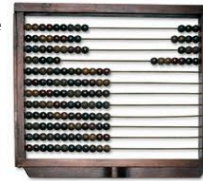


## NETWORKS

A network is a number of things connected in some way. There are three main forms of computer networks that can connect computers and peripherals, such as printers.



**c.2000 BCE**  
The Chinese invent the abacus, the world's first counting machine.



Abacus



**1666**  
Samuel Morland invents a machine that can add and subtract.

Morland's calculating machine

**2000 BCE**

## COMPUTER HISTORY

The first calculating machines were invented to add numbers, which was important for buying and selling goods. They were continually improved, until we arrived at the modern computer.

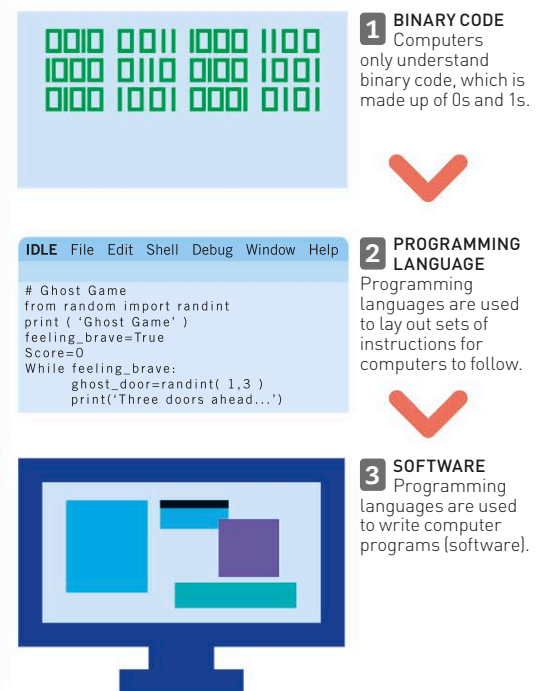
**1642**  
Blaise Pascal invents the Pascaline, a mechanical and automatic calculator.



Pascaline

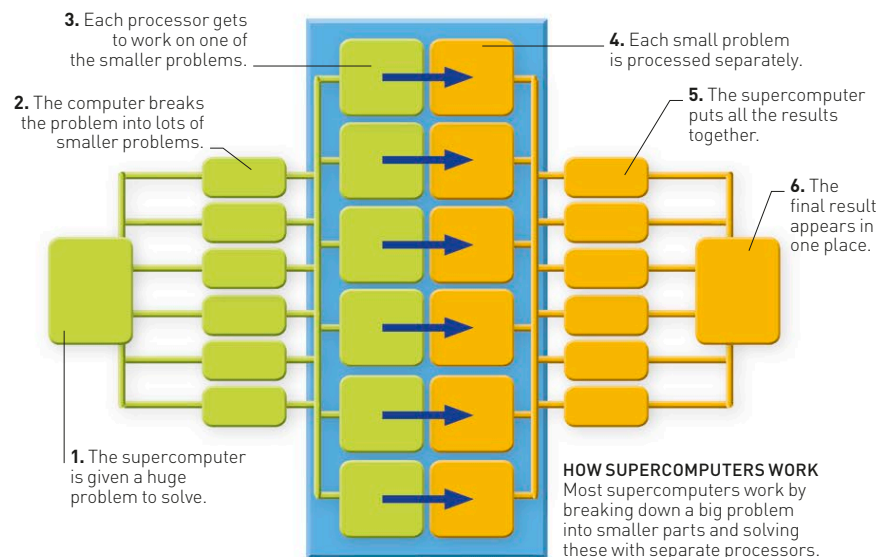
## SOFTWARE

Software is the name for ready-made programs we use to make one computer do many things. Software allows us to write, edit photos, use the Internet, and so on without having to program a computer ourselves.



## SUPERCOMPUTERS

Some scientific problems are so vast that they need huge amounts of processing power, delivered by "supercomputers." Some of these have tens of thousands of processors all working on one thing at the same time.





1801

Joseph Jacquard's loom uses a program (run by punched cards) to weave fabric.

1822

Charles Babbage's engine has an input, a memory, and a number cruncher (processor).

1886

Herman Hollerith builds the first punched-card tabulating and sorting machine.

1906

The vacuum tube, an essential part of modern computers, is invented.

1943

British engineer Thomas Flowers builds Colossus—the first electronic, digital computer—to aid wartime codebreakers.

1946

ENIAC is created—the world's first general-purpose electronic computer. It weighs 110 tons and contains 18,000 electronic switches.

1947

The transistor is invented. It allows electronic devices to become much smaller.

1962

Computer company IBM sets up SABRE, a system that connects up to 1,500 computer terminals.

1971

Intel 404, the first single-chip microprocessor, is invented.

1976

The world's first supercomputer, CRAY-1, is built.

1981

IBM launches a PC (personal computer) that uses MS-DOS as an operating system.

1995

A USB is used for the first time to connect other devices to a computer.

2007

Computer company Apple launches the iPhone, the first successful smartphone.

2019

Google builds a quantum computer, which uses atoms to process information.

2025

Vacuum tube

Babbage Engine

Herman Hollerith

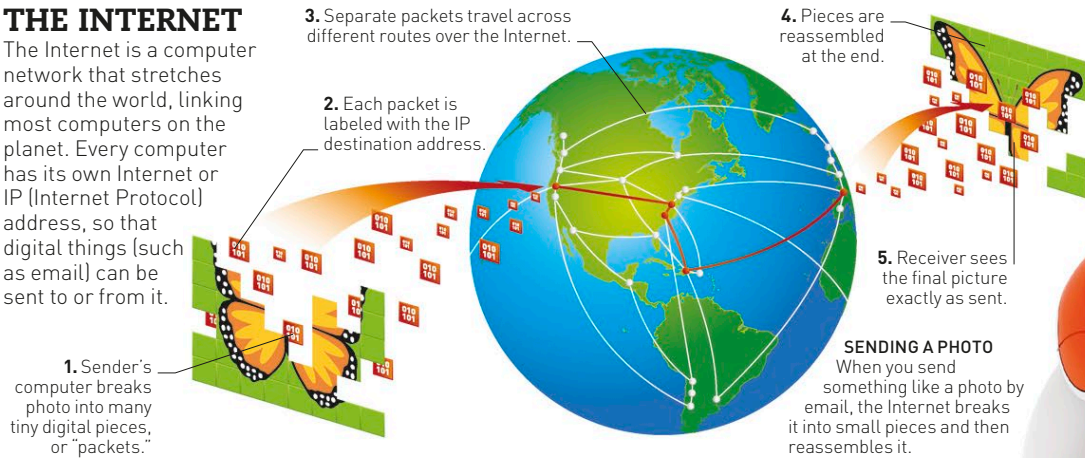
Transistor

Microchip

USB

## THE INTERNET

The Internet is a computer network that stretches around the world, linking most computers on the planet. Every computer has its own Internet or IP (Internet Protocol) address, so that digital things (such as email) can be sent to or from it.



**SENDING A PHOTO**  
When you send something like a photo by email, the Internet breaks it into small pieces and then reassembles it.

## WHAT DO WE DO ONLINE

We now use the Internet for all sorts of activities where we want to connect with someone else—either for fun or for business.

**EMAIL**  
Emails are an instant way to send a digital letter.

**GAMES**  
We can play games with distant friends via the Internet.

**SHOPPING**  
We can buy things online from anywhere in the world.

**SOCIAL MEDIA**  
Groups of people can communicate easily online.

## COMPUTERS EVERYWHERE

Computers are used in all sorts of devices, from personal music players and phones to microwave ovens and surveillance cameras.

PORTABLE GPS

PORTABLE MEDIA PLAYER

SMARTPHONE

DIGITAL TELESCOPE

DIGITAL RADIO

SURVEILLANCE CAMERA

MICROWAVE OVEN

CYCLE COMPUTER

DIGITAL CLOCK

NAO ROBOT



# Inventions

The work of inventors is all around you. Not just your phone and game consoles—the chair you are sitting on, the car outside, even the light bulb above your head was invented by somebody. Some early inventions, like the wheel, will be used forever. Others, such as the spear, have been replaced by newer, more effective models.

▶ 1,760,000 BCE



FLINT HANDAX

## HANDAX

Flint is a special kind of rock because it breaks into sharp pieces. Stone Age people discovered that its hard, sharp edges made it very useful as a tool. Shaped into an ax, it could be used for cutting meat, scraping skins (to make clothes), chopping wood, and as a weapon.

▶ 35,000 BCE

## SPEAR

The problem with hand-held weapons was that hunters had to stand very close to their prey, which was dangerous. The invention of the spear solved this problem. The hunter could stand back some distance, take aim, and throw the weapon. Early spears had flint heads. Later ones used metal heads shaped into long, thin blades.



SHORT SPEARS

▶ 17,500 BCE

ANCIENT EGYPTIAN JAR



## POTTERY

Chinese inventors realized they could dig clay from the ground, shape it into pots, and harden them in hot ashes. The pots were watertight, so they could be used to carry or heat up water and food.

◀ 1876



ROTARY PHONE

## TELEPHONE

Early in the 19th century, people found they could send signals through wires, but it was not until the development of the telephone by Alexander Graham Bell in 1876 that voices could be sent along wires at long distance. This invention revolutionized the ways in which we communicate.

▶ 1862

## PLASTIC

British inventor Alexander Parkes was trying to create a synthetic material that could be easily shaped when hot but would be hard when cold. In 1862, he exhibited Parkesine, the world's first type of plastic.



MODERN PLASTIC BOTTLES

◀ 1834

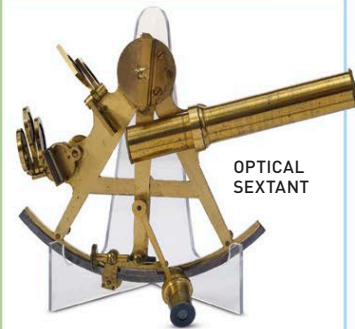
## REFRIGERATOR

Until 1834, people kept food cool in insulated boxes filled with ice, which was delivered to their door. Then Jacob Perkins of Philadelphia invented a water-freezing machine that led to the first domestic fridge.



1950s REFRIGERATOR

◀ 1759



OPTICAL SEXTANT

## SEXTANT

As explorers continued their long journeys across oceans, there was a need for accurate instruments for navigation. In 1759, British instrument maker John Bird perfected the sextant, which is still kept on ships today as a back-up device in case GPS (satnav) navigation fails.



▶ 1878



EDISON'S LAMP

## LIGHT BULB

Scientists across the world experimented with lamps and light in the 19th century, but it was Thomas Edison in the US who created a light bulb that could last for more than 1,200 hours. Light bulbs have since been redesigned to use less energy.

▶ 1886

## CAR

Karl Benz of Germany built the first stationary gas engine in 1879, and decided to work out how to use this in a "horseless carriage." By 1885, he had invented a two-seater vehicle with a compact, single-cylinder engine. The patent for this car, filed in 1886, is seen as the "birth certificate" of the motor car.



1900 BENZ IDEAL

▶ 1895



CABINET WIRELESS RADIO, 1932

## RADIO COMMUNICATION

In 1895, Italian inventor Guglielmo Marconi managed to send Morse code signals using radio waves instead of wires. The instrument he used became known as the radio.

▶ 1903

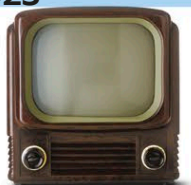
## AIRPLANE

Orville Wright from the US first took to the skies with an airplane powered by a small gas engine in North Carolina in 1903. He flew for 12 seconds over a distance of 120 ft (37 m). He and his brother Wilbur had spent five years in their workshop in Ohio designing machines that were strong, light, and had enough balance and control to fly.



MODEL OF THE 1903 WRIGHT FLYER

▶ 1923



TV SET FROM THE 1950s

## TELEVISION

John Logie Baird from Scotland was the first person to transmit a TV picture in 1923. In 1927, American Philo Taylor Farnsworth created the first form of electronic television.



8000 BCE



MODEL OF FIJIAN BATTLE CANOE

## BOAT

Early people needed some form of floating raft to take them fishing and from one island to another. The earliest boats were wooden logs or bamboo trunks tied together, but by around 3000 BCE, people had developed metal tools to cut tree trunks into wooden planks to build the first ships.

6000 BCE



WOODEN PLOW

## PLOW

People hunted for food until around 8500 BCE, when they began to farm the land to grow grains, such as wheat. Wooden plows were invented to make use of animal power. Plows could be joined to oxen and used to dig up much bigger areas of land.

3500 BCE

## WHEEL

The first wheels were solid wooden disks with a hole through the center. They helped potters make pots. Later, the wheels were connected by a rod called an axle. Wheels could now help transport people and materials.



WOODEN WHEEL

900 CE



GUNPOWDER BURNING

## GUNPOWDER

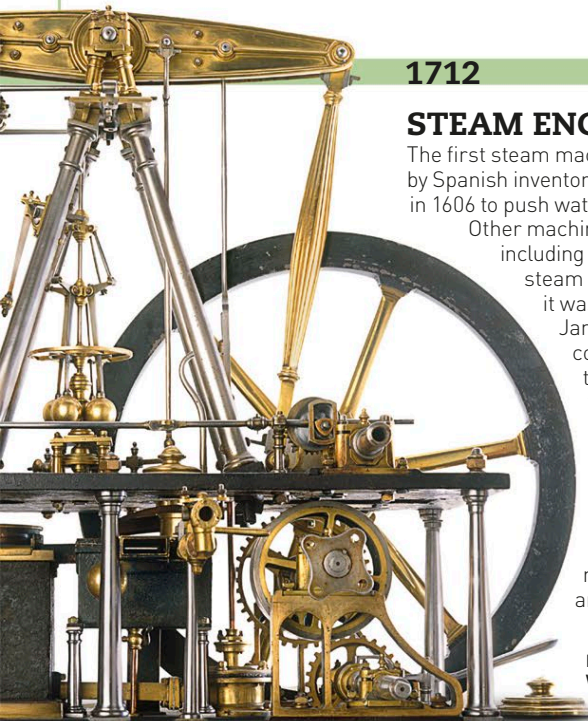
Chinese alchemists (early chemists) had been experimenting with chemicals for centuries when a group discovered that a mix of saltpeter, sulfur, and charcoal exploded into flame. The mix was used in fireworks to scare away evil spirits and later in weapons. The recipe was kept from the rest of the world until the 13th century.

1712

## STEAM ENGINE

The first steam machine was designed by Spanish inventor Jerónimo de Ayanz in 1606 to push water out of mines.

Other machines followed, including Thomas Newcomen's steam engine in 1712, but it was not until Scotsman James Watt added a condenser (for cooling the steam back to water) and gears (for making the engine faster) that the steam engine became a useful form of power for factories, mines, farming, and transportation.



REPLICA OF JAMES WATT'S STEAM ENGINE

1590

## COMPOUND MICROSCOPE

Zacharias Janssen, the son of a spectacles maker in Holland, invented the microscope using a long tube and a mix of curved lenses. In 1665, English scientist Robert Hooke improved the design and added an oil lamp to light up the specimens. Microscopes have been used by scientists ever since.



REPLICA OF ROBERT HOOKE'S MICROSCOPE

1300



EYE GLASSES

## EYE GLASSES

Early peoples such as the Vikings used rock crystals to act as lenses and increase their viewing power. Wearable lenses in the form of eye glasses were invented in the 14th century—probably in Italy, where glassblowing techniques were advanced. These early spectacles were made of two magnifying lenses set into bone, metal, or leather mountings and were balanced on the nose.

1928



ANTIBIOTIC PILLS

## ANTIBIOTIC

Scottish biologist Alexander Fleming's discovery that a mold juice (now known as penicillin) could kill a wide range of bacteria changed the course of modern medicine. Today, there are many types of antibiotics, targeting bacteria, fungi, and parasites.

1946

## COMPUTER

Developed for the US government, the world's first electronic general-purpose computer was called ENIAC: Electronic Numerical Integrator and Computer. This huge computer led the way for smaller and more powerful ones in the decades to come.



COMMODORE (PERSONAL) COMPUTER FROM 1977

1957

## SPACE SATELLITE

The Soviet Union put the first satellite into space on October 4, 1957. Called Sputnik 1, it was the size of a beach ball and took 98 minutes to orbit Earth. This marked the beginning of the Space Age.



SPUTNIK 1

1973



1990s MOBILE PHONE

## MOBILE PHONE

Martin Cooper, working at Motorola in the US, developed and demonstrated the first mobile phone. It was the size of a brick and would not be sold to the general public for another 10 years, but it marked the start of mobile personal communication systems.

1989

## WORLD WIDE WEB

In the 1970s, American computer scientist Vinton Cerf developed a system that allowed mini-networks of computers all over the world to send files to each other. Then, in 1991, English computer scientist Tim Berners-Lee introduced a World Wide Web of information that anyone with an online computer could access and helped to create the Internet we know and use today.

2010

## 3-D BODY PARTS

Invented in the US, 3-D printing has been used since the 1980s to build up three-dimensional objects in layers from digital information. More recently, scientists have been developing 3-D printers to make human organs and body tissue.

4.1 BILLION OF THE NEARLY 8 BILLION PEOPLE ON EARTH USE THE INTERNET.



# Numbers

Numbers are symbols that are used to represent a quantity of something. They have been used for thousands of years to answer the question “How many?” At first, people only used whole numbers (integers), but then came the idea of fractions and negative numbers.

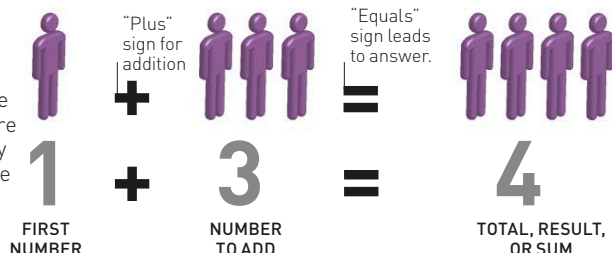
## NUMBER SYMBOLS

Many ancient civilizations used some form of number system. The modern Hindu-Arabic system is the simplest and most useful for mathematical calculations.

Modern Hindu-Arabic	1	2	3	4	5	6	7	8	9	10
Mayan	•	••	•••	••••	—	—•	—••	—•••	—••••	==
Ancient Chinese	一	二	三	四	五	六	七	八	九	十
Ancient Rome	I	II	III	IV	V	VI	VII	VIII	IX	X
Ancient Egypt										⌢
Babylonian	𐎶	𐎶𐎶	𐎶𐎶𐎶	𐎶𐎶𐎶𐎶	𐎶𐎶𐎶𐎶𐎶	𐎶𐎶𐎶𐎶𐎶𐎶	𐎶𐎶𐎶𐎶𐎶𐎶𐎶	𐎶𐎶𐎶𐎶𐎶𐎶𐎶𐎶	𐎶𐎶𐎶𐎶𐎶𐎶𐎶𐎶𐎶	𐎶𐎶𐎶𐎶𐎶𐎶𐎶𐎶𐎶𐎶

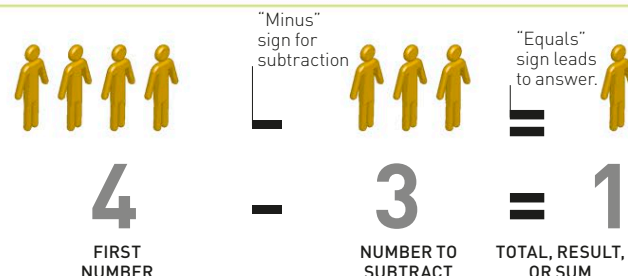
## ADDITION

Numbers can be added together to find the total of two or more quantities. Additions are written as equations by placing “+” between the numbers being added.



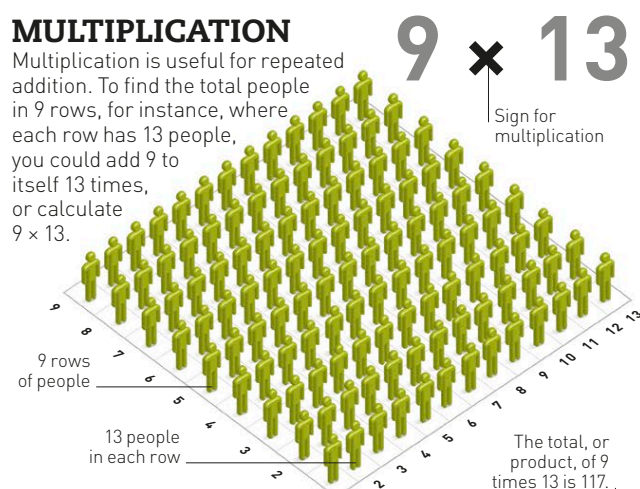
## SUBTRACTION

Subtraction is a mathematical way of working out how many are left if you take some of an original quantity away. It uses the “-” sign.



## MULTIPLICATION

Multiplication is useful for repeated addition. To find the total people in 9 rows, for instance, where each row has 13 people, you could add 9 to itself 13 times, or calculate  $9 \times 13$ .



**$9 \times 13 = 13 + 13 + 13 + 13 + 13 + 13 + 13 + 13 + 13 = 117$**

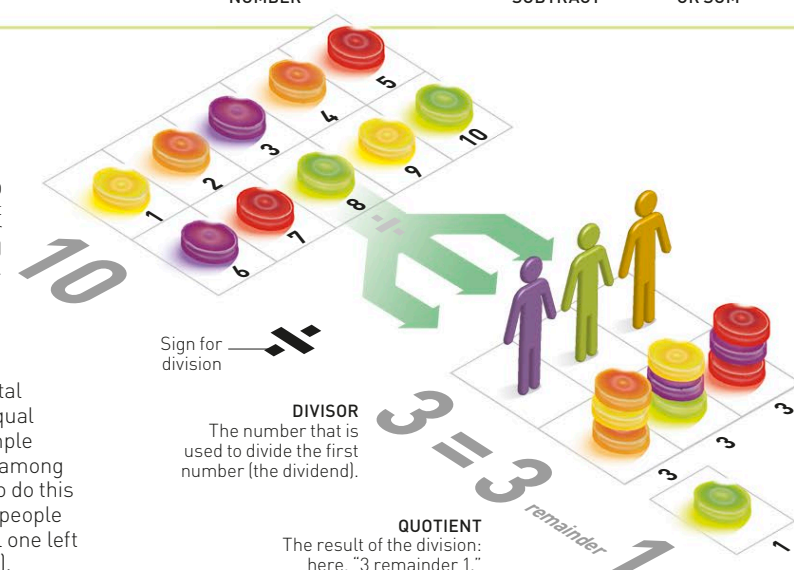
**$10 \div 3$**

Division sign

**DIVIDEND**  
This is the number that is being divided by (or shared out among) another number.

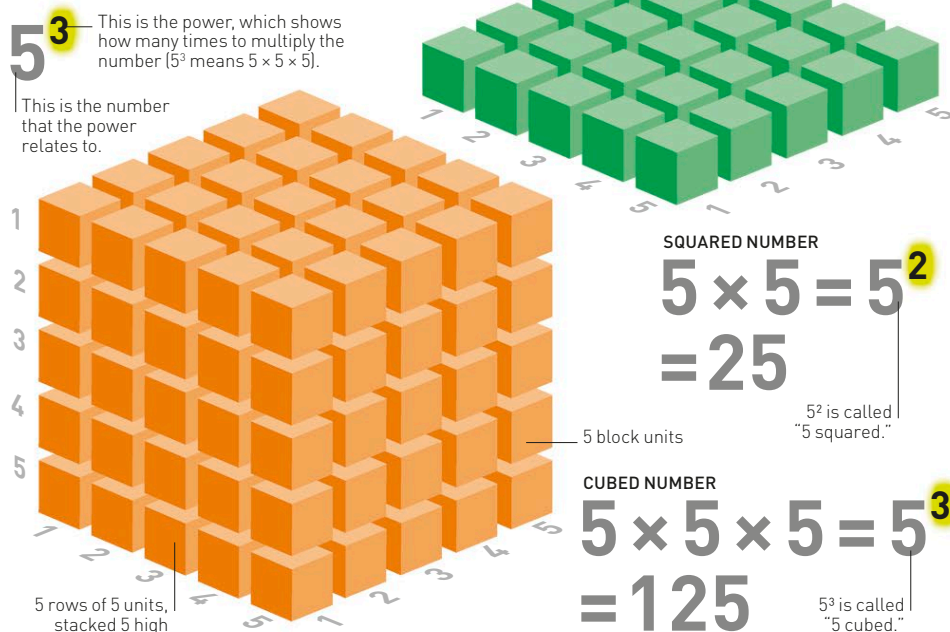
## DIVISION

Division is used to divide up a total number of things into several equal bundles, or amounts. This example shows how to divide 10 candies among three people. It is not possible to do this evenly, so after giving the three people three candies each, there is still one left over (known as the “remainder”).



## POWERS

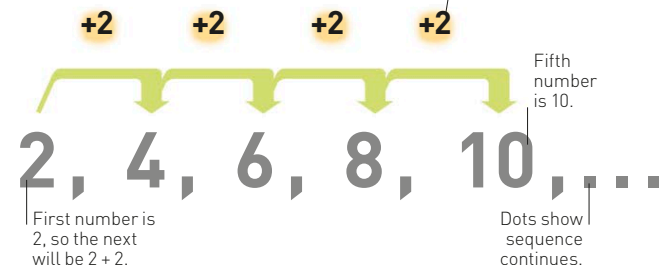
A “power” is the number of times a number is multiplied by itself. So “ $5 \times 5 \times 5 \times 5$ ” is said to be “five to the power of four,” which is written mathematically as  $5^4$ .



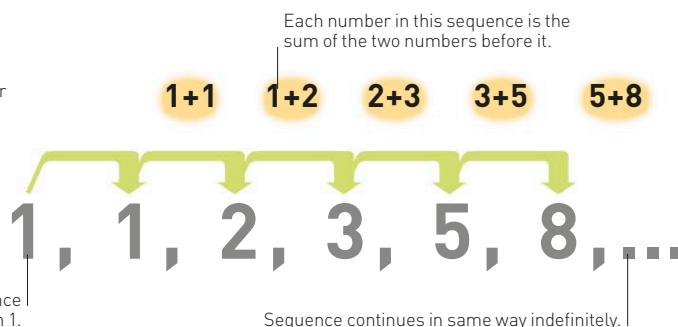
## NUMBER SEQUENCES

A sequence of numbers is a series of numbers that follow one another according to a pattern, such as each number being two higher than the previous term.

**A BASIC SEQUENCE**  
The rule for this sequence is that each number equals the previous number plus 2.



**FIBONACCI SEQUENCE**  
This is a very famous number sequence that appears in lots of natural formations such as flower petals and spiral galaxies.





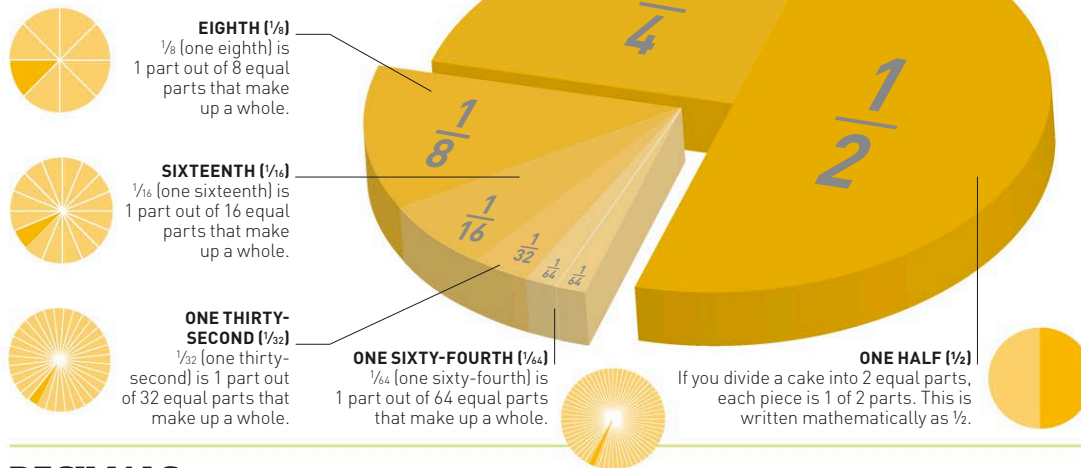
## POSITIVE AND NEGATIVE NUMBERS

Positive numbers count up from zero; negative numbers count down from zero. This means they are less than zero. If you had \$5 in your bank account and withdrew \$10 from a cash machine, your bank balance would show as -\$5.



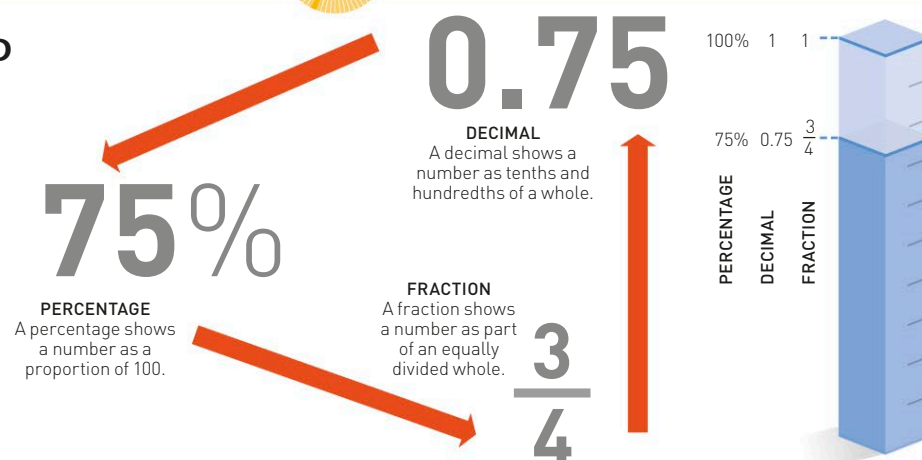
## FRACTIONS

Fractions are a way of expressing parts of an object or number. If you cut a cake, for instance, into 2 equal parts, each piece is now 1 of 2 parts; this is written as 1 over 2, like this:  $\frac{1}{2}$ .



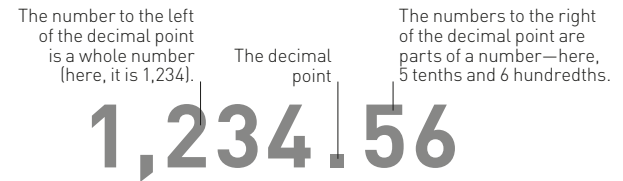
## DECIMALS, FRACTIONS, AND PERCENTAGES

These are all ways of talking about parts of a number, or something that is less than a whole (such as half a cake, 50% of a class, or 0.5 of a meter). We can "translate" fractions, percentages, or decimals into each other. For instance,  $\frac{3}{4}$  is the same as 75% or 0.75.



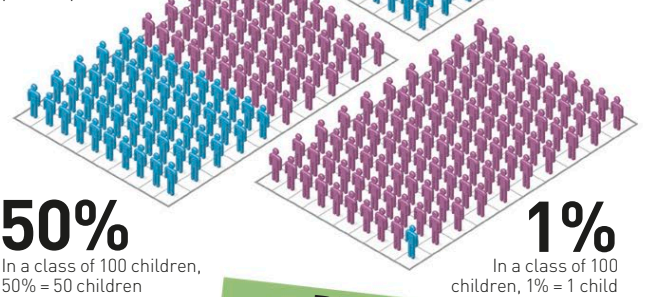
## DECIMALS

Decimals are a way of expressing parts of things or numbers as tenths or hundredths of a whole number.



## PERCENTAGES

Percentages are another way of talking about parts of an object or number. Here, the whole (such as the whole of a school class) is said to be 100 percent, or 100%. Half the class is therefore half that: 50%. The whole can be broken into very fine parts up to 100%.



**DECIMALS, FRACTIONS, AND PERCENTAGES ARE DIFFERENT WAYS OF SAYING THE SAME THING.**

### COMMON NUMBERS

The table below shows some commonly used fractions, decimals, and percentages.

Decimal	Fraction	%	Decimal	Fraction	%
0.1	$\frac{1}{10}$	10%	0.625	$\frac{5}{8}$	62.5%
0.125	$\frac{1}{8}$	12.5%	0.666	$\frac{2}{3}$	66.7%
0.25	$\frac{1}{4}$	25%	0.7	$\frac{7}{10}$	70%
0.333	$\frac{1}{3}$	33.3%	0.75	$\frac{3}{4}$	75%
0.4	$\frac{2}{5}$	40%	0.8	$\frac{4}{5}$	80%
0.5	$\frac{1}{2}$	50%	1	1	100%

## PRIME NUMBERS

These are special numbers that cannot be divided by any other number except themselves and 1. For example, 13 cannot be divided by any number other than 13 or 1. Numbers that can be divided by others are known as "composite numbers."

### KEY TO TABLE

**17**

**PRIME NUMBER**  
A green box on the table indicates that the number is a prime number.

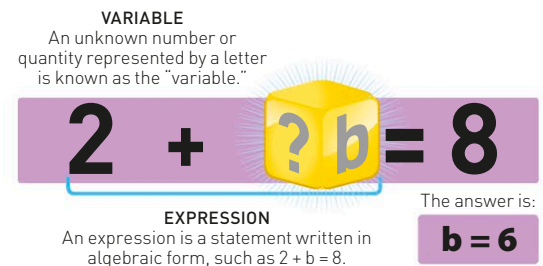
**42**

**COMPOSITE NUMBER**  
A blue box indicates that a number is a composite number. The numbers it is divisible by are given as smaller numbers below it (2, 3, 7 in the example above).

1	2	3	4	5	6	7	8	9	10
11	12	13	14	15	16	17	18	19	20
21	22	23	24	25	26	27	28	29	30
31	32	33	34	35	36	37	38	39	40
41	42	43	44	45	46	47	48	49	50
51	52	53	54	55	56	57	58	59	60
61	62	63	64	65	66	67	68	69	70
71	72	73	74	75	76	77	78	79	80
81	82	83	84	85	86	87	88	89	90
91	92	93	94	95	96	97	98	99	100

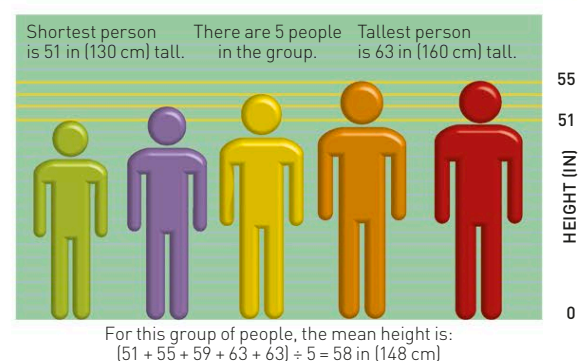
## ALGEBRA

When mathematicians are trying to work out a missing number in an equation, they use a symbol to represent the missing number. In this example, we know that 2 plus something (here, called "b") equals 8.



## AVERAGES

An average is the middle value of a set of data. The most common type of average is the mean, which is found by adding up a set of numbers, then dividing the total by the amount of numbers in the set.



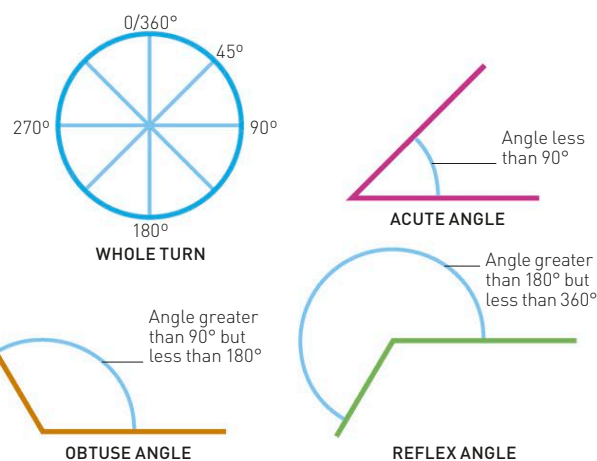


# Geometry

Geometry is the part of math that looks at lines, angles, shapes, and space. It is used to work out distances, areas, and volumes in a wide range of tasks, from building houses to astronomy.

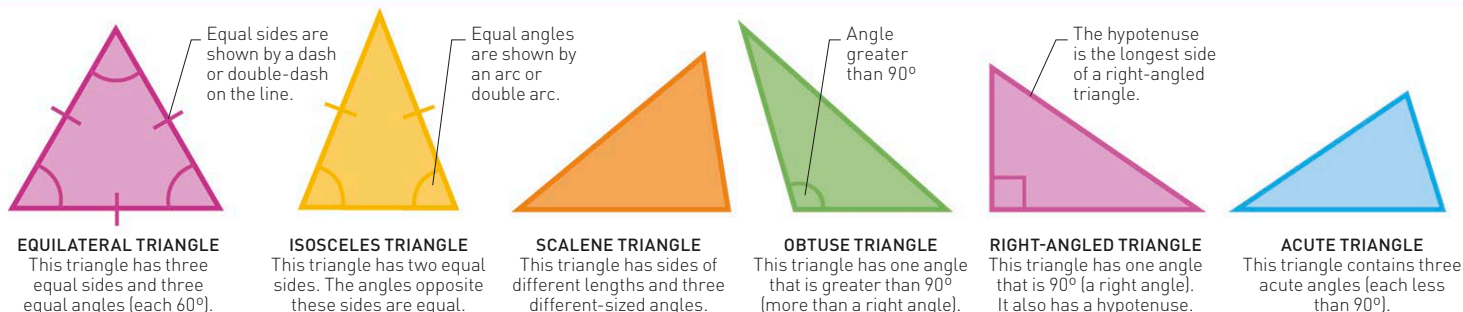
## COMMON ANGLES

The symbol  $^{\circ}$  stands for degrees. If you draw a line out from a center point and move it around 360°, it will return to the starting point. So the angles surrounding a point make up a whole turn, and they add up to 360°. The angles on a straight line make up a half turn and add up to 180°.



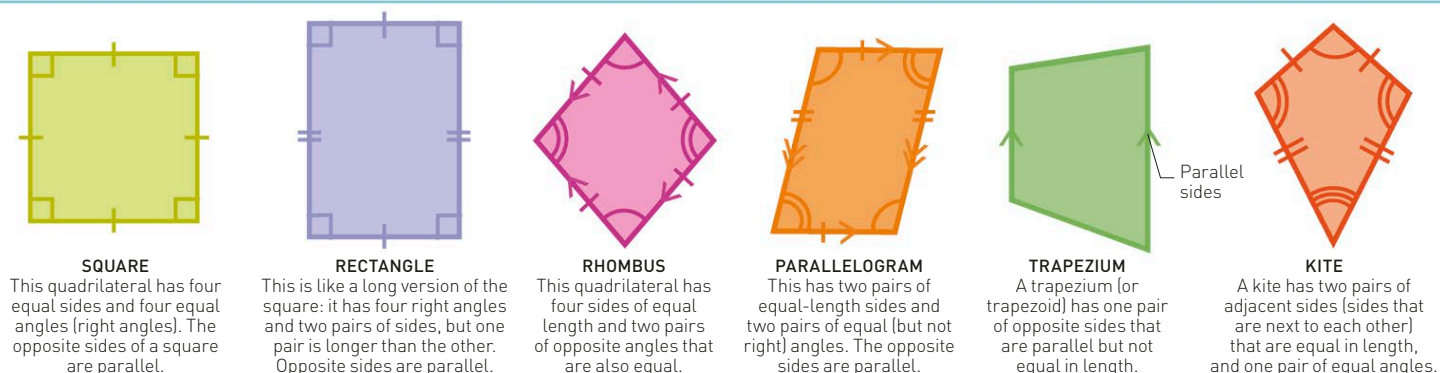
## TRIANGLES

Shapes made of straight lines are called polygons. Triangles are the simplest polygons, because they are made from three straight lines joined at three corners. All three angles inside a triangle always add up to 180°. There are several different types of triangles.



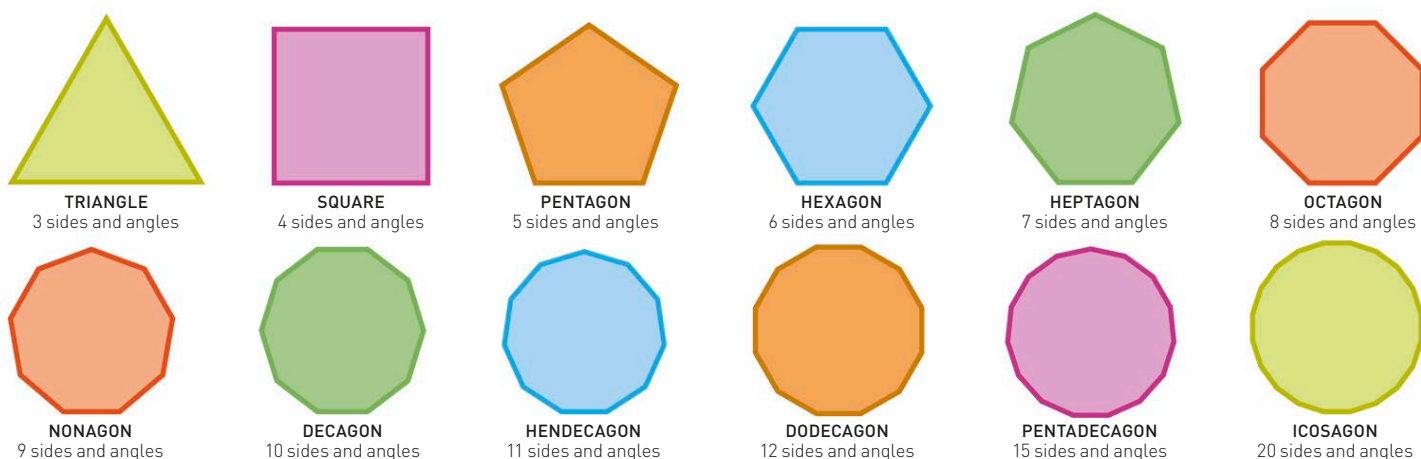
## QUADRILATERALS

Shapes that are made from four straight lines are called quadrilaterals. They have four vertices (points where the sides meet)—each of these is called a vertex. The interior angles of a quadrilateral always add up to a total of 360°. There are several different types of quadrilaterals.



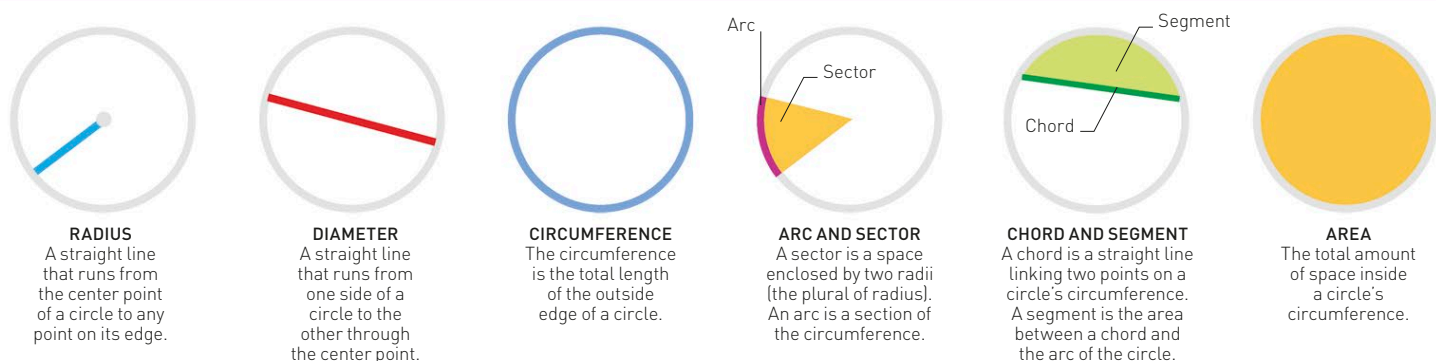
## POLYGONS

A polygon is a closed two-dimensional shape that has three or more sides. It is usually named according to how many sides it has. For example, *hexa* is Greek for "six," so a hexagon is a polygon with six sides. Every type of polygon has the same number of sides as it has angles. The shapes may be regular—with equal-length sides and angles—or irregular, with unequal sides and angles.



## CIRCLES

A circle is a closed curved line surrounding a central point, where every point along the curved line is the same distance from the center point. In math, the parts of a circle all have their own names.





## PI

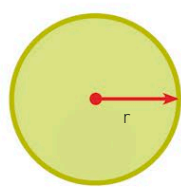
If you divide the circumference of a circle by its diameter, the answer is always 3 and a bit, or pi ( $\pi$ ). It is impossible to write pi precisely, because the numbers after the decimal point continue indefinitely.

$$\pi = 3.14159265...$$

PI SYMBOL

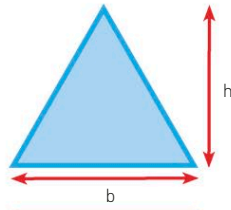
## FINDING AREA

The area of a two-dimensional shape is the amount of space inside it. There are formulae that can be used to work out how much space there is inside any polygon.



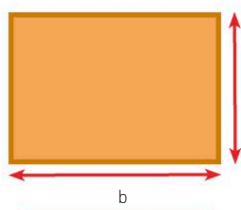
$$\text{area} = \pi r^2$$

**CIRCLE**  
The area of a circle is pi (3.14) multiplied by the square of the circle's radius.



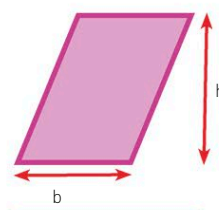
$$\text{area} = \frac{1}{2}bh$$

**TRIANGLE**  
To find the area of a triangle, multiply the base by the height, then halve your answer.



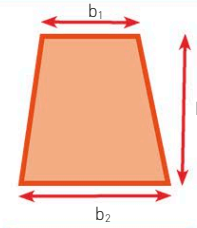
$$\text{area} = bh$$

**RECTANGLE**  
The area of a rectangle can be found by multiplying its base by its height.



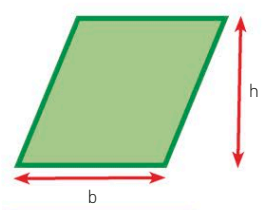
$$\text{area} = bh$$

**PARALLELOGRAM**  
Find the area of a parallelogram by multiplying its base by its vertical height.



$$\text{area} = \frac{1}{2}h(b_1 + b_2)$$

**TRAPEZIUM**  
Find the area by adding the two parallel sides, multiplying the total by the height, then dividing by 2.

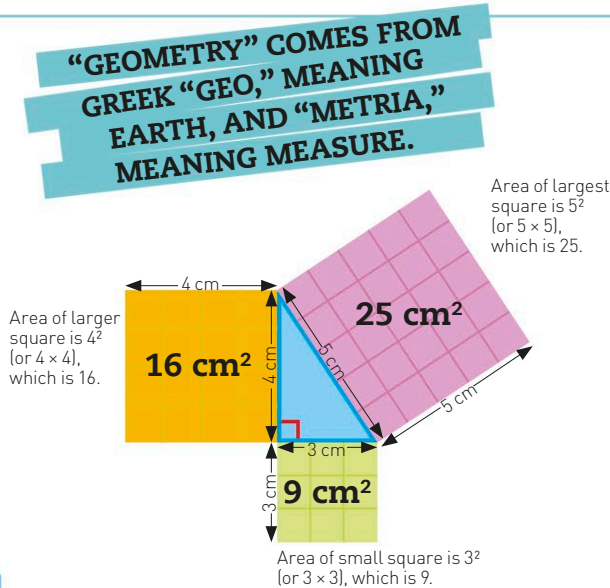


$$\text{area} = bh$$

**RHOMBUS**  
The area of a rhombus can be found by multiplying its base by its vertical height.

## PYTHAGORAS'S THEOREM

This theory is named after an ancient Greek mathematician called Pythagoras. He observed that if you draw squares from each side of a right-angled triangle, the area of the two smaller squares added together is equal to the area of the largest square.



### USING THE THEOREM

Pythagoras's theorem can be used to find the length of the longest side of a right-angled triangle (c) if you know the length of the two shorter sides (a and b).

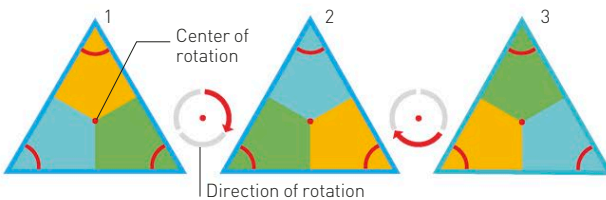
$$a^2 + b^2 = c^2$$

## ROTATIONAL SYMMETRY

If a shape can be moved around a center point and still fit its original outline exactly, it is said to have rotational symmetry. The order of rotational symmetry is the number of ways a shape can fit into its original outline when rotated.

### EQUILATERAL TRIANGLE

An equilateral triangle has rotational symmetry of order 3—when rotated, it fits its original outline in three different ways.



### SQUARE

When rotated around its center, a square fits its original outline in four different ways—its rotational symmetry is order 4.

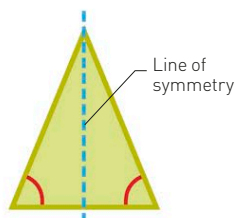


## REFLECTIVE SYMMETRY

A reflection shows a shape in its mirror image, like a mountain reflection in a lake. When a flat shape can be divided in half so that each half is the exact mirror image of the other, it is said to have reflective symmetry. The line that divides the shape to perform the reflection is called a line of symmetry.

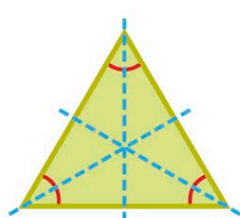
### ISOSCELES TRIANGLE

This is symmetrical across a central line: the sides and angles on either side of the line are equal, and the line cuts the base in half at right angles.



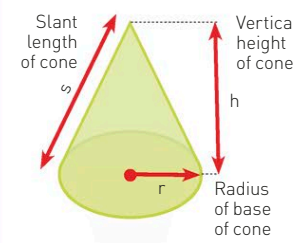
### EQUILATERAL TRIANGLE

An equilateral triangle has a line of symmetry through the middle of each side—not just the base.



## FINDING VOLUME AND SURFACE AREA

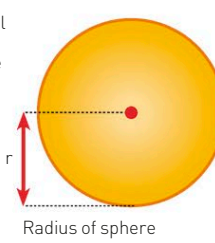
Volume is the amount of space enclosed within a three-dimensional (3-D) object. Surface area is the total area around the outside of a 3-D object.



$$\begin{aligned} \text{surface area} &= \pi rs + \pi r^2 \\ \text{volume} &= \frac{1}{3}\pi r^2 h \end{aligned}$$

### CONE

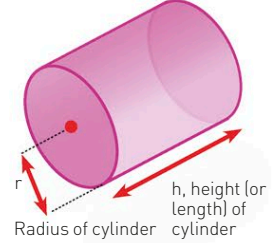
Find the surface area of a cone using the radius of its base, its height, and its slant length. Find the volume using the height and radius.



$$\begin{aligned} \text{surface area} &= 4\pi r^2 \\ \text{volume} &= \frac{4}{3}\pi r^3 \end{aligned}$$

### SPHERE

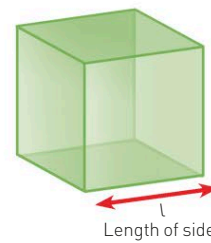
You can find the surface area and volume of a sphere using only its radius and the value of pi (often shortened to just 3.14).



$$\begin{aligned} \text{surface area} &= 2\pi r(h + r) \\ \text{volume} &= \pi r^2 h \end{aligned}$$

### CYLINDER

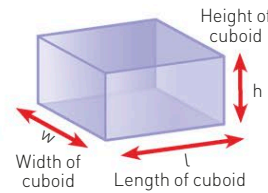
The surface area and volume of a cylinder can be found from its radius and height (or length).



$$\begin{aligned} \text{surface area} &= 6l^2 \\ \text{volume} &= l^3 \end{aligned}$$

### CUBE

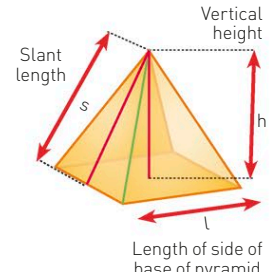
The surface area and volume of a cube can be found by using only the length of its sides. No other information is needed.



$$\begin{aligned} \text{surface area} &= 2(lh + lw + hw) \\ \text{volume} &= lwh \end{aligned}$$

### CUBOID

The surface area or volume of a cuboid can be found if you know its length, width, and height.



$$\begin{aligned} \text{surface area} &= 2ls + l^2 \\ \text{volume} &= \frac{1}{3}l^2 h \end{aligned}$$

### SQUARE PYRAMID

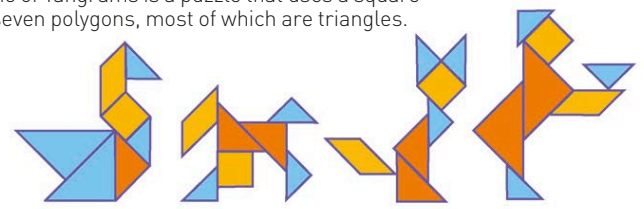
Find the surface area of a square pyramid by using the lengths of its slant and the side of its base. Its volume can be found from its height and the side of its base.

## TANGRAMS

Any shape that is made of straight sides can be split into triangles. If you were to cut up a piece of paper into triangles, for instance, you could reassemble the pieces in different ways to create new shapes. The game of Tangrams is a puzzle that uses a square shape split into seven polygons, most of which are triangles.



TANGRAM



POSSIBLE SHAPES USING TANGRAM PIECES



# Cars

The first cars were invented in the late 19th century. Originally known as “horseless carriages,” these early models were slow, open-topped vehicles. Today’s cars are fast, and can be powered by gas, diesel, or electricity.

## HOW A GAS CAR WORKS

The power that turns a gas car’s wheels comes from the car’s internal combustion engine. Combustion is a kind of burning that takes place inside the engine when air is mixed with gasoline, compressed, and ignited with a spark.

### 1 INSIDE THE ENGINE

Air and gas are sucked into cylinders inside the engine by pistons, which then compress the mixture. A spark plug ignites it, providing energy.

### 2 IN GEAR

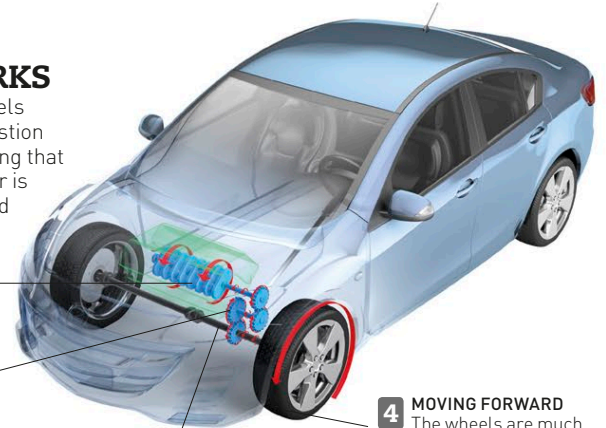
The pistons move very fast, but a car needs more force and less speed to start moving. Gears control the force and speed the car receives.

### 3 TURNING WHEELS

The gears turn rods called axles. Wheels are attached to these axles, so they turn, too.

### 4 MOVING FORWARD

The wheels are much bigger than the axles, so as they turn, they cover a lot of ground quickly, moving the car forward.



## BESTSELLING CARS

In 1901, only 600 cars were sold around the world. Today, yearly car sales are about 75 million worldwide. These models have sold in huge numbers.

### 1 TOYOTA COROLLA

The world’s bestselling car, more than 43 million of this Japanese model have been sold since 1966.

### 2 FORD F-SERIES

Ford have sold more than 40 million of these chunky pick-up trucks since they were introduced in 1948.



FORD F-SERIES  
1948

### 3 VOLKSWAGEN GOLF

Introduced in 1974, the Golf has been consistently popular—more than 30 million have been sold.

### 4 VOLKSWAGEN BEETLE

First produced in 1933, 23.5 million Beetles have been sold worldwide.



VOLKSWAGEN  
BEETLE 1948

### 5 LADA RIVA

Based on an older model from 1966, the Lada Riva was launched in 1980, and has sold more than 19 million units since then.

### 6 HONDA CIVIC

Honda was about to stop making cars before creating the Civic in 1972; 18.5 million have sold.

### 7 FORD ESCORT

These family cars were produced from 1968. Sales eventually topped 18 million.

### 8 HONDA ACCORD

This was the first Japanese car produced in the USA. Honda has sold more than 17 million Accords since 1976.

### 9 FORD MODEL T

The original affordable car. Ford sold more than 15 million of these between 1908 and 1927.

### 10 VOLKSWAGEN PASSAT

Seven generations of Passat have seen total sales of above 15 million since 1973.

**THE FERRARI F8 TRIBUTO  
CAN REACH 124 MPH  
(200 KPH) IN UNDER  
NINE SECONDS.**



MASERATI  
GRANTURISMO  
MC STRADALE  
2011

FERRARI F8  
TRIBUTO  
2019



## SUPERCARS

Cars that are designed to be faster, sleeker, and more powerful than normal cars are called supercars. They use cutting-edge materials and technology and are very expensive. These are the road cars that make onlookers say “Wow!” Supercars are often made in limited numbers.



Benz Patent-  
Motorwagen

**1886**  
Benz Patent-Motorwagen is the first gas-fueled automobile.

**1901**  
Lohner-Porsche produces the first hybrid cars, which can run on an electric battery and gas.

**1908**  
The Ford Model T is the first affordable car.

**1913**  
Ford operates first moving car assembly line.

**1928**  
Bentley wins Le Mans race.



Bentley  
4 1/2 Litre

**1954**  
Mercedes-Benz 300 SL “Gull Wing” is first production car to exceed 150 mph (241 kph).

## 1886

## CARS THROUGH TIME

The first gas-fueled cars reached a top speed of 12 mph (19 kph). Since then, technology has given us affordable, faster, and safer cars, with some reaching speeds of up to 300 mph (480 kph).

**1893**  
Duryea Motor Wagon is the first successful car powered by gas.



Mercedes Simplex 60HP

**1903**  
Mercedes Simplex 60HP can reach 75 mph (120 kph).

**1910**  
First four-wheel brake system is patented by Argyll Motors, Scotland.



Argyll Landaulette

**1934**  
Citroën Traction Avant is first successful front-wheel-drive made for the mass market.



Citroën Traction Avant

**1948**  
Jaguar XK120 reaches 124.6 mph (200 kph).



## OFF-ROAD ADVENTURERS

These cars are specially built to travel along difficult terrain, such as muddy or very uneven roads. They are also known as "four-by-fours" because all four wheels are powered by the engine. This gives each wheel the ability to pull the vehicle out of a sticky situation.



LAND ROVER SERIES 1  
1949



MERCEDES-BENZ G300D  
1993



RANGE ROVER  
2002



HUMMER H3  
2008



TOYOTA LAND CRUISER PRADO  
2007

## THE FUTURE IS GREEN

Hybrid cars are powered by a gas or diesel engine and an electric motor. When the car is using the engine, it also charges up the batteries, which power the motor. These cars use less energy and cause less pollution than other cars. Purely electric cars are the most environmentally friendly.



FORD ESCAPE HYBRID  
2009

New York City is now using more and more hybrid taxicabs.



TESLA MODEL 3  
2017

This car is purely electric.



BMW i8  
2014

This hybrid sports car can reach speeds of up to 155 mph (250 kph).



MCLAREN F1 GT  
1997



BUGATTI VEYRON  
2005



KOENIGSEGG  
AGERA RS  
2015



LAMBORGHINI  
HURACÁN  
2014

PORSCHE 918  
SPYDER  
2015



## RACING DEMONS

Race cars come in several shapes and sizes. Each one is built to suit a particular kind of race, such as Formula 1, rallying, endurance, or stock car racing.



FORMULA 1 RACING: 2008 MCLAREN-MERCEDES  
Driven by 2008 World Champion Lewis Hamilton.



TOURING CAR RACING: 2003 MERCEDES BENZ  
This won nine of the 10 races in Germany's Touring Car Masters (DTM).



ENDURANCE RACING: 2009 PEUGEOT  
Winner of Le Mans 24-hour race in France; driven by a team of three.



STOCK CAR RACING: 2009 TOYOTA CAMRY  
Brian Vickers won the Carfax 400 in this hybrid car.



FORMULA E RACING: DS E-TENSE FE19 GEN2  
Driven by 2019 World Champion Jean-Eric Vergne.

## RECORD BREAKERS

Over the years, manufacturers have tried to outdo each other with new refinements. Here are some remarkable record-breaking cars.

### FIRST AFFORDABLE CAR

In the early years of driving, cars were driven only by wealthy people. Henry Ford changed this in 1908, when he produced the affordable Model T.

FORD  
MODEL T



### LAND SPEED RECORD

Thrust SSC (SuperSonic Car) used two turbojets to drive faster than sound in 1997 in the Nevada Desert, reaching 763 mph (1,228 kph).



THRUST SSC

### SMALLEST ROADWORTHY CAR

Built by Austin Colson in the US in 2012, this car measures just 25 in (63.5 cm) high x 25.8 in (65.41 cm) wide x 50 in (126.47 cm) long. It is just big enough to be allowed on roads.

### MOST EXPENSIVE CAR

In 2019, Bugatti unveiled the world's most expensive car: La Voiture Noire. It costs almost \$19 million (£15.5 million) and has a top speed of 261 mph (420 kph).

### FASTEST PRODUCTION CAR

The fastest series production car is the Bugatti Chiron. It hit a speed of 304.773 mph (490.484 kph) in 2019, and is powered by a 8.0-liter, quad-turbo W16 engine.

Mercedes-Benz  
300 SL "Gull Wing"



1959

The space-saving, compact Mini boosts the appeal of economy cars.

Mini



1971

Chrysler Imperial introduces a reliable electronic four-wheel anti-lock braking system called Sure-Brake.

1982

Bosch produces the first fully digital electronic fuel injection system.



Fuel injection system

2019

The Bugatti Chiron breaks the 300-mile speed barrier when it hits 304.773 mph (490.484 kph).

1958

Aston Martin DB4 achieves 141 mph (227 kph).



Aston Martin DB4

1966

Lamborghini Miura reaches 171 mph (275 kph).



Lamborghini Miura

1973

Catalytic converter invented. This device filters vehicle exhausts to reduce pollution.



Catalytic converter

1997

Toyota Prius is the first mass-produced hybrid car.



Toyota Prius (2009 model)

2008

Tesla Motors launches its first fully electric car, the Tesla Roadster.



Tesla Roadster

2025

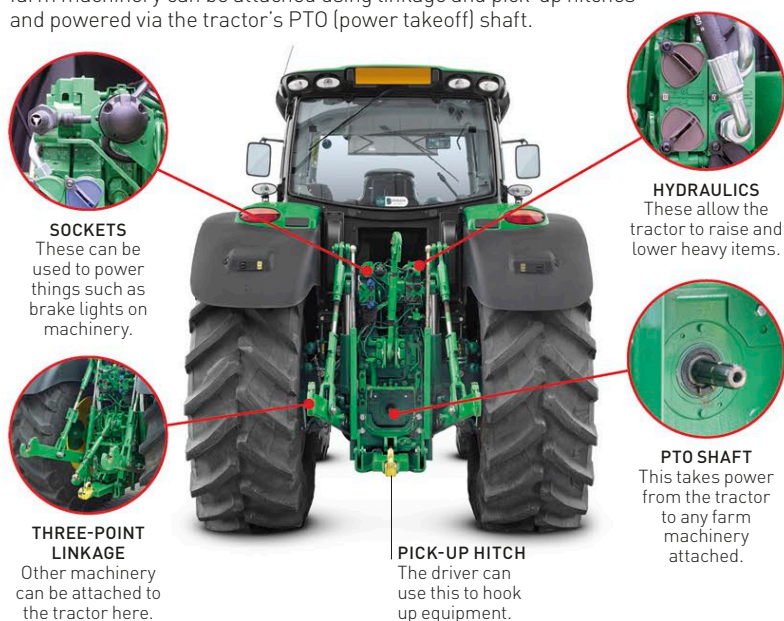


# Tractors

A tractor is a vehicle designed to pull things—especially large farm machinery. Tractors have engines with a special gearbox that allows them to use all the engine's power for strength, not speed. Once fueled by coal, they now run on diesel.

## MODERN MACHINE ANATOMY

Modern tractors are very large and powerful. They have four huge wheels with grooved tires that allow them to travel over wet, muddy ground and reinforced cabs to keep the driver safe even if the tractor tips over. Other farm machinery can be attached using linkage and pick-up hitches and powered via the tractor's PTO (power takeoff) shaft.



## A YEAR ON THE FARM

Farmers work with the seasons, as seeds and crops will grow only when conditions are right. Tractors are useful at every stage of the process, from preparing the land to harvesting the crops.

### 1 PLOWING AND CULTIVATING

After the harvest, tractors are used to pull plows, preparing the soil for seeding.

### 2 PLANTING SEEDS

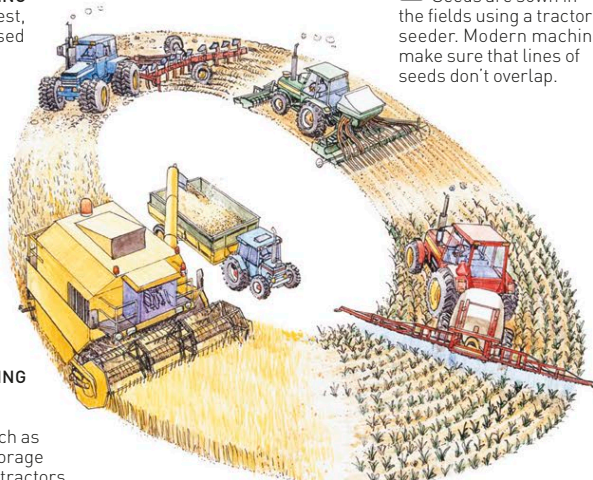
Seeds are sown in the fields using a tractor seeder. Modern machines make sure that lines of seeds don't overlap.

### 4 HARVESTING

Farmers attach special machinery, such as combine and forage harvesters, to tractors to harvest the crops (such as wheat) from the fields.

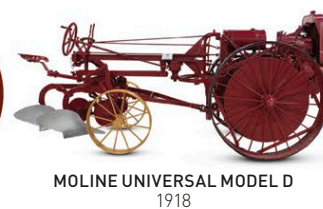
### 3 SPRAYING FERTILIZERS

Fertilizer spreaders are attached to tractors to distribute growth-enhancing fertilizer across the fields.



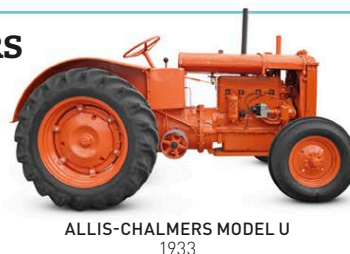
## FIRST TRACTORS

Tractors were invented in the 1860s to do the job of horses around the farm. They had steam engines, large metal wheels, and a seat at the back.



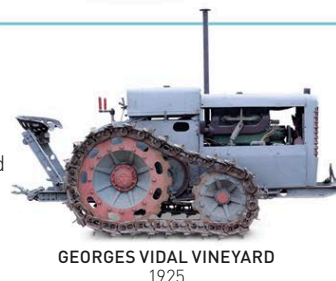
## FARM TRACTORS

Gas tractors were invented in the 1890s, with wheels designed to give them great pulling power. They were also faster and quickly became indispensable on farms.



## CRAWLERS

From the 1920s, farms also began to use the "crawler" or "caterpillar." These have tracks rather than wheels and can travel safely over slippery ground and steep hills.







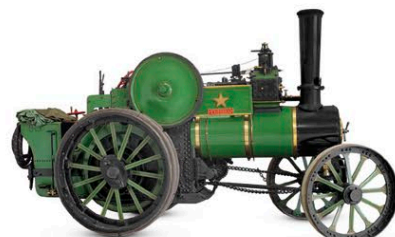
MARSHALL COLONIAL  
CLASS A  
1908



INTERNATIONAL TITAN TYPE D  
1910



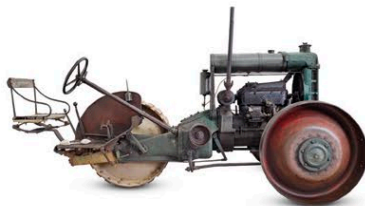
TWIN CITY 40-65  
1913



CLAYTON & SHUTTLEWORTH  
DOROTHY  
1914



TITAN 10-20  
1919



GLASGOW TRACTOR  
1919



SCEMIA UNIVERSAL  
1919



FOWLER BB1  
1920



MASSEY-HARRIS  
101 JUNIOR  
1939

The engine  
is hidden under  
the hood.



MASSEY FERGUSON 8740S  
2019

Air-conditioned cab,  
reinforced by roll-bars to  
protect the driver should  
the tractor tip over.

Thick treads,  
or grooves,  
provide grip  
on muddy  
ground.



CASE MODEL L ROADLESS  
1938



CATERPILLAR D2  
1942



INTERNATIONAL TD14  
1944



TRACK-MARSHALL  
1958



MINNEAPOLIS-MOLINE MOTRAC  
1960

1880

## TRACTOR HISTORY

Today's tractors have come a long way from 1869 in the US, where the first steam-engine tractor was pulled by horses.

1892

In Iowa, John Froelich invents the first self-propelled gas-engine tractor that can move forward and backward.

1896

A Hornsby-Akroyd engine is used to power the first gas tractor.



Hornsby-Akroyd  
Tractor

1908

Australia's tractor industry begins with the building of the first McDonald Imperial.



McDonald Imperial



Pavesi America

1913-1917

As Europe prepares for World War I, the Italian company Pavesi realizes the demand for military tractors to replace horses for pulling heavy loads. The result is the US model known as Pavesi America.

1918

The Fordson Model F becomes the first mass-produced and affordable tractor.



Fordson Model F

1924

International Harvester launches the Farmall model, introducing the idea of a general-purpose row-crop tractor.

1931

The Caterpillar 60 Atlas is the first diesel tractor by the Caterpillar Tractor Company.



Caterpillar 60

1940

Tractors capable of towing aircraft are supplied to the RAF in the UK during World War II.

1958

Sir Edmund Hillary arrives at the South Pole on a tractor.



Doe Triple-D

1964

Built by British farmer George Pryor, Doe Triple-D is the first double tractor.

1990

JCB launches the Fastrac, which has a top speed of 40 mph (64 kph).



JCB Fastrac

2013

India becomes the world's largest tractor producer.

2019

John Deere, an American company, announces a fully electric, self-driving tractor.

2025



# Trucks and diggers

People are often fascinated by the vehicles they see on our roads and hard at work on construction sites. These machines come in all shapes and sizes and do very different jobs.

## WHAT ARE THEY FOR?

Trucks carry every kind of load. Oil and other liquids are transported in tankers, while huge transporters carry other vehicles. Some trucks, such as road gritters, refuse trucks, and ambulances, provide vital services.

**THE LONGEST TRUCKS, CALLED "ROAD TRAINS," HAUL SEVERAL TRAILERS AT ONCE.**



**CONSTRUCTION**  
Cement mixers, diggers, and bulldozers are vital for building work.



**EMERGENCY VEHICLES**  
Specialized trucks, such as fire engines and police vans, respond to emergencies.



**HAULAGE**  
Large trucks and tankers haul their heavy loads over long distances.



**SPECIALTY**  
Highly specialized machines, such as tracked diggers, do specific jobs.

## LIGHT TRUCKS

While some light trucks may only be car-sized, they are hard-wearing, practical vehicles. These trucks are useful for carrying small loads and operating in small spaces.



THREE-WHEELER



SMALL FLATBED



FORKLIFT



PICK-UP TRUCK



MINI DUMPER

## MEDIUM TRUCKS

Local delivery vehicles and trucks providing public services, such as trash collection or breakdown recovery, are usually medium-sized.



STREET-SWEEPER VEHICLE



PICK-UP TRUCK WITH SMALL CRANE



DELIVERY TRUCK



REFUSE TRUCK

## HEAVY TRUCKS

These huge vehicles have very powerful engines and strong structures to support their heavy cargoes. They are often "articulated," meaning a tractor unit pulls a trailer. The largest trucks are mining dump trucks, used to shift huge loads of earth and rocks.



MONSTER TRUCK



HAULAGE TRUCK



TIMBER TRUCK



CEMENT MIXER

Cars are loaded on to the transporter's decks.



TRANSPORTER



TANKER



BIG RIG

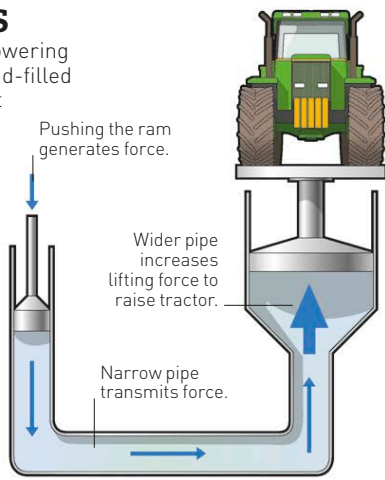


DUMP TRUCK



## HYDRAULICS

Hydraulics means powering a machine using liquid-filled pipes. Liquids cannot be squeezed into a smaller space, so a pipe filled with oil can be used to exert force. If the pipe is wider at one end than the other, the force is increased.



### HOW A HYDRAULIC RAM WORKS

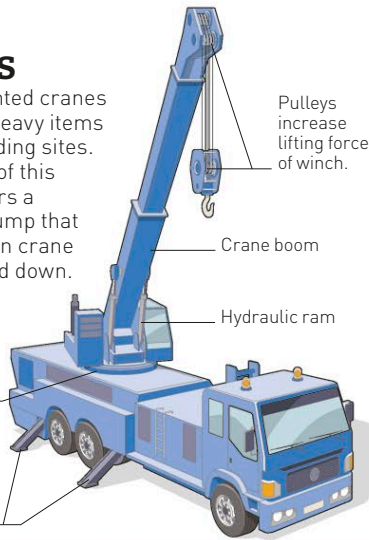
Since the lift pipe is wider than the ram pipe, the lifting force is multiplied.

## CRANES

Truck-mounted cranes move very heavy items around building sites. The engine of this crane powers a hydraulic pump that lifts the main crane boom up and down.

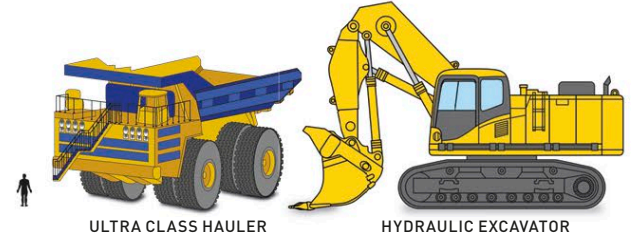
Turntable swings the boom over a large area.

Hydraulic stabilizers stop the crane from tipping over.



## MIGHTY MACHINES

The world's biggest dump trucks—or ultra class haulers—stand at around 26 ft (8 m) high. These mechanical monsters are used in mines and can carry 550 tons (500 tonnes) of debris—the weight of about 100 elephants. At 33 ft (10 m) high, the largest hydraulic diggers weigh 1,080 tons (980 tonnes). They can shovel 1,100 tons (1,000 tonnes) of material an hour.



## EMERGENCY VEHICLES

The most important trucks are those that save lives. Fire engines are equipped with water tanks and other tools. Armored SWAT trucks are used by the military and police, while ambulances ferry the sick and injured to hospitals.



## DIGGERS

Also known as excavators, these machines use a bucket on the end of a hinged arm (boom) to dig into the ground. Wheeled diggers are suitable for moving across hard surfaces, while tracked wheels are best for mud. Loaders are used to scoop up loose material, such as gravel, from the ground.



SKILLED OPERATORS USE BACKHOE LOADERS TO PERFORM STUNTS CALLED "DIGGER DANCING."



# Trains

In 1804, British engineer Richard Trevithick tried attaching a steam engine to a wagon. It easily pulled enormous weights, a job that had been done by horses. The steam railway was born. Today's trains use diesel or electricity to run fast and cleanly. Some use magnetic levitation.

## STEAM POWER

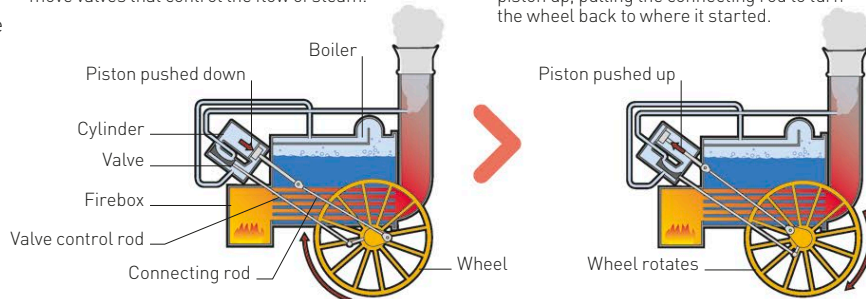
A steam engine runs on the heat energy that is produced by burning coal or other fuel. Inside the steam engine, there is a fire that heats a boiler filled with water. The steam that is produced goes into cylinders and pushes pistons backward and forward. The pistons are connected to the driving wheels and push and pull them around.

### 1 PISTON MOVES DOWN

Steam moves from the boiler into cylinders. The steam pressure pushes pistons, which move rods to turn the wheels. The turning wheels move valves that control the flow of steam.

### 2 PISTON MOVES UP

When the piston nears the bottom of the cylinder, the valve swaps the steam flow from the top to the bottom. The steam pushes the piston up, pulling the connecting rod to turn the wheel back to where it started.



## DIESEL TRAINS

Steam engines polluted the air and were inefficient, so people began to look for better ways of powering trains. In 1892, German Rudolf Diesel invented the diesel engine, which ran on a liquid type of fuel.



BOXLEY WHITCOMB 30-DM-31  
1941

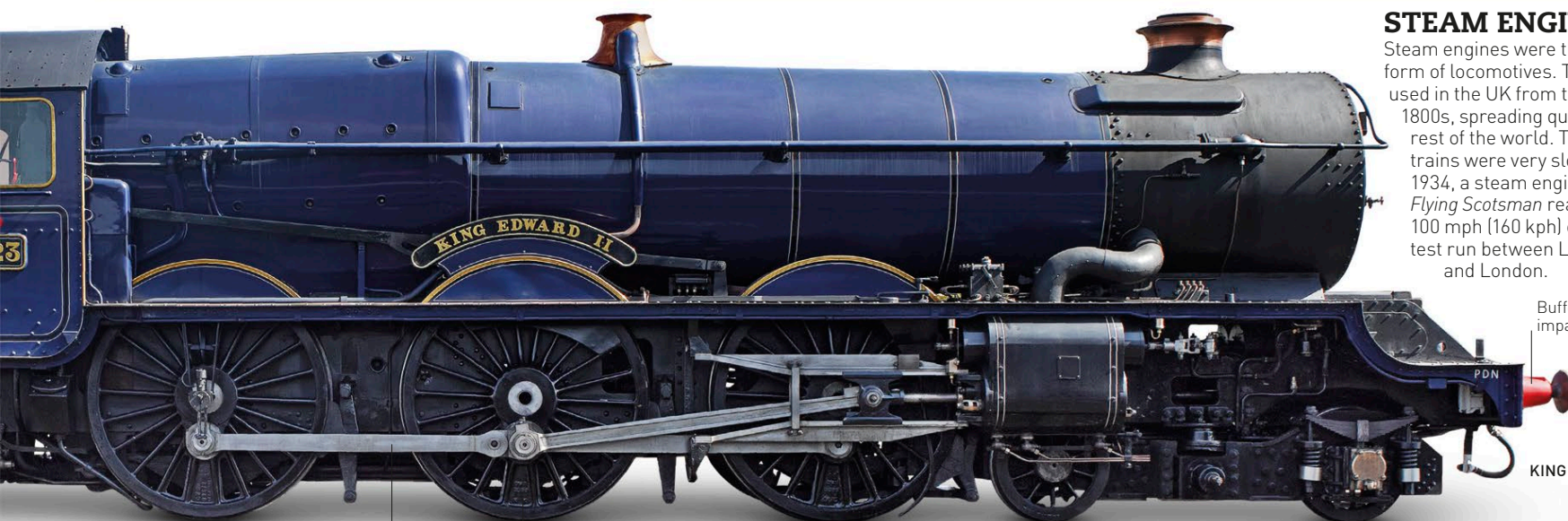


ENGLISH ELECTRIC DELTIC  
1955

ONE EARLY DIESEL PASSENGER TRAIN WAS CALLED THE FLYING HAMBURGER.

## STEAM ENGINES

Steam engines were the first form of locomotives. They were used in the UK from the early 1800s, spreading quickly to the rest of the world. The early trains were very slow, but in 1934, a steam engine called *Flying Scotsman* reached 100 mph (160 kph) on a test run between Leeds and London.



Buffer to absorb impacts

KING EDWARD II  
1930

Coupling rod connects the wheels.

Driving wheel moved by piston



ROCKET  
1829



TALIESIN  
1876



MERDDIN EMRYS  
1879



LB&SCR B1 CLASS  
1882



LYR WREN  
1887



NER (CLASS XL NO. 66)  
1902



VGN (CLASS SA NO. 4)  
1910



GWR HALL CLASS  
1928



MALLARD  
1938



HUNSLET AUSTERITY  
1944



DR (CLASS 99.73-76)  
1954





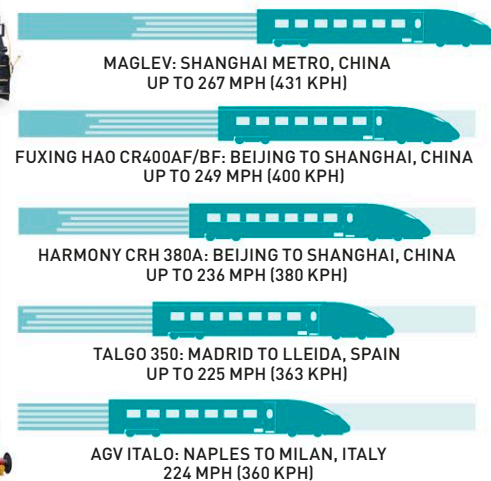
## ELECTRIC TRAINS

Electric trains run on electricity that is provided by an overhead line or an electrified rail. They do not give off smoke and can travel very fast.



## FASTEST TRAINS

An early record-setting train was Stephenson's *Rocket*, at 29 mph (46 kph). In the 1960s, Japan opened the world's first high-speed rail line, capable of carrying "bullet trains" that traveled at around 130 mph (210 kph). Some trains today can travel even faster.



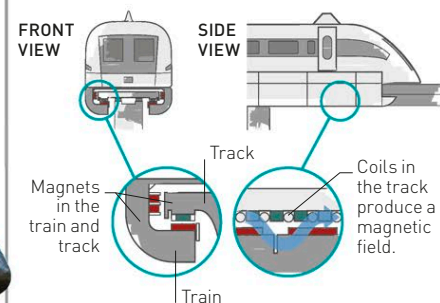
## MAGNETIC TRAINS

Maglev trains use magnetic levitation to move trains along without having to touch the ground or any form of rail. Magnets allow them to rise and then travel extremely fast above special rails.



MAGLEV TRAIN

### HOW MAGLEV WORKS



1808

Trevithick runs a steam engine in Bloomsbury, London.

**Trevithick's Puffing Billy**



1829

George Stephenson's *Rocket* becomes the fastest train when it reaches 29 mph (46 kph).

1869

The transcontinental railway opens, making the US a dominant economic power. Railways create big business in America, driving the Industrial Revolution.

1914-1918

Large armies are moved by train during World War I.

1964

Japan introduces a high-speed "bullet" train.



**Japanese bullet train**

1800

1804

Trevithick's Penryn locomotive is tried in South Wales.

1812

First successful commercial use of steam in Yorkshire, England.

1863

Underground railway opens in London, UK.



**Map of London Underground**

1913

Sweden uses the first diesel-powered mainline trains.

1890

First use of electric locomotives on London's underground.

1960s

The US and UK phase out steam engines in favor of diesel and electric.



**East German Battery shunter**  
1966

2025

2015

Japan's Maglev train Series L0 (A07) hits a top speed of 375 mph (603 kph) on a test track.

## TRAIN HISTORY

Trains have changed significantly over their 300-year history. The first trains were steady and steam-powered. Modern trains are usually electric and can reach very high speeds.



# Motorcycles

A popular means of transportation for more than 100 years, motorcycles can move faster than any other road vehicles. There are specialized bikes for almost every purpose, from town riding to fun sports and racing.

## STUNTS

Motorcycle stunt riding is a sport in which riders perform daring tricks, often making their bikes leave the ground. Lightweight sports bikes are most commonly used.



## CLOTHING

Riders need protective clothes that will help save them from injury if they fall off their bikes. The most vital piece of equipment is the helmet.



## STANDARD BIKES

These bikes have little or no extra bodywork. They let riders sit upright, allowing them to see far ahead. This improves safety, especially in busy towns. Standard bikes are often the first choice for new riders.



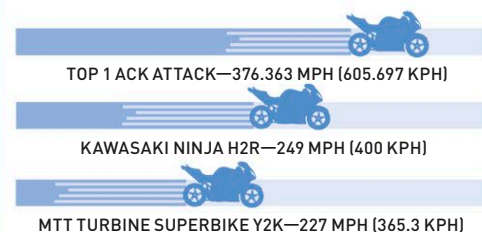
## TOURERS

Comfortable rather than ultra-fast, touring bikes provide an easy ride over long distances. They are also popular for everyday travel.



## FASTEST BIKES

Some specially built motorcycles can travel at more than 373 mph (600 kph). Such high speeds are not allowed on public roads.



## SPORT BIKES

These bikes are designed for thrills. They have fast acceleration, powerful brakes, and can take corners at high speed. Some models are used for road riding, as well as racing.



## CRUISERS

Modern cruisers are powerful luxury bikes, at their best on open roads. They are built to look stylish, but many riders find them less comfortable than touring bikes.



## SIDECARS

A sidecar is a small, one-wheeled vehicle that attaches to the side of a bike. It usually provides a passenger seat and some luggage space.





1850

## HISTORY OF MOTORCYCLES

The motorcycle had its beginnings in the late 19th century, when inventors discovered how to power bicycles with fuel-driven engines.



**Daimler Reitwagen**

1885 A gas-powered wooden bike is designed and built by German inventors Gottlieb Daimler and Wilhelm Maybach.

1894 The Hildebrand & Wolfmüller Motorrad is the first real motorcycle to come off a production line.



**Hildebrand & Wolfmüller Motorrad**

1908 The first-ever motorcycle race is held at Brooklands, Surrey, in England, and won by a 944cc NLG Peugeot bike.



**NLG Peugeot**

1936 The first scooters are made in the US. The Cushman Auto-Glide is produced in 1938 and later adapted for wartime use.



**Auto-Glide Model 1**

1969 Honda launches the first superbike—the Honda CB750. It is the first standard bike to offer features such as an overhead-camshaft four-cylinder engine and front disk brake.



**Honda CB750**



**Mighty Mouse**

1977 Raced by Brian Chapman, "Mighty Mouse" is the first dragster (bike built for drag races) to cover 1,312 ft (400 m) in less than nine seconds.



**Triumph Thunderbird 1600**

2010 The world's biggest parallel-twin engine appears when the Triumph Thunderbird 1600 comes off the production line.

2011 The Triumph Rocket III Roadster features the largest-ever production motorcycle engine, at 2,294 cc.

2015 Bharat Singh Parmar from Gujarat, India, builds the world's longest motorcycle, 86 ft 3 in (26.29 m) in length.

2019 Harley-Davidson, the iconic American motorcycle maker, launches its first electric motorcycle.

2025



**NSU 18PS SPORT 1924**



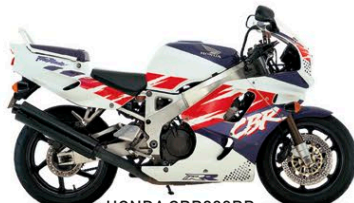
**EXCELSIOR JAP SPEEDWAY 1949**



**WESLAKE HOBBIT DRAGSTER 1978**



**HONDA RC30 1988**



**HONDA CBR900RR FIREBLADE 1992**



**SUZUKI GSX-R1100 1994**



**KAWASAKI ZX7R 1995**



**KAWASAKI NINJA ZX-12R 2000**



**TRIUMPH DAYTONA 675 2006**



**DUCATI MONSTER 821 2014**

A SPECIAL EDITION OF THE DUCATI 1098S WAS MADE IN THE COLORS OF THE ITALIAN FLAG.



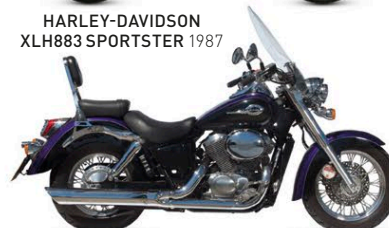
**FRANCIS-BARNETT CRUISER 1933**



**HONDA VF500C MAGNA 1983**



**HARLEY-DAVIDSON XLH883 SPORTSTER 1987**



**HONDA VT 750C2 SHADOW 1998**



**MOTO GUZZI CALIFORNIA EV 2001**



**SUZUKI BOULEVARD M90 2019**



**TRIUMPH AMERICA 2012**



**KIRBY BSA RACING SIDECAR 1968**



**BMW R50 COMBO 1957**

## WARTIME SPACE SAVER

During World War II, the British Army used a lightweight bike that could be dropped by parachute. Named the Welbike, it weighed just 75 lb (34 kg) and fit into a small canister.



**SCOOTER FOLDED INTO CANISTER**



**WELBIKE SCOOTER 1942**



## FIGHTER PLANES

Small, fast, and agile, fighter planes are designed for attacking other aircraft. The first fighters appeared during World War I. Today's planes have highly sophisticated tracking and weapons systems.



SOPWITH PUP



SOPWITH F.1 CAMEL



BRISTOL BULLDOG



P-38 LIGHTNING



MESSERSCHMITT ME262



NIEUPORT 17



FOKKER DR.1



SUPERMARINE SPITFIRE



P-51 MUSTANG



F-86 SABRE



ROYAL AIRCRAFT FACTORY S.E.5A



SOPWITH DOLPHIN



A6M ZERO



YAKOVLEV YAK-9



F-4 PHANTOM II



HAWKER HUNTER

## BOMBERS AND STRIKE AIRCRAFT

The role of these aircraft is to strike ground and sea targets. Heavy bombers carry out long-range strategic missions. Low-flying strike aircraft can attack battlefield targets, such as tanks and troops, with great precision.



ROYAL AIRCRAFT FACTORY B.E.2C



DE HAVILLAND MOSQUITO



B-25 MITCHELL



B-52 STRATOFORTRESS



VICKERS VIMY



AVRO LANCASTER



JUNKERS JU 87B



AVRO 698 VULCAN



A-4 SKYHAWK



B-17 FLYING FORTRESS



VICKERS WELLINGTON X



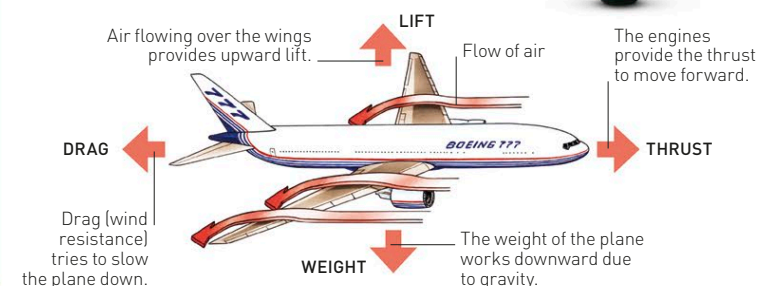
B-58A HUSTLER

# Aircraft

Aviation has come a long way since the first powered aircraft flight took place in 1903. Today, huge planes can carry hundreds of passengers halfway around the world, while supersonic fighter jets can fly faster than the speed of sound.

## HOW PLANES FLY

All airplanes have wings and an engine. In order to fly, a plane must engage in a "tug-of-war" between the forces of lift versus weight, and thrust versus drag.







F-14 TOMCAT



AV-8B HARRIER II



F-35 LIGHTNING II



B-2 SPIRIT



A-10 THUNDERBOLT II



DESIGNED TO BE INVISIBLE TO RADAR, THE NIGHTHAWK WAS THE WORLD'S FIRST "STEALTH" AIRCRAFT.

## PASSENGER PLANES

The first commercial flight took place in 1914, with just one paying passenger. Today's largest airliner, the Airbus A380, can carry up to 853 passengers.



DOUGLAS DC3



LOCKHEED L-1049 G SUPER CONSTELLATION



DE HAVILLAND DH106 COMET 4C



FOKKER F27 FRIENDSHIP



CONCORDE



BOEING 737-800



AIRBUS A380

## PRIVATE AIRCRAFT

A range of light, propeller-driven aircraft are privately flown for both pleasure and transportation. Some business travelers use private, often luxurious jets as air taxis.



BOEING STEARMAN MODEL 75



AUSTER J/1 AUTOCRAT



DH60M GIPSY MOTH



PITTS S1-S



CESSNA F177RG CARDINAL



LEARJET 75

## HELICOPTERS

The rotating blades of helicopters allow them to take off and land vertically, hover, and fly in all directions. These agile aircraft can land in small spaces and reach isolated locations.



BELL JETRANGER



BELL UH-1D IROQUOIS



WESTLAND WS-61 SEA KING



AIRBUS H160



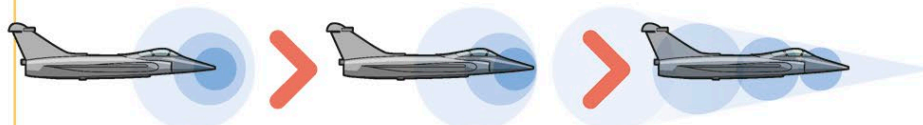
SIKORSKY UH-60 BLACK HAWK



WESTLAND LYNX

## BREAKING THE SOUND BARRIER

Supersonic jets flying faster than the speed of sound create a shock wave called a "sonic boom." To slice through the air at such incredible speed, these planes need a slim body, thin wings, and a sharp nose.



**1 SLOWER THAN SOUND**  
Ordinary planes trail behind their own sounds, so you can hear them coming.

**2 AT THE SPEED OF SOUND**  
As a supersonic plane nears the speed of sound, sound waves bunch together to form a shock wave.

**3 FASTER THAN SOUND**  
Shock waves trail behind the plane, creating a loud sonic boom.

## HOW HELICOPTERS FLY

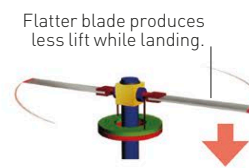
The rotor blades on a helicopter are like spinning plane wings. As each blade rotates, air is forced over its curved surface and pushed down. This produces the upward force called "lift."



Tilted blade produces more lift for takeoff.

### TAKEOFF

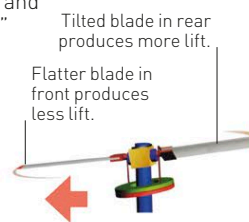
When the lift produced by the tilted blades is greater than the aircraft's weight, the helicopter rises.



Flatter blade produces less lift while landing.

### LANDING

The helicopter descends when the lift produced by the flattened blades is less than the aircraft's weight.



Tilted blade in rear produces more lift.

Flatter blade in front produces less lift.

### STRAIGHT AHEAD

When the rotor is tilted forward, the resulting thrust propels the helicopter forward.



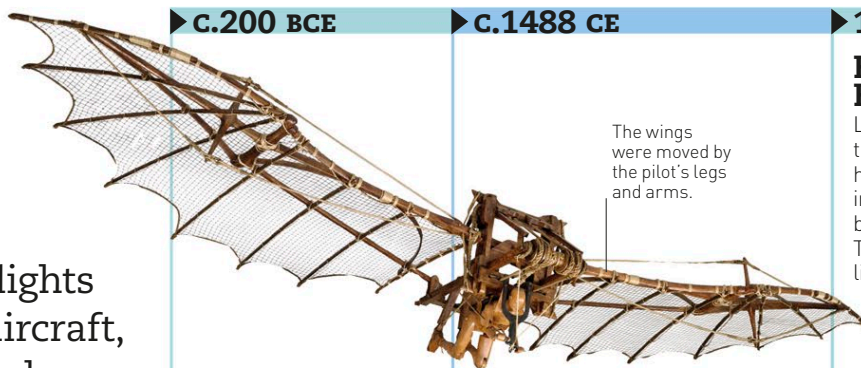
# The story of flight

From the first balloon and glider flights to the launch of a solar-powered aircraft, people have always been fascinated by the idea of flying. The invention of aircraft that can carry people was one of the 20th century's great triumphs and helped shape the modern world.

◀ C.200 BCE

▶ C.1488 CE

▶ 1783



The wings were moved by the pilot's legs and arms.

ORNITHOPTER

## KONGMING LANTERN

The Chinese-invented sky lantern (a hot-air balloon made from paper) was named the Kongming lantern. It was used for signaling between military troops.

## LEONARDO DA VINCI

An ornithopter—a wing-flapping aircraft—was designed by Italian Renaissance artist Leonardo da Vinci. He also sketched flying machines such as helicopters and parachutes (although he did not build them) and studied airflows and streamlined shapes.

## FIRST HUMAN FLIGHT

Lasting about 25 minutes, the first recorded flight by a human took place in France, in a hot-air balloon built by the Montgolfier brothers. The balloon was made of linen lined with paper.



MONTGOLFIER BROTHERS' HOT-AIR BALLOON

◀ 1947

◀ 1944

◀ 1939

◀ 1932

## FIRST SUPERSONIC FLIGHT

US Air Force captain Charles "Chuck" Yeager became the first pilot to travel faster than the speed of sound in the Bell X-1. This rocket-powered aircraft did not take off from the ground but was launched from the belly of a Boeing B-29 at an altitude of 23,000 ft (7,000 m).



GLOSTER METEOR F MK8

## FIRST COMBAT JET

In July, the British Gloster Meteor Mk1 became the world's first operational jet fighter. It was followed closely by Nazi Germany's Messerschmitt Me262s, which began attacking American bombers in October the same year.

## FIRST HELICOPTER FLIGHT

Russian-born Igor Sikorsky made the first flight in his VS-300 helicopter, establishing the single main rotor and smaller tail rotor layout that is now so familiar.

SIKORSKY'S R-4 HELICOPTERS WERE USED IN WORLD WAR II.

## AMELIA EARHART

The first woman to fly solo across the Atlantic, Amelia Earhart faced strong winds and mechanical problems on her 15-hour journey from Newfoundland to Ireland. The flight was made in a bright red Lockheed Vega 5B.



AMELIA EARHART

▶ 1952

▶ 1967

▶ 1969

▶ 1976



DE HAVILLAND DH106 COMET 4C

## FIRST JETLINER

The de Havilland Comet 1, the world's first ever jetliner, entered service. There were 36 passengers on the maiden flight between London and Johannesburg, South Africa. The journey, including stops, took 23 hours, 38 minutes, and the return fare cost \$250.



NORTH AMERICAN X-15

## FASTEST PILOTED AIRCRAFT

An experimental rocket-powered aircraft, the X-15, achieved 4,520 mph (7,273 kph)—nearly seven times the speed of sound. This remains the record for an aircraft with a pilot.

## FIRST SUPERSONIC AIRLINER

Concorde, the world's first supersonic airliner, made its maiden flight. The jet entered service in 1976, with a typical London-to-New-York journey taking just under three and a half hours. However, Concorde's huge operating costs made the price of tickets very expensive.

CONCORDE

## FASTEST JET AIRCRAFT

The Lockheed SR-71 Blackbird set the official air speed record for a jet aircraft with a pilot, with a speed of 2,193 mph (3,530 kph).

SR-71 BLACKBIRD





► 1853

## FIRST HUMAN-CARRYING GLIDER

British engineer Sir George Cayley was the first person to understand the forces acting upon an aircraft wing. In 1853, he transported his coachman across a small valley in what he called a "governable parachute"—the first human-carrying glider.

AS A RESULT OF HIS RESEARCH, GEORGE CAYLEY IS OFTEN CALLED THE "FATHER OF FLIGHT."

► 1896

## OTTO LILIENTHAL

After making over 2,000 glides in weight-shift controlled gliders, German pioneer Otto Lilienthal died in the hospital after his glider stalled and he crashed from a height of 50 ft (15 m). His scientific data on flight inspired many others.



OTTO LILIENTHAL'S HANG-GLIDER

► 1900



1928 ZEPPELIN

## FIRST AIRSHIP

LZ1, the first rigid airship (designed by Ferdinand, Graf von Zeppelin), made its initial flight from a floating hangar on Lake Constance near Friedrichshafen, Germany. Carrying five people, it stayed airborne for 17 minutes.

► 1903

## FIRST POWERED FLIGHT

The first engine-powered airplane flight was achieved by American inventors the Wright brothers. It lasted just 12 seconds and covered 120 ft (36.5 m).



WRIGHT FLYER

► 1909

## FIRST CHANNEL CROSSING

Flying his Type XI monoplane, Frenchman Louis Blériot crossed the English Channel for the first time in a heavier-than-air aircraft. He crash-landed in a field above the cliffs of Dover on the English coast.

◀ 1930

## AMY JOHNSON

The first woman to fly solo from England to Australia made the journey in a Gipsy Moth named "Jason." Having only ever flown from London to Hull in the UK, Amy Johnson made her epic 11,000-mile (18,000-km)-trip in a small, low-powered biplane more suited to club flying.



GIPSY MOTH

◀ 1927

## FIRST TRANSATLANTIC SOLO FLIGHT

American pilot Charles Lindbergh took 33.5 hours to complete the first solo, nonstop, transatlantic flight, traveling from New York to Paris. Flying in a single-engine aircraft, he encountered fog and icy conditions, though his biggest challenge was staying awake for the entire journey.

◀ 1919

## FIRST TRANSATLANTIC FLIGHTS

In May, an NC-4 commanded by Albert C. Read crossed the Atlantic in several stages from Long Island, New York, to Portugal. In June, John Alcock and Arthur Brown flew nonstop from Newfoundland, in Canada, to Ireland.



CURTISS NC-4 FLYING BOAT

◀ 1917

## EUGENE JACQUES BULLARD



## FIRST BLACK COMBAT PILOT

Georgia-born Eugene Jacques Bullard—who was denied entry into the US Army Air Corps because of his race—served throughout World War I in the French Flying Corps. He was awarded the Legion of Honor.

◀ 1910

## FIRST TAKEOFF FROM A SHIP

In November, American flight pioneer Eugene Burton Ely successfully took off from the deck of a ship. Two months later, he made the first successful landing aboard a ship.

FOR PROTECTION, ELY WORE A PADDED LEATHER FOOTBALL HELMET AND A LIFE JACKET MADE FROM PARTS OF BICYCLE TIRES.

► 1988

## HEAVIEST AIRCRAFT

Designed to transport the Soviet Union's 275-ton (250-tonne) *Buran* space shuttle, the six-engine Antonov An-225 set the record for the world's biggest and heaviest aircraft.

THE AN-225 HOLDS THE RECORD FOR AIRLIFTING THE HEAVIEST CARGO.



► 1991



F-117 NIGHTHAWK

## FIRST STEALTH FIGHTER

The American Lockheed F-117 Nighthawk saw its first active service during Operation Just Cause in Panama.

► 2005



AIRBUS A380

## LARGEST MASS-PRODUCED AIRCRAFT

The double-deck, four-engine Airbus A380 was launched. This airliner can transport 853 passengers and can carry enough fuel to fly nonstop from Sydney, Australia, to Dallas, Texas—a distance of 8,577 miles (13,804 km).

► 2017

## LARGEST WINGSPAN AIRCRAFT

America's gigantic Stratolaunch aircraft was designed to carry rockets to the edge of Earth's atmosphere, and then launch them into space. Its wingspan of 385 ft (117 m) is the length of about five tennis courts and the largest of any aircraft that has ever flown.



ANTONOV AN-225

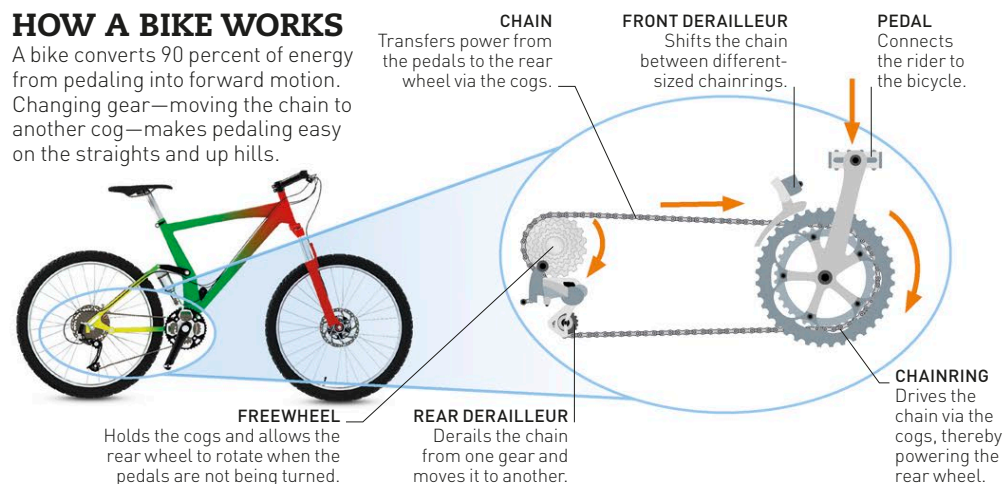


# Bicycles

Millions of people around the world use bicycles as an efficient means of transportation. Cheap to buy, they are easy to run and produce no pollution. Cyclists can select special types of bikes for different terrains or tracks.

## HOW A BIKE WORKS

A bike converts 90 percent of energy from pedaling into forward motion. Changing gear—moving the chain to another cog—makes pedaling easy on the straights and up hills.



## OFF-ROADERS

These hardy bikes are built to withstand tough, off-road conditions. They have a strong frame, knobby tires for extra grip on rough ground, and are usually equipped with a good range of gears.



FAT CHANCE YO EDDY



TREK 6000



TREK 8900 PRO



DMR TRAILSTAR



MARIN PALISADES TRAIL



STUMPJUMPER FSR PRO



ROCKY MOUNTAIN VERTEX TEAM



KONA STAB PRIMO



## SPECIALTY BIKES

Like any great invention, the bicycle has been adapted over the years. Recumbent bikes, for example, allow differently abled people to use them. They enable the cyclist to lean back in a more efficient and comfortable riding position. Tandem cycling is a good way for people of different abilities to ride together.



SINCLAIR C5



WINDCHEETAH SL MARK VI



VELOCAR



KINGCYCLE BEAN



KINGCYCLE



DAWES GALAXY TWIN



## EARLY BIKES

The very first bicycles were wooden and had no brakes. In 1863, the first successful pedal bicycle, the velocipede, appeared. During the 1880s, a chain, rubber tires, and wheels of roughly the same size greatly improved bicycle design.



DANDY HORSE  
1817



MICHAUX VELOCIPEDE (BONESHAKER)  
1869



PENNY FARTHING  
1871



SWIFT SAFETY BICYCLE  
1887



FACILE DWARF SAFETY BICYCLE  
1888

VELOCIPEDES WERE SO BUMPY TO RIDE, THEY WERE CALLED "BONESHAKERS."

Iron-rimmed wheel

Huge front wheel increased speed.

Smaller front wheel than the Penny Farthing made it safer.

## ROAD AND TRACK BIKES

Ideal for speedy cycling on hard, smooth surfaces, road bikes have lightweight frames and narrow tires. Track bikes are built for speed. They usually have just one gear and no brakes—the rider slows down by pushing against the pedals.



ROSSIN TIME TRIAL



WINDCHEETAH CARBON CANTILEVER



CERVELO P5



LOTUS TYPE 108



LITESPEED SIRIUS



ISAAC FORCE



COUGAR



DEDACCIAI STRADA ASSOLUTO



PINARELLO PRINCE



CANNONDALE ST1000



TREK 1000



CORIMA

DURING THE SECOND BOER WAR, TANDEM CYCLES WERE ADAPTED TO BE USED ON RAIL TRACKS WITH 8-PERSON CREWS.



UNICYCLE



SANTANA TRIPLET

Drop handlebars

### BROMPTON FOLDING BICYCLE

Made from more than 1,200 parts, this small-wheeled British bike folds up into a compact, portable package. It is ideal for commuters traveling by train or bus and for people who have limited storage space at home.



#### 1 FOLDED

The bike can be folded in less than 20 seconds and is carried by grasping the saddle or frame.



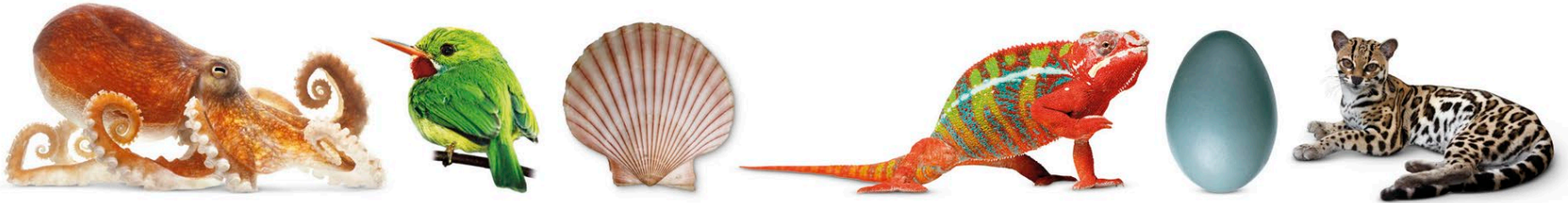
#### 2 UNFOLDED

All models have a full-sized frame, made mainly from steel. The Brompton provides an upright riding position and is designed to be light, agile, and speedy.

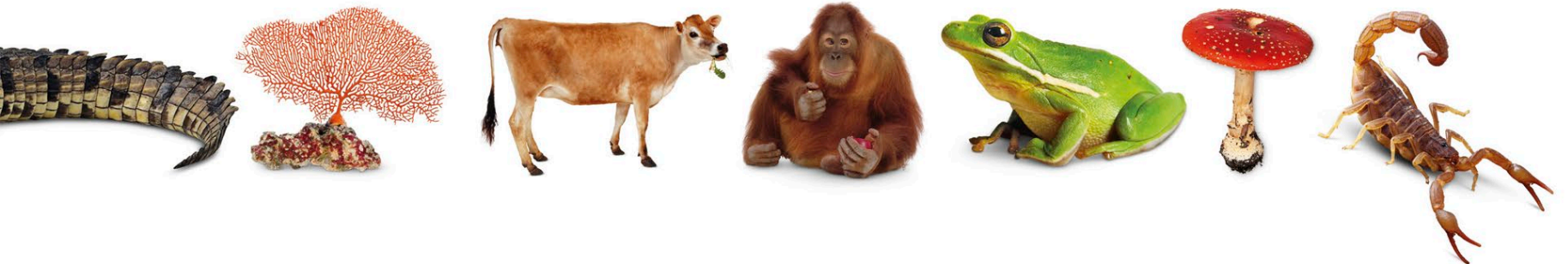




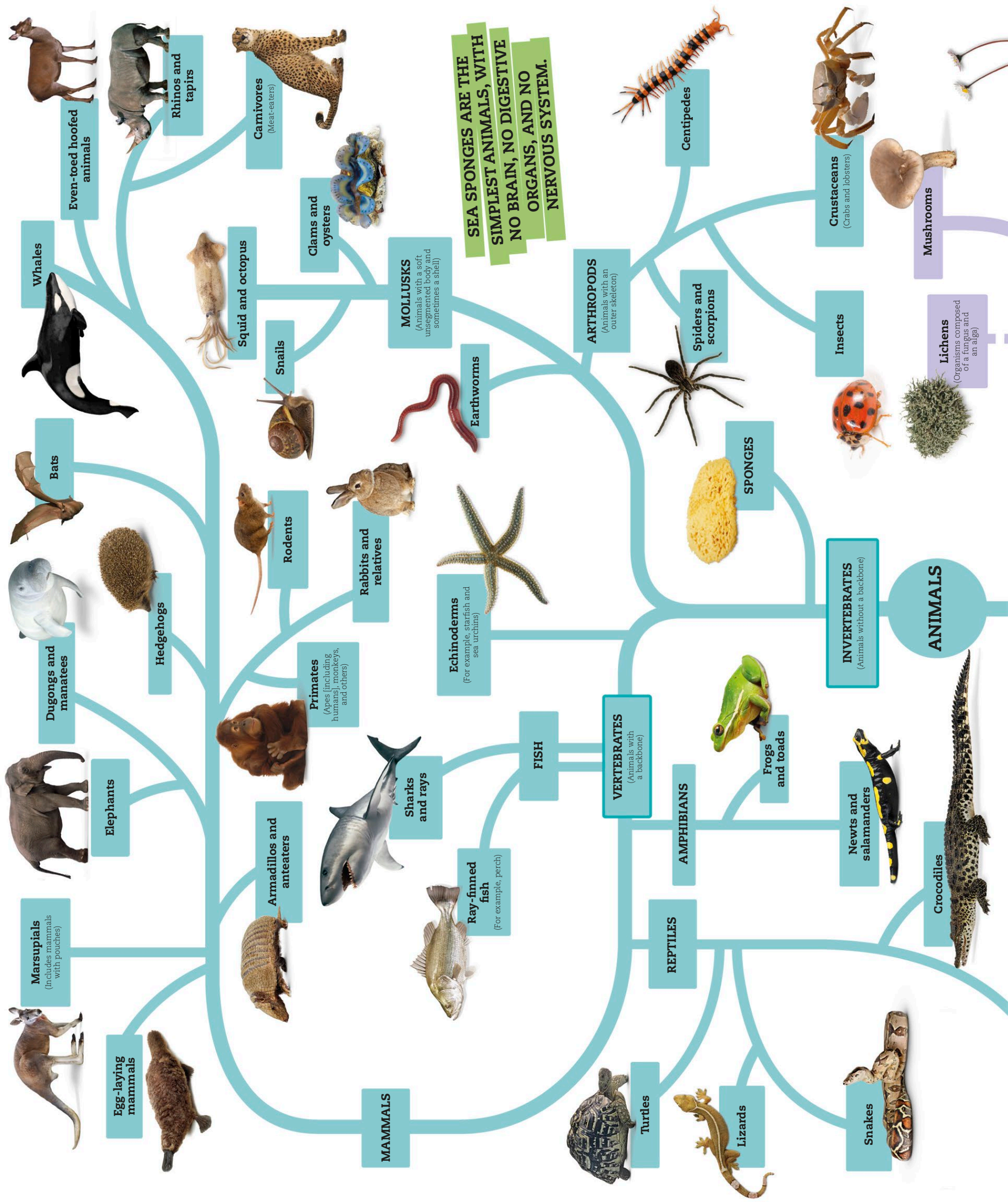




# Nature







SEA SPONGES ARE THE  
SIMPLEST ANIMALS, WITH  
NO BRAIN, NO DIGESTIVE  
ORGANS, AND NO  
NERVOUS SYSTEM.

Lichens  
(Organisms composed  
of a fungus and  
an alga)



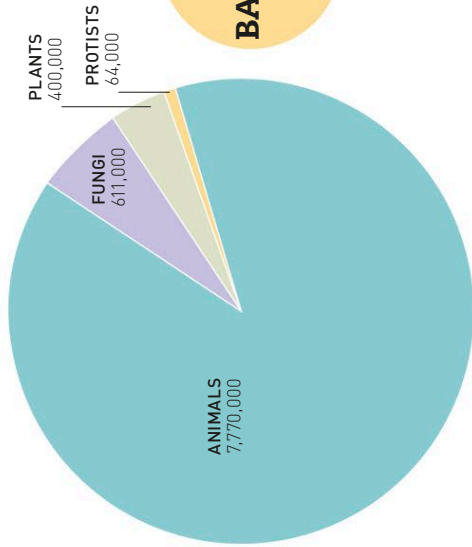
BIRDS



BRANCHING OUT

For well over two centuries, scientists have been using diagrams similar to this one to explain how life evolved. By following the “branches,” we can trace the relationships of the main groups of animals, plants, and fungi to the earliest types of life. Only living species are shown here. Extinct animals, such as most types of dinosaur, are not included.

ESTIMATED NUMBER OF SPECIES



ARCHAEA

BACTERIA

HOW MANY SPECIES

There are far more species of animals than there are of plants, fungi, and protists added together. No one could possibly count up all the bacteria and archaea because there are simply too many millions of them.

Tree of life

The first living things that appeared on Earth, billions of years ago, were tiny organisms made of just one cell. This “tree” shows how such simple beginnings led to the development of the wonderful variety of life we know today.

CLASSIFICATION OF LIFE

Starting with the kingdoms, all living things are arranged, or classified, into further groups according to how they are related. This works in stages: the group called a

phylum is divided into classes, classes are split into orders, and so on. Shown below is how a tiger (scientific name *Panthera tigris*)

is classified. *Panthera* is the name of the genus, and *tigris* is what the species is called.

KINGDOM	PHYLUM	CLASS	ORDER	FAMILY	GENUS	SPECIES
1 ANIMALS Multicelled living things that feed on other organisms. Most are able to move around.	2 CHORDATES Animals with a rodlike structure in their bodies. Includes vertebrates, which have a backbone.	3 MAMMALS Warm-blooded vertebrates with hair whose females feed their young on milk.	4 CARNIVORES Mostly mammals that hunt other animals for food and have special teeth for cutting through meat.	5 CATS Agile, specialized hunters. Many have sheathed toes into which their claws can disappear.	6 BIG CATS The largest and most powerful members of the cat family, including lions, tigers, and leopards.	7 TIGER The largest and heaviest of the forest-dwelling big cats, with distinctively striped fur.



THE SIX KINGDOMS

The tree of life is divided into six main branches, which scientists call kingdoms. Three kingdoms are mainly made up of tiny single-celled organisms. The others are fungi, plants, and animals.

**ARCHAEA**  
Early life, made of one cell. Can live in extreme habitats, such as those that are very hot or salty.

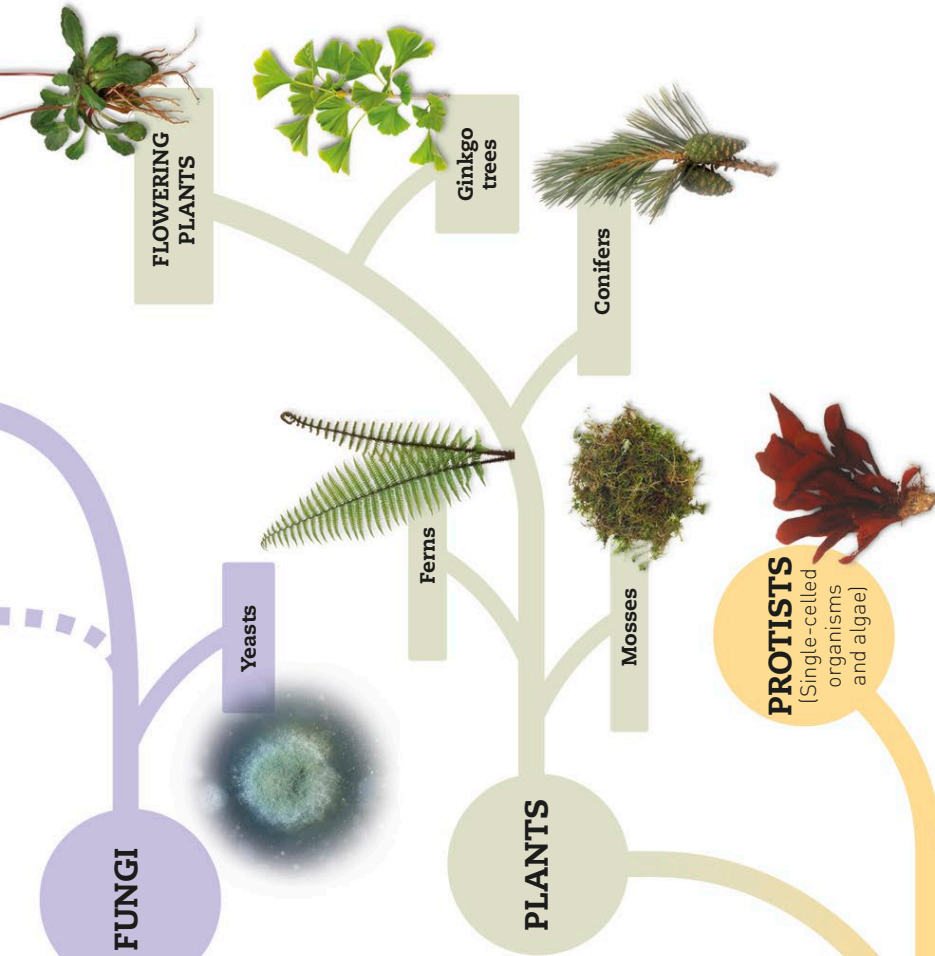
**BACTERIA**  
Cells similar to archaea but not suited to their extreme habitats. Many are vital to life; others cause diseases.

**PROTISTS**  
Single cells with a nucleus. Some make their own food; others must feed on other organisms.

**FUNGI**  
Some are single-celled, but the best known are mushrooms. They break down organic matter.

**PLANTS**  
From tiny mosses to big trees, nearly all plants use sunlight to make food and release oxygen into the air.

**ANIMALS**  
These eat other organisms. Most use their senses for finding food. Some have backbones.





# How life began

The very first life forms appeared on Earth around 3.5 billion (3,500 million) years ago. Fossils preserved in rock help us chart the story of life from the first single-celled bacteria to the modern animals that roam Earth today.

## DIVISION OF TIME

Earth's geological history can be divided into blocks of time. An era represents several hundred million years and is split into smaller periods. Earth is currently in the Quaternary Period of the Cenozoic Era.

- PRECAMBRIAN**  
4.6 BYA–541 MYA
- PALEOZOIC ERA**  
541–252 MYA
- MESOZOIC ERA**  
252–66 MYA
- CENOZOIC ERA**  
66 MYA–PRESENT DAY

BYA = Billion years ago  
MYA = Million years ago

## ▶ 4.6 BYA–541 MYA

### PRECAMBRIAN

This represents 80 percent of total geological time. Volcanic activity on the new Earth produced water. Simple lifeforms appeared, and some produced oxygen.



VOLCANIC EARTH

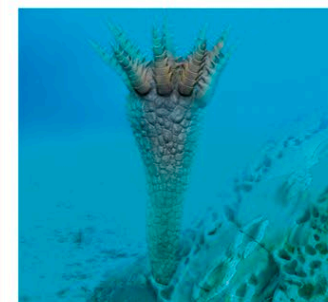
## ▶ 541–485 MYA

### CAMBRIAN

Many types of marine life evolved in the so-called "Cambrian explosion." They included mollusks, sponges, and animals with jointed legs (arthropods).



TRILOBITE



ECHMATOCRINUS

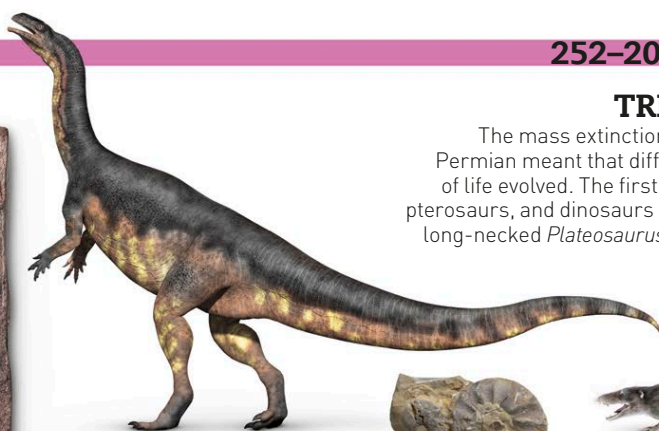
## 252–201 MYA

### TRIASSIC

The mass extinction of the late Permian meant that different types of life evolved. The first mammals, pterosaurs, and dinosaurs such as the long-necked *Plateosaurus* appeared.



DICROIDIUM (PLANT)



PLATEOSAURUS  
(DINOSAUR)



AMMONITE



MORGANUCODON  
(MAMMAL)



EUDIMORPHODON  
(PTEROSAUR)



HEXAGONOCAULON (PLANT)



CRINOID (MARINE ANIMAL)



ROBERTIA  
(THERAPSID)



OLIGOCARPIA  
(FERN)



TUBICAILIS  
(FERN)



SCUTOSAURUS  
(REPTILE)



AMMONITE

## ▶ 201–145 MYA

### JURASSIC

Reptiles began to dominate the land and sea, and some took to the air. Different dinosaurs roamed Earth, from giant plant-eaters to fierce predators. Some began to fly. They were the first birds.



PTERODACTYLUS (PTEROSAUR)



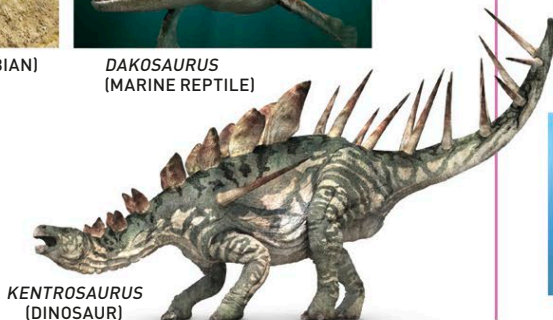
EOCAECILIA (AMPHIBIAN)



DAKOSAURUS  
(MARINE REPTILE)



WILLIAMSONIA  
(PLANT)



KENTROSAURUS  
(DINOSAUR)

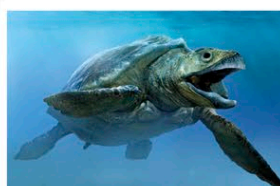
## ▶ 145–66 MYA

### CRETACEOUS

The climate was mostly warm, but cooled toward the end of the period. Flowering plants spread. The period ended with a mass extinction that killed 75 percent of species.



VEGAVIS (BIRD)



PROTOSTEGA (TURTLE)



CONFUCIUSORNIS  
(BIRD)



HOPLOPTERYX (FISH)



SCAPHITES (AMMONITE)



ARCHAEANTHUS  
(PLANT)



ARCHELON  
(TURTLE)



CARCHARODONTOSAURUS  
(DINOSAUR)



EOMAIA (MAMMAL)



## 485–443 MYA

### ORDOVICIAN

The first fish appeared, such as the scaly, jawless *Astraspis*. Mollusks and corals dominated the oceans. The period ended with mass extinctions.



SPONGE



MARRELLA



HALLUCIGENIA



BRACHIOPOD (SHELL)



SEA MAT



TRILOBITE



FALSE MUSSEL



ASTRASPIS (FISH)

## 443–419 MYA

### SILURIAN

Plants, such as the leafless *Cooksonia*, grew on land. In the seas, there were more fish, and spiny animals called echinoderms thrived. Early arthropods began to leave the oceans for land.



COOKSONIA (PLANT)



CORAL



ECHINODERM



LOGANELLIA (FISH)

## 419–358 MYA

### DEVONIAN

Many new types of fish evolved, such as the *Tiktaalik*. This was a lobe-finned fish belonging to the group from which the amphibians eventually evolved.



SOLICLYMENIA (AMMONITE)



STENACANTHUS (SHARK)



TIKTAALIK (FISH)



DISCALIS (PLANT)

## 298–252 MYA

### PERMIAN

The hot, dry conditions of this period favored cold-blooded animals like *Eothyris*. At the end of this period, a catastrophic mass extinction wiped out 70 percent of land species and 90 percent of marine life.



EOTHYRIS (SYNAPSID)



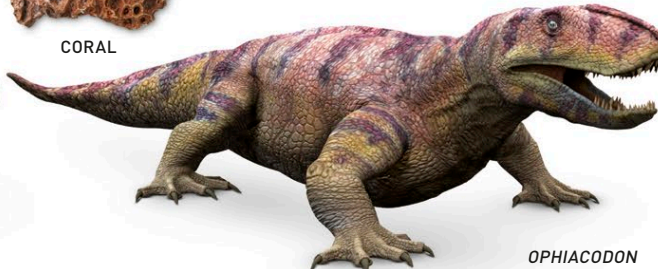
ECHINODERM



CORAL



SPINOAEQUALIS (REPTILE)



OPHIACODON (SYNAPSID)

## 358–298 MYA

### CARBONIFEROUS

As lush swamp forests grew, life on Earth flourished. Reptiles such as *Spinoaequalis* and synapsids (mammal ancestors) such as *Ophiacodon* evolved.



ODONTOPTERIS (FERN)



CLUB MOSS



AMPHIBAMUS (AMPHIBIAN)



COCKROACH

## 66–23 MYA

### PALEOGENE

With all the dinosaurs extinct apart from the birds, the surviving mammals evolved rapidly. Most of the main groups of mammals had their beginnings in this period.



AMMONITE



OSMUNDA (FERN)



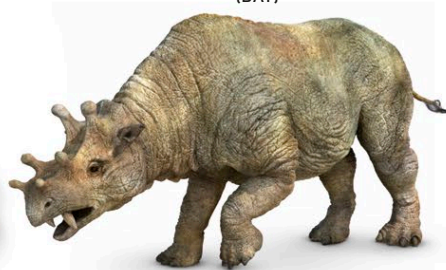
ROTULARIA (WORMS)



CHAMA AND XENOPHORA (MOLLUSKS)



ICARONYCTERIS (BAT)



UINTATHERIUM (MAMMAL)

## 23–2 MYA

### NEOGENE

The ancestors of modern humans evolved in this era. Familiar types of mammals, such as kangaroos and giraffes, appeared.



THYLACOSMILUS (MAMMAL)



CARCHARODON (SHARK)

## 2 MYA–PRESENT DAY

### QUATERNARY

Ice ages with warmer phases in between have dominated the last 2 million years. Modern humans (*Homo sapiens*) arose in eastern Africa and spread across the world.



NEPTUNEA (SEA SNAIL)



HUMAN ANCESTOR

MAMMOTH

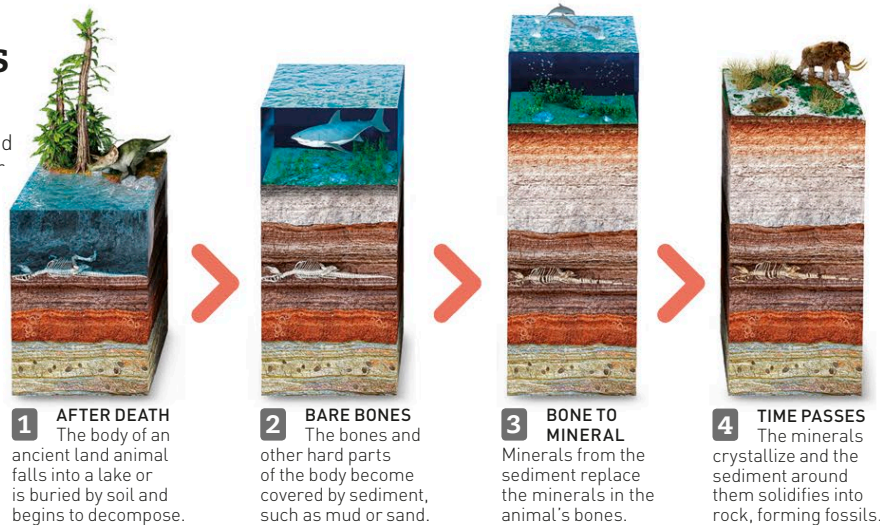


# Fossils

Fossils are clues preserved in rocks, amber (tree resin), tar, or ice. They show us what plants and animals looked like thousands or millions of years ago and can sometimes tell us where and how they lived.

## HOW FOSSILS FORM

Fossils form when a plant or animal is buried quickly and deeply after it dies. The sediment that surrounds the animal gradually turns its body into rock over thousands of years. This is called fossilization.



## PLANTS

Fossil plants are usually fossils of parts of the plant rather than the whole thing. They include leaves, flowers, cones, bark, and wood.



CALCIFIED ALGA STEM



LIQUIDAMBAR LEAF



SEED FERN LEAFLETS



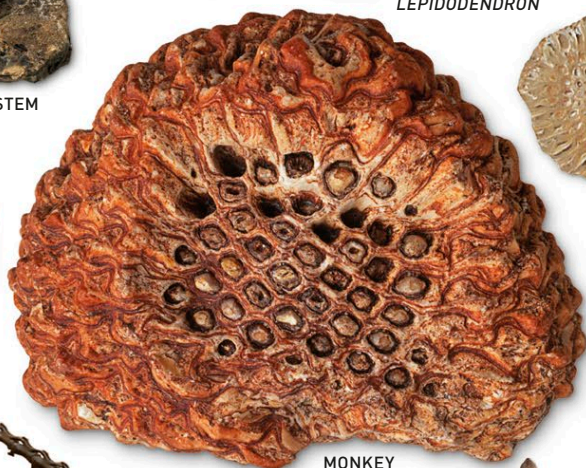
LEPIDODENDRON



TREE TRUNK



CONE



MONKEY PUZZLE CONE FRAGMENT



PTERIDOSPERM SEEDS



PECOETERIS MILTONI FROND



TECTOCARYA SEEDS

## INVERTEBRATES

Fossils of animals without backbones have been found in large numbers and from a wide range of animal types.



BRYOZOAN



AMMONITE



HORN CORAL



ACTINOCYATHUS CORAL



LITHOSTROTION CORAL



SEA PEN



SPIDER TRAPPED IN AMBER



BRAIN CORAL



TRILOBITE



COCKROACH



CLAM SHELL



SEA LILY



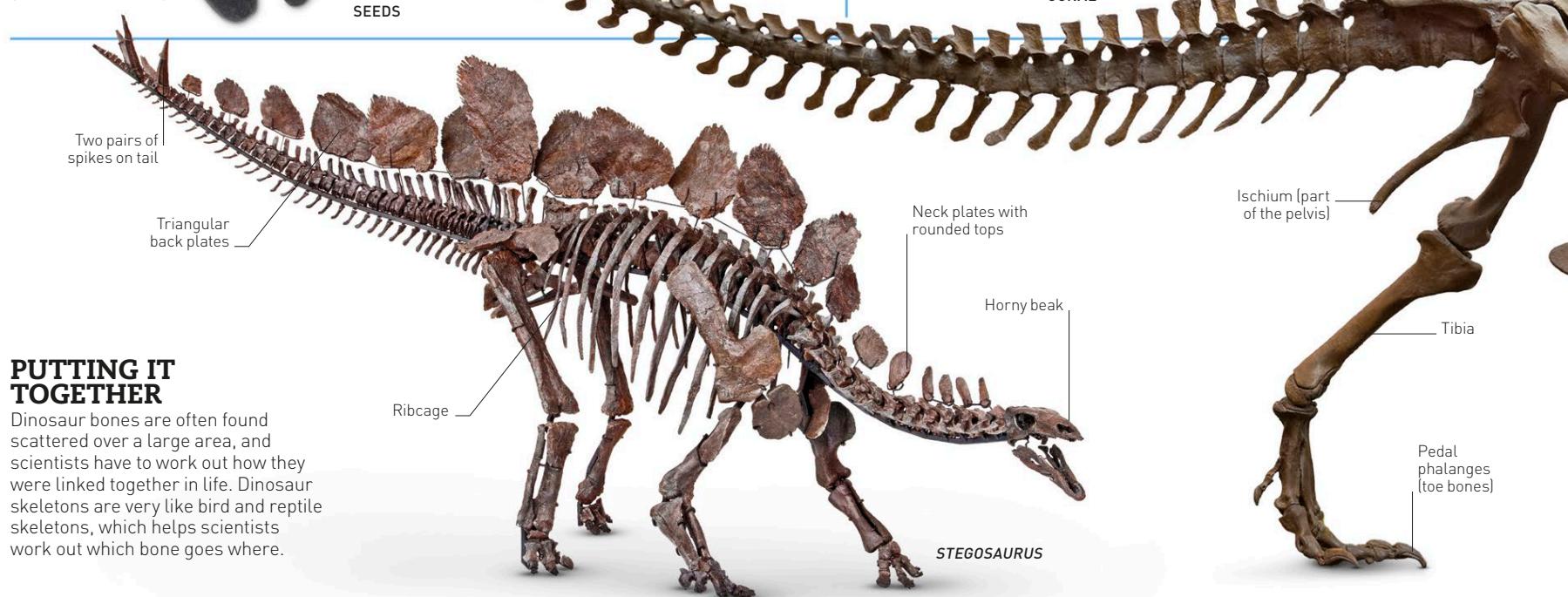
LACE CORAL



SEA SNAIL SHELL



HEART URCHIN



## PUTTING IT TOGETHER

Dinosaur bones are often found scattered over a large area, and scientists have to work out how they were linked together in life. Dinosaur skeletons are very like bird and reptile skeletons, which helps scientists work out which bone goes where.





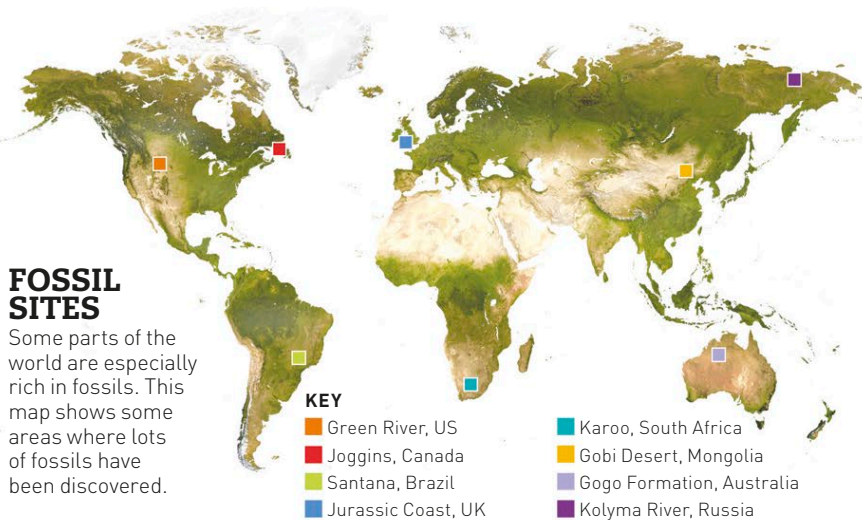
**5 SURFACE EROSION**  
Fossilized remains of creatures begin to be revealed as the land is eroded slowly over thousands of years.



**6 EXCAVATION**  
Fossils are excavated by being carefully freed from the rock that has long surrounded them.

## FOSSIL SITES

Some parts of the world are especially rich in fossils. This map shows some areas where lots of fossils have been discovered.



## FOSSIL TYPES

Fossils may be formed from the remains of plants or animals or from traces of their activities during life.



### TRACE FOSSIL

These are fossils showing animal activity, such as footprints, burrows, or nests.



### IMPRESSIONS

These are fossils where the animal or plant body has decayed completely but left an impression in the sediment.



### PETRIFICATION

This type of fossil is formed when minerals crystallize inside the body cells, preserving them in stone.



### NATURAL CAST

In cast fossils, sediment hardens in natural gaps inside an animal, such as the inside of a shell.

## VERTEBRATES

Fossils of vertebrate animals are some of the most exciting fossils ever found. They reveal species—such as dinosaurs and flying reptiles—that existed millions of years ago.



PARADOXIDES (TRILOBITE)



CONSTELLARIA



AMMONITE



REMAINS OF HOMOEOSAURUS



RAY-FINNED BONY FISH



DINOSAUR VERTEBRA



DINOSAUR VERTEBRA



PLIOSAUR SKULL



SYNAPSID SKULL



SHARK TOOTH



JAW OF THECODONTOSAURUS



FOOT SKELETON OF PLATEOSAURUS



UPPER CHEEK TOOTH OF A MAMMOTH



GALLIMIMUS SKULL



PANTHERA LOWER JAW



EARLY FROG



OVIPTOR PHILOCERATOPS EGG



THUMB CLAW OF BARYONYX



Cervical vertebrae

Manual phalanges (finger bones)

Mandible (jaw bone)

Ribcage

Very long tail

Long, powerful legs

Long, thin hand claws

TYRANNOSAURUS REX

STRUTHIOMIMUS

Very long tail

Strong hindlegs

Flexible neck

Long front teeth

Three-fingered forelimbs

ORNITHOLESTES

**DINOSAUR FOSSILS HAVE BEEN DISCOVERED ON EVERY CONTINENT, INCLUDING ANTARCTICA.**

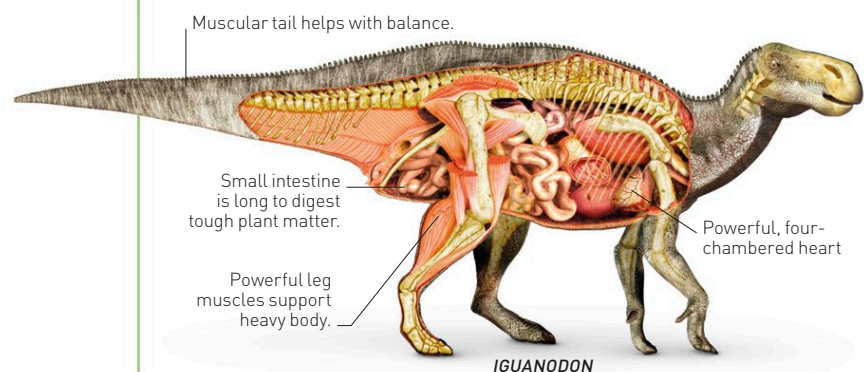


# Plant-eating dinosaurs

Plant-eating dinosaurs roamed Earth for more than 140 million years. There were many different kinds, and they included some of the largest land creatures the world has ever seen.

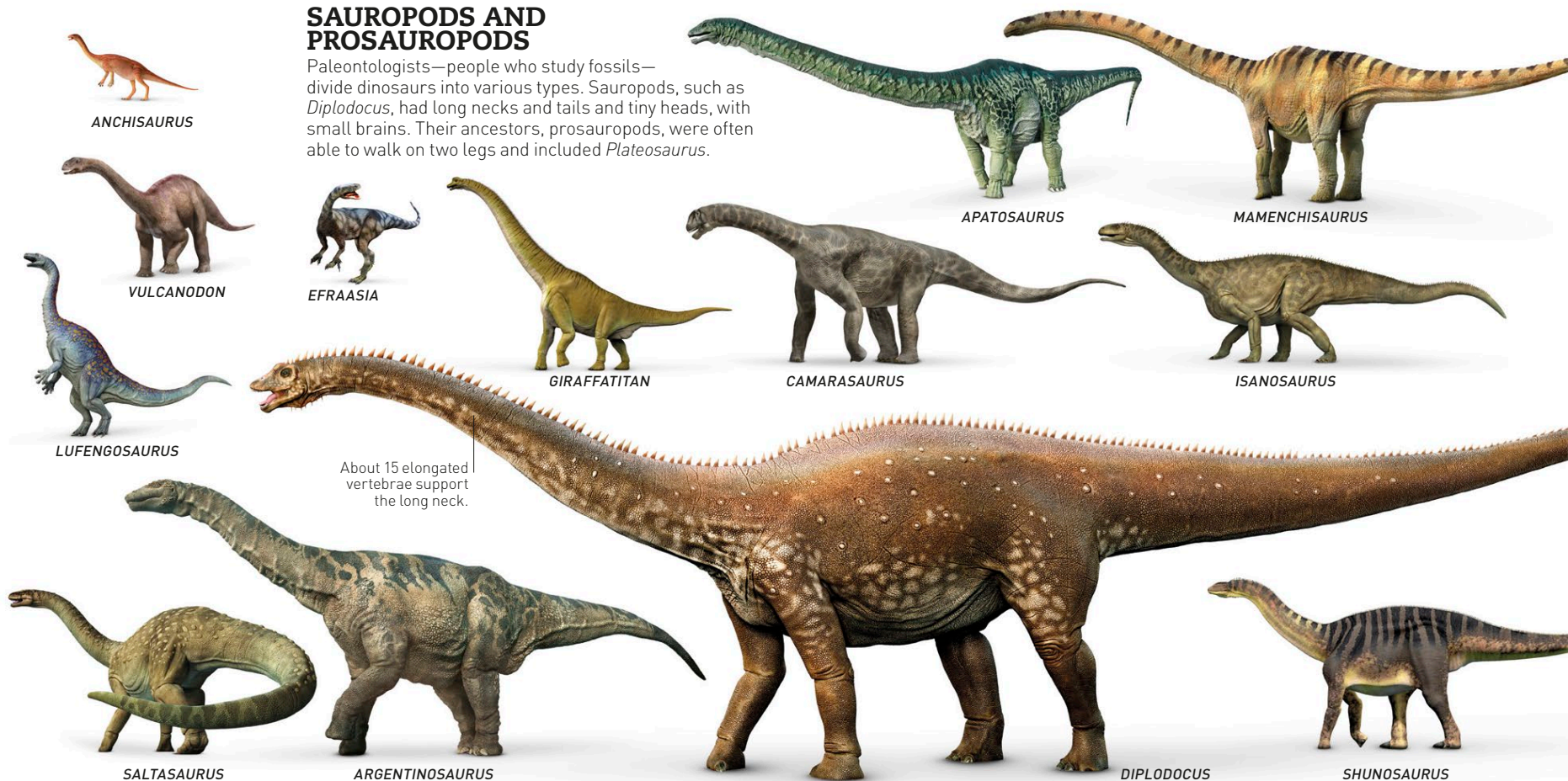
## HERBIVORE ANATOMY

Many herbivorous (plant-eating) dinosaurs were quadrupeds—they walked on all fours. The largest herbivores had powerful muscles and strong bones to support their weight. Their digestive systems were adapted for eating plants, which are more difficult to digest than meat.



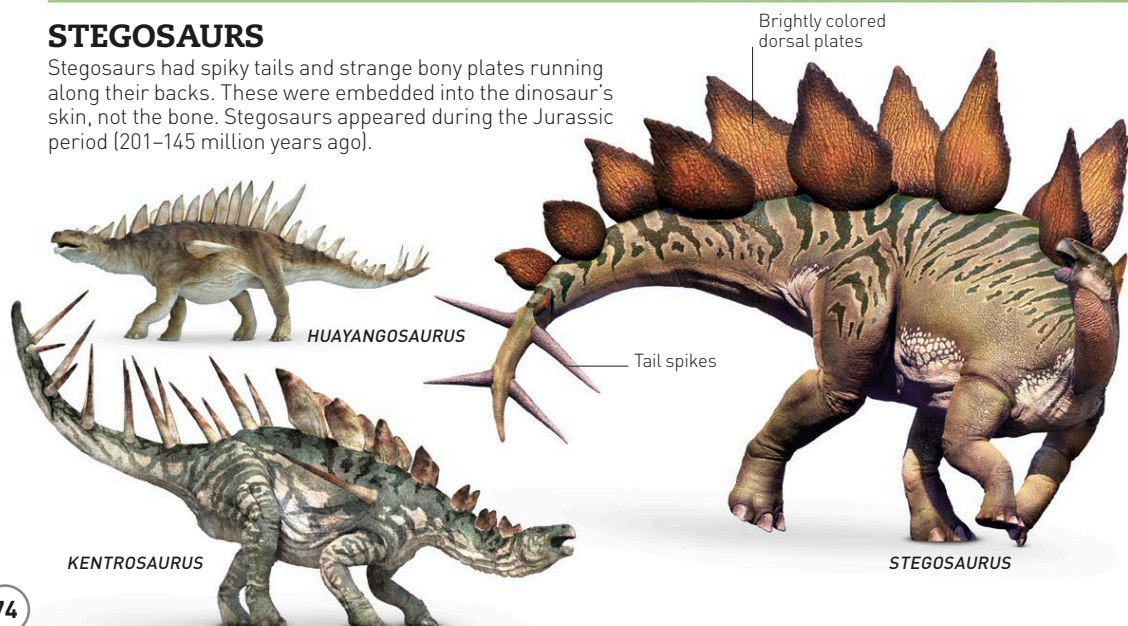
## SAUROPODS AND PROSAUROPODS

Paleontologists—people who study fossils—divide dinosaurs into various types. Sauropods, such as *Diplodocus*, had long necks and tails and tiny heads, with small brains. Their ancestors, prosauropods, were often able to walk on two legs and included *Plateosaurus*.



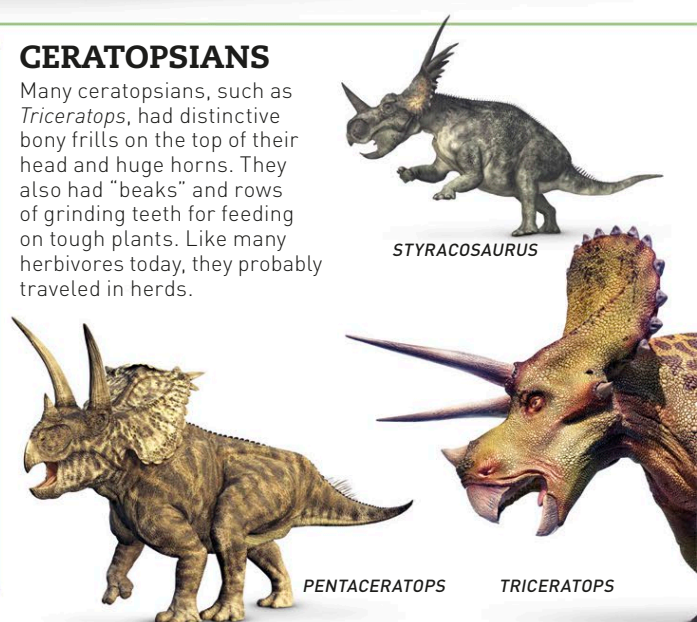
## STEGOSAURS

Stegosaurs had spiky tails and strange bony plates running along their backs. These were embedded into the dinosaur's skin, not the bone. Stegosaurs appeared during the Jurassic period (201–145 million years ago).



## CERATOPSAINS

Many ceratopsians, such as *Triceratops*, had distinctive bony frills on the top of their head and huge horns. They also had "beaks" and rows of grinding teeth for feeding on tough plants. Like many herbivores today, they probably traveled in herds.





## SELF-DEFENSE

Even the largest plant-eating dinosaurs risked being hunted and killed by meat-eating dinosaurs. Over time, herbivores developed specialized body defenses for survival. These included horns, spikes, spines, and heavy tails that could inflict terrible injuries.



### BONY PLATES

Covering the head of *Euoplocephalus*, these bony plates provided protection against the jaws and teeth of meat-eating dinosaurs.



### SPINY SKULL

A thick skull topped with spines protected a *Sauropelta's* vulnerable brain.



### TAIL CLUB

Some plant-eaters, particularly ankylosaurs, had heavy, clublike tails made of fused bone that could break a predator's leg.



### SPIKY TAIL

*Stegosaurus* had very sharp spikes on the end of its tail that could inflict terrible injuries on an opponent.



### SHARP HORNS

Huge plant-eater *Triceratops* had extremely long, sharp horns, which it used to fight off predators, such as the giant meat-eating *Tyrannosaurus*.



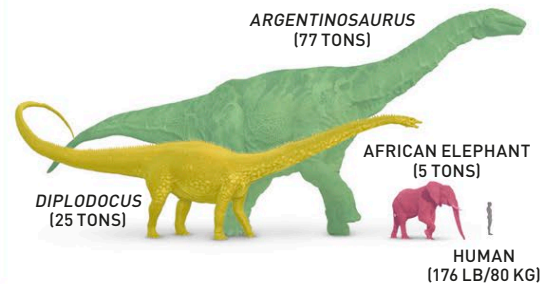
### SHEER SIZE

Giant sauropods were dangerous targets, because attackers risked being crushed beneath their feet.

**THE HORNS OF TRICERATOPS WERE AN AMAZING 3 FT (1 M) IN LENGTH.**

## HEAVYWEIGHTS

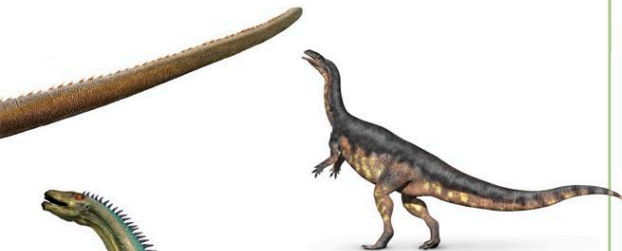
Like elephants, ostriches, and crocodiles, dinosaurs were vertebrates: they had an internal skeleton with a backbone to support their bodies. Many, though, were much heavier. At 77 tons, *Argentinosaurus* was 15 times heavier than an elephant.



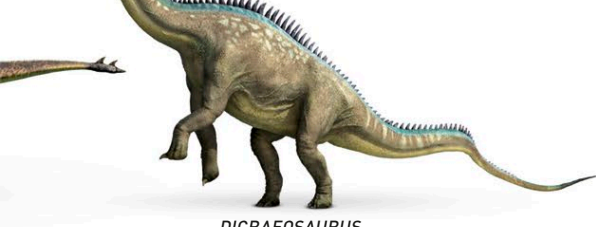
TITANOSAURUS



BARAPASAURUS



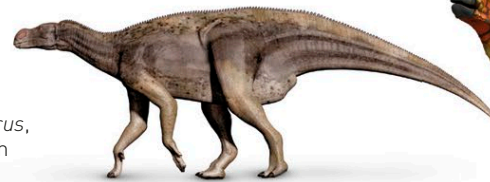
PLATEOSAURUS



DICRAEOSAURUS

## ORNITHOPODS

Ornithopods, including *Iguanodon*, lived 145–66 million years ago. They could stand on two legs to reach into trees and could chew plants very efficiently. *Corythosaurus*, for instance, had hundreds of teeth for grinding plants.



MUTTABURRASAUURUS



LESOTHOOSAURUS



LEAELLYNASAUURA



HETERODONTOSAURUS



DRYOSAURUS



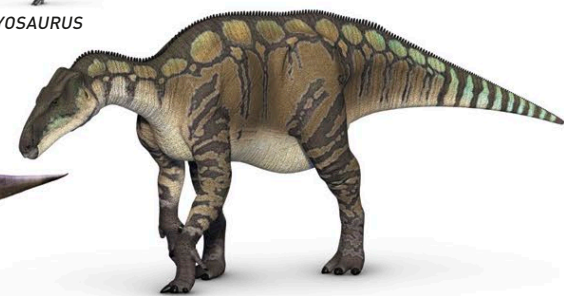
CORYTHOSAURUS



EDMONTOSAURUS



PARASAUROLOPHUS



IGUANODON



TENONTOSAURUS



MAIASAURA

## ANKYLOSAURS

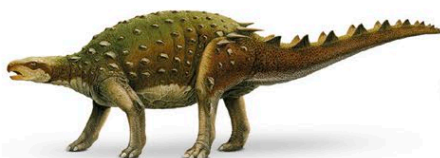
Looking similar to prehistoric armored tanks or armadillos, ankylosaurs had bony plates over their head and shoulders to protect them from predators. They had short, thick legs to support their heavy bodies.



PSITTACOSAURUS



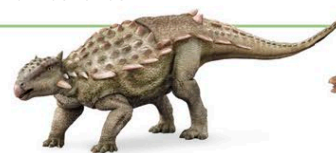
PROTOCERATOPS



MINMI



EUOPOLOCEPHALUS



GARGOYLEOSAURUS



GASTONIA



SAUROPELTA



ANKYLOSAURUS



EDMONTONIA



# Meat-eating dinosaurs

Dinosaurs evolved about 245 million years ago. They spread to every continent and dominated the land for millions of years before most of them died out at the end of the Cretaceous Period. Many were powerful predators, with bodies built for attack.

## THEROPODS

All carnivorous (meat-eating) dinosaurs belong to a group called theropods. The word "theropod" means "beast-footed." Theropods moved on their hindlegs and ranged in size from huge carnivores such as *Allosaurus* to the smaller feathery *Citipati*.

## CARNIVORE ANATOMY

The biggest predators such as this *Tyrannosaurus rex* were formidable hunters, able to bring down giant plant-eating dinosaurs. Smaller ones were fast and agile and could catch swift-moving prey. We may never know what dinosaurs really looked like, but we can imagine based on fossil evidence. This *T. rex* may have had more feathers on its back!

Fearsome jaws for ripping flesh

Heart

*Tyrannosaurus* had tiny but strong arms.

Powerful thigh muscles

Short digestive tract relies on powerful stomach acids to break down meat.

TYRANNOSAURUS REX

SUCHOMIMUS

EO RAPTOR

SINOSAUROPTERYX

GUANLONG

VELOCIRAPTOR

CAUDIPTERYX

GALLIMIMUS

The sail-shaped structure was made up of spines that were nearly 6½ ft (2 m) tall.

Tail helped balance *Gallimimus* when it ran.

CERATOSAURUS

SPINOSAURUS

BOMBING RAIDS ON MUNICH, GERMANY, DURING WORLD WAR II DESTROYED MANY SPINOSAURUS FOSSILS HOUSED AT THE CITY'S PALEONTOLOGICAL MUSEUM.

COELOPHYSIS

TROODON

BARYONYX

CITIPATI

DEINONYCHUS

MONOLOPHOSAURUS

GASOSAURUS

AUCASAURUS

LILIENSTERNUS

CRYOLOPHOSAURUS

IRRITATOR



## DIET

These dinosaurs were the most powerful predators on land. They fed on insects, fish, and small mammals, plus birds and other dinosaurs.



**INSECTS**  
Insects evolved more than 350 million years ago.



**FISH**  
Oceans and rivers teemed with fish.



**DINOSAURS**  
Plant-eating dinosaurs were prey.



**EARLY MAMMALS**  
Rodentlike mammals existed with dinosaurs.



**EARLY BIRDS**  
Birds evolved from small predatory dinosaurs.

## TEETH

Scientists can learn a lot about dinosaurs from their fossilized jaws and teeth. Their size, shape, and strength shows what the dinosaurs ate and can even reveal how they hunted their prey.



**KNIFELIKE**  
Typical hunters like *Allosaurus* had sharp teeth that they used to slice meat from the bone.



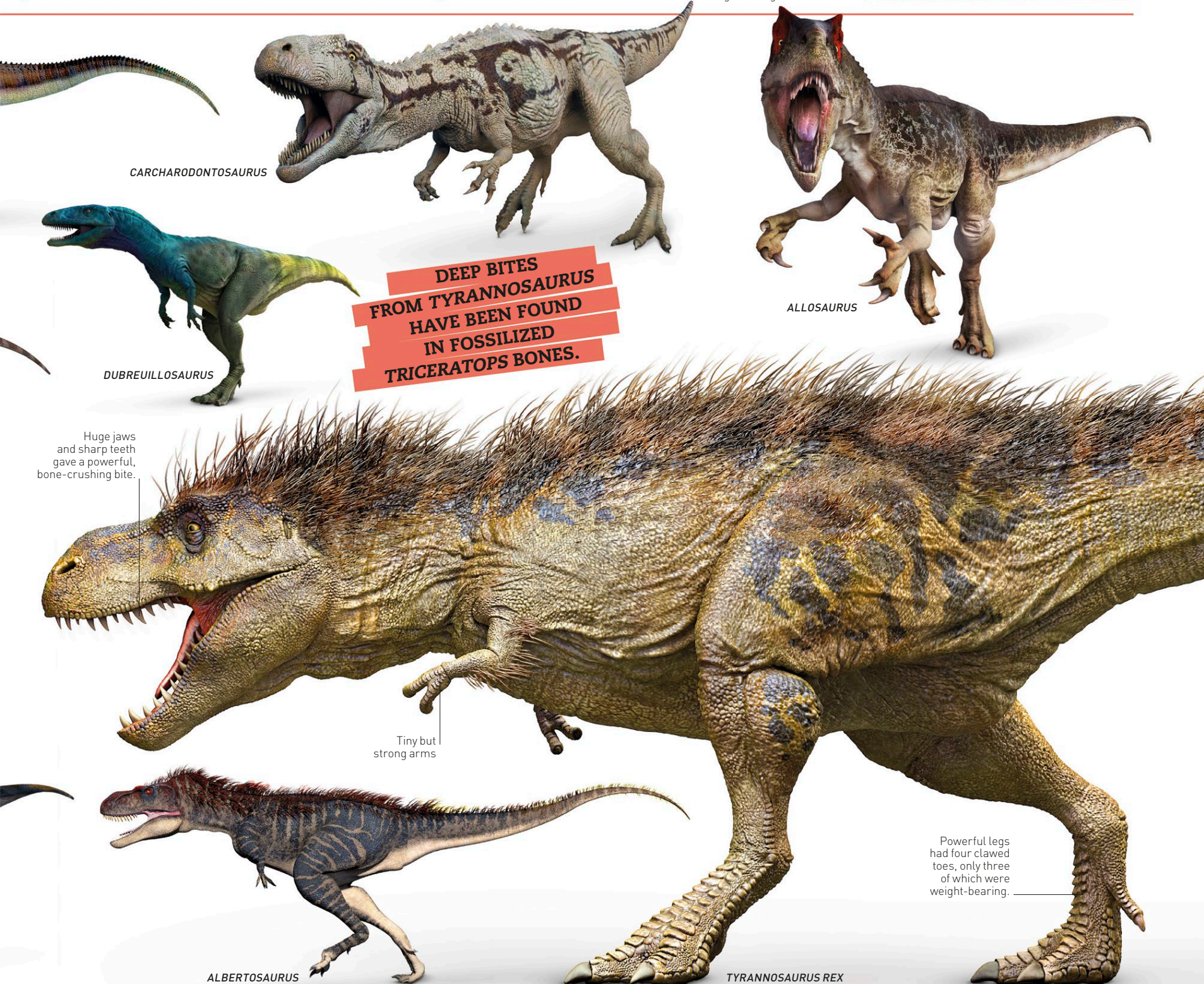
**SHARP POINTS**  
*Baryonyx* and other fish-eaters had pointed needlelike teeth for piercing fish skin.



**CRUSHING BONES**  
The large teeth of *Tyrannosaurus* could bite straight through bone.

## PACK HUNTING

Evidence from fossilized footprints suggests that some dinosaurs such as these *Deinonychus* may have hunted in packs to bring down big plant-eaters like *Tenontosaurus*. But if so, they probably did not plan their attack like modern pack hunters.



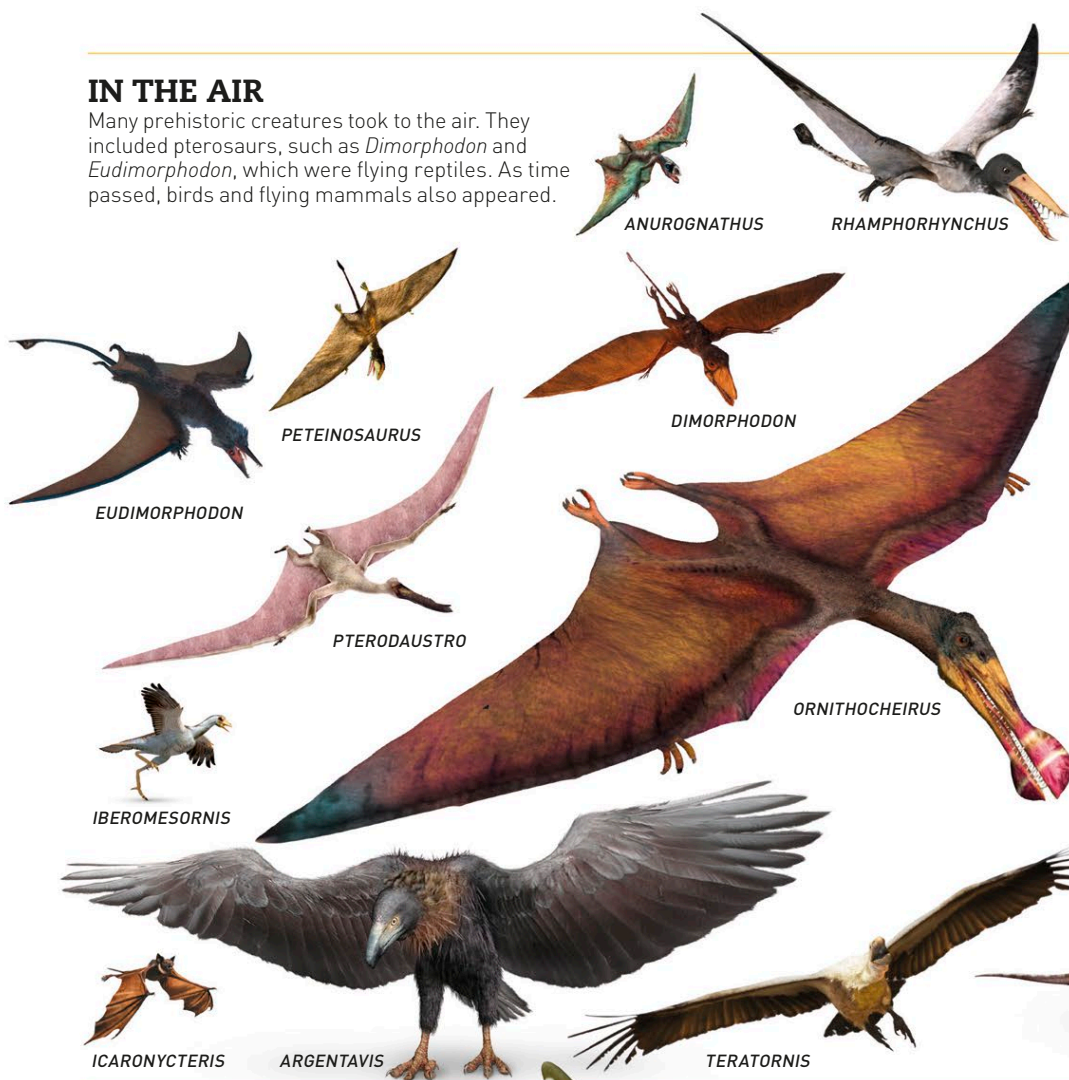


# Prehistoric animals

The first signs of life appeared more than 3.5 billion years ago, when tiny single-celled organisms evolved in the oceans. Over millions of years, other organisms evolved, moved on to land, and even took to the air.

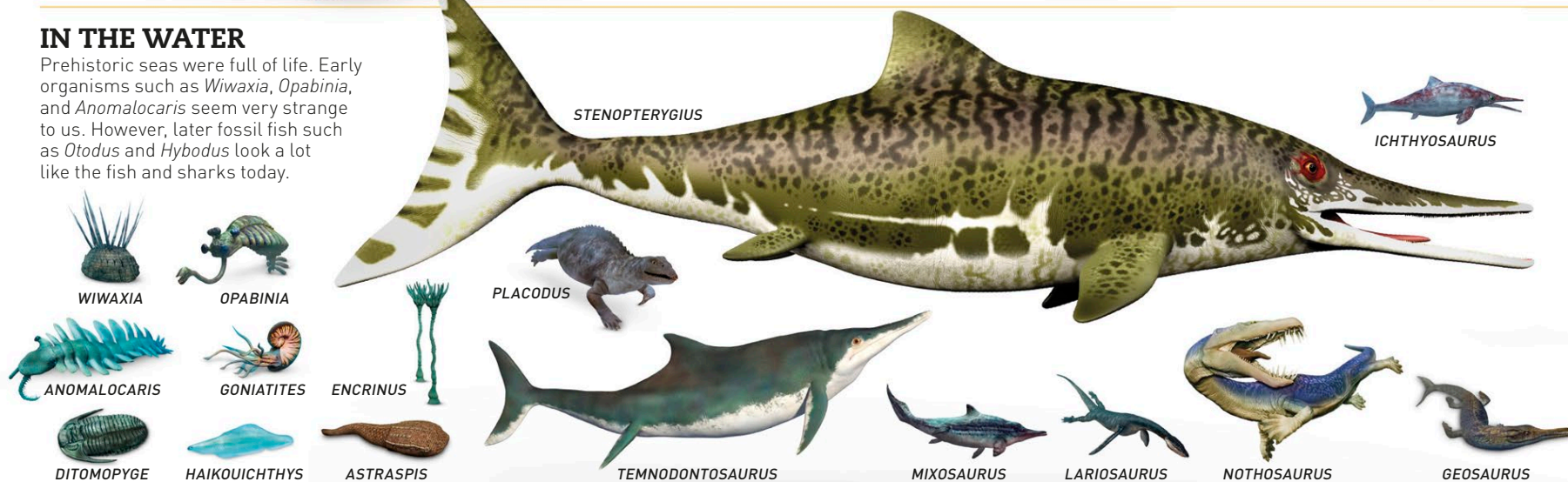
## IN THE AIR

Many prehistoric creatures took to the air. They included pterosaurs, such as *Dimorphodon* and *Eudimorphodon*, which were flying reptiles. As time passed, birds and flying mammals also appeared.



## IN THE WATER

Prehistoric seas were full of life. Early organisms such as *Wiwaxia*, *Opabinia*, and *Anomalocaris* seem very strange to us. However, later fossil fish such as *Otodus* and *Hybodus* look a lot like the fish and sharks today.



## TYPES OF PREHISTORIC ANIMAL

We use the term "prehistoric" for creatures that existed before recorded history. They were very diverse. The dinosaurs are probably the best known and most familiar, but there were also invertebrates (animals without backbones), fish, amphibians, reptiles, and mammals.

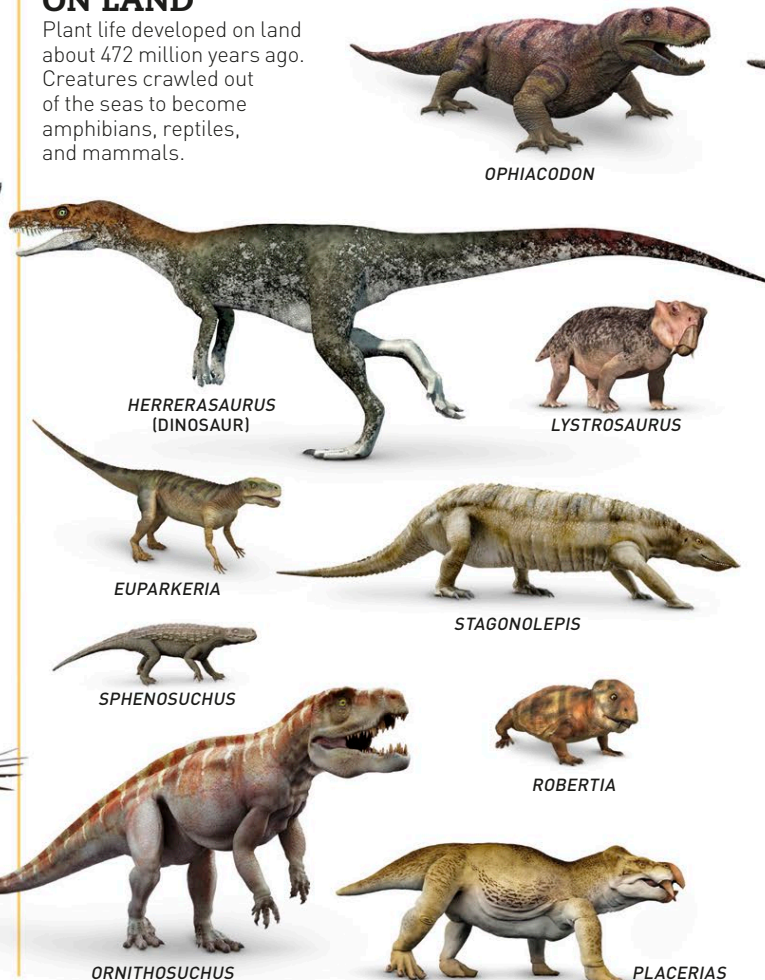


**INVERTEBRATES**  
This squidlike belemnite lived in the prehistoric oceans some 200 million years ago.

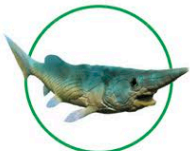
**SCIENTISTS THINK A MASSIVE ASTEROID STRIKE CAUSED A MASS EXTINCTION OF PREHISTORIC ANIMALS 66 MILLION YEARS AGO.**

## ON LAND

Plant life developed on land about 472 million years ago. Creatures crawled out of the seas to become amphibians, reptiles, and mammals.







#### FISH

The very first vertebrates (animals with backbones) to evolve were fish.



#### REPTILES

The earliest reptiles evolved from amphibians about 315 million years ago. They had scaly skin.



#### AMPHIBIANS

Like frogs today, prehistoric amphibians could breathe air but bred in fresh water.

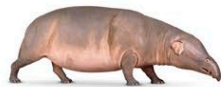


#### MAMMALS

The first mammals appeared on Earth about 220 million years ago.

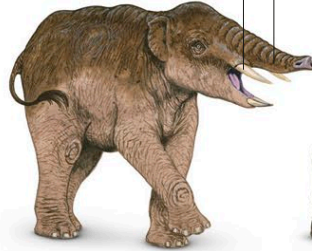
## TRANSITION TO MODERN ANIMALS

About 66 million years ago, a huge catastrophe wiped out many prehistoric creatures. Birds and some mammals survived. Later, new animals emerged, including the ancestors of the mammals we know today.



#### MOERITHERIUM

This pig-sized relative of the elephant family lived in African swamps and woodlands more than 35 million years ago.



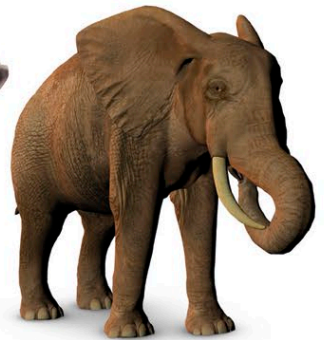
#### PHIOMIA

Appeared around 35 million years ago. Like modern elephants, it had air-filled spaces in its skull to reduce its weight.



#### DEINOTHERIUM

Standing 14.8 ft (4.5 m) high, *Deinotherium* roamed Africa, Asia, and Europe around 24 million years ago.



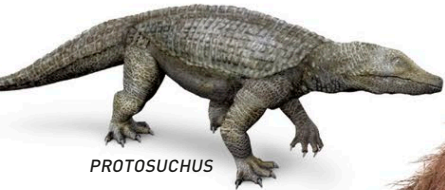
#### ELEPHANT

The modern elephant, the largest living land animal, has features in common with its prehistoric ancestors, including its trunk.

Short tapir-like trunk

Tusks for digging up vegetation

Unlike modern elephants, curved tusks point downward.



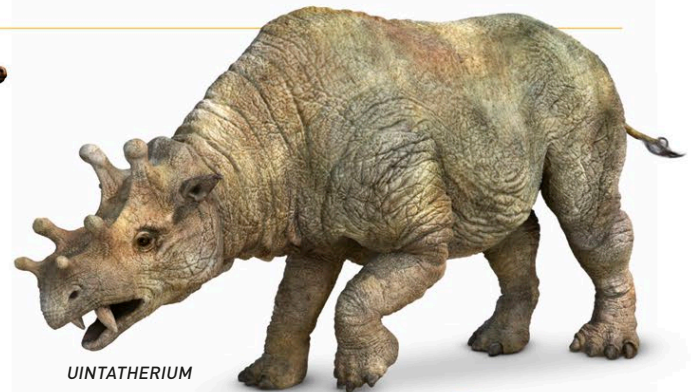
PROTOSUCHUS



PLIOHIPPIUS



NEMEGTBAATAR



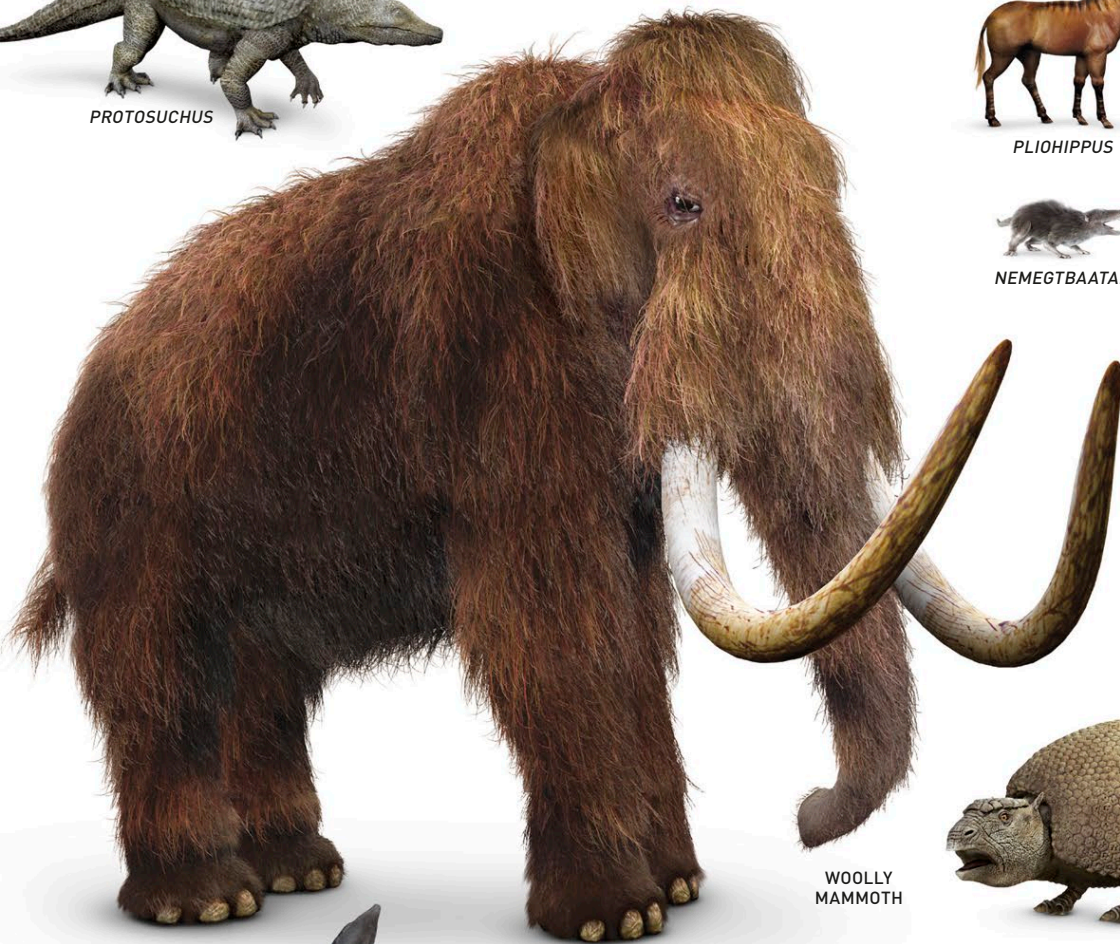
UINTATHERIUM



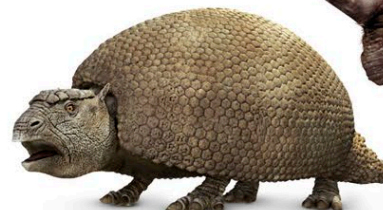
DIRE WOLF



SMILODON



WOOLLY MAMMOTH



GLYPTODON



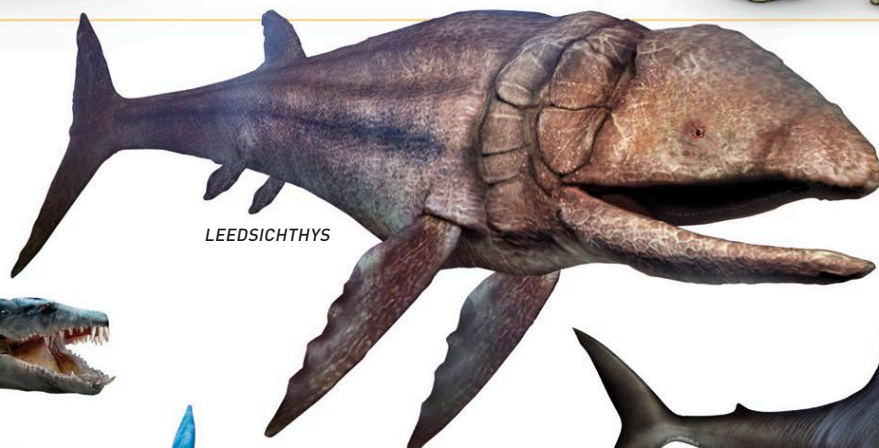
WOOLLY RHINOCEROS



LIOPLEURODON



HYBODUS



LEEDSICHTHYS



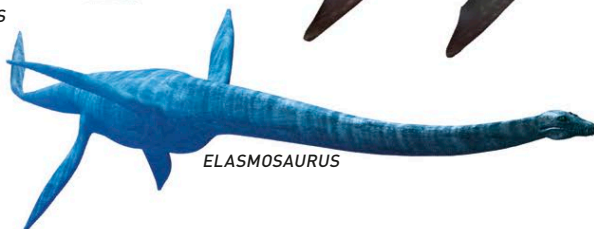
ISCHYODUS



KRONOSAURUS



MOSASAURUS



ELASMOSAURUS



OTODUS

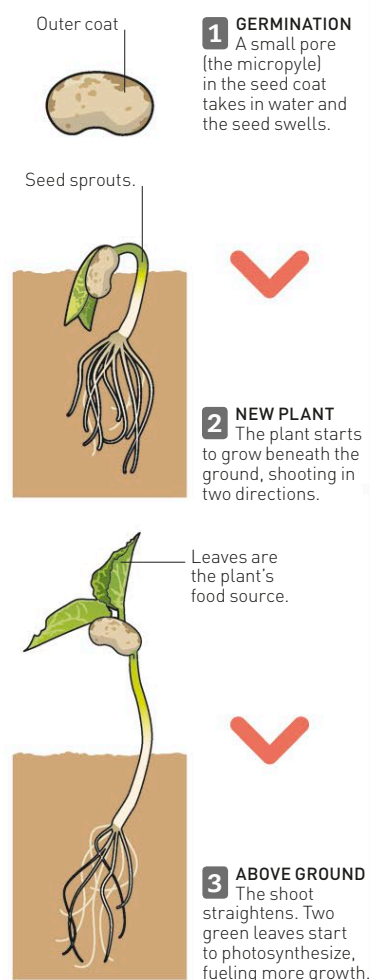


# Plants

There are around 400,000 species of plants on Earth. Plants make their food using sunlight, water, and carbon dioxide, and they are an important food source for all land animals. They also produce oxygen, which is vital to all life.

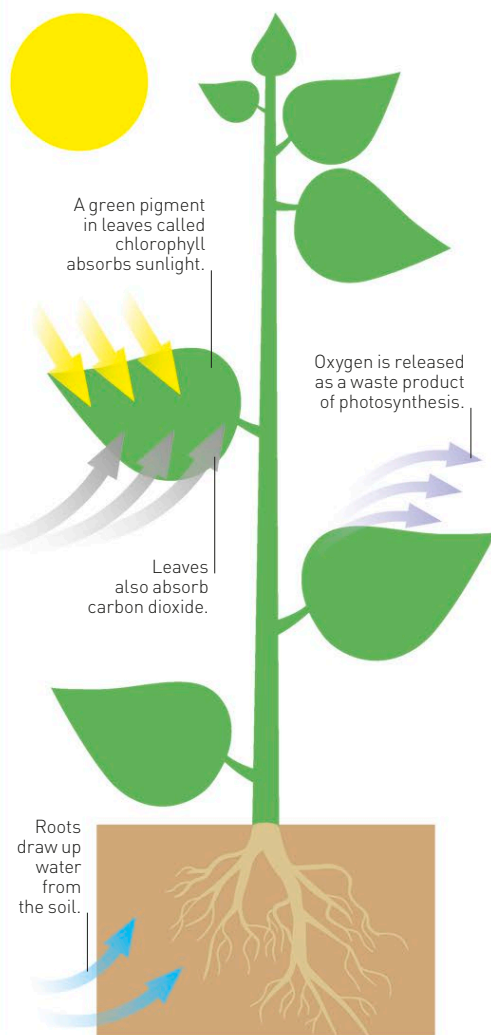
## HOW PLANTS GROW

When seeds warm up and absorb water, they start to sprout (germinate). Roots begin to grow downward to get water and nutrients from the soil, while shoots grow upward, toward the light.



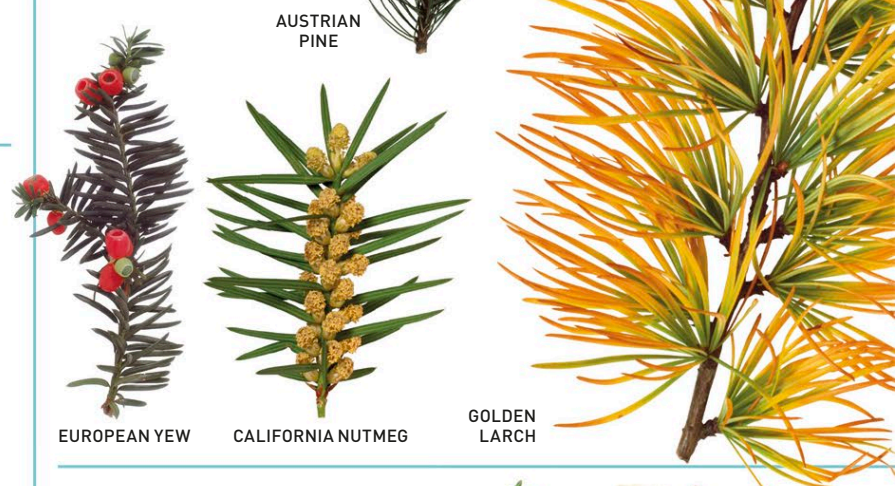
## PHOTOSYNTHESIS

Plants make their own food using a process called photosynthesis. They soak up water from the soil, take in carbon dioxide from the air, and use sunlight to produce glucose (sugar) for energy.



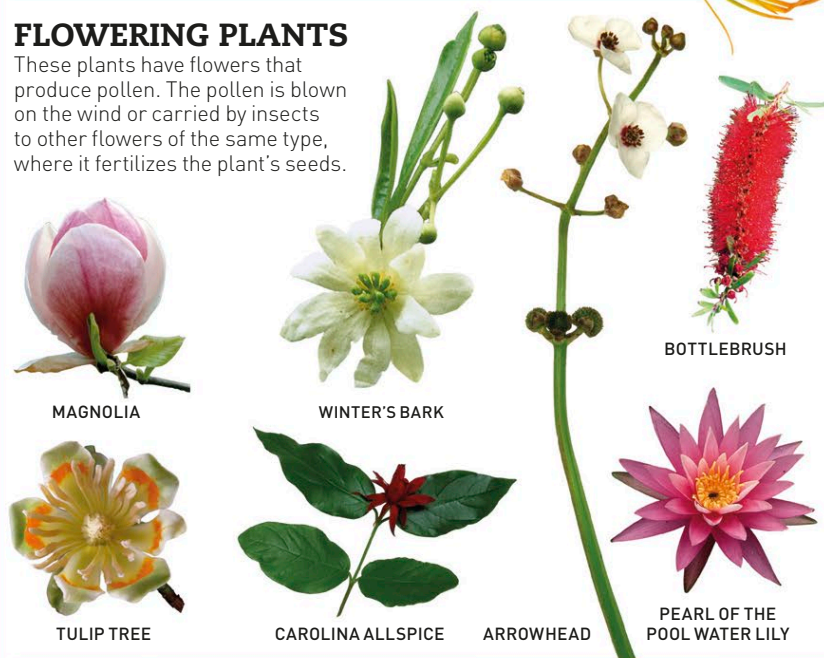
## NONFLOWERING PLANTS

Many of these plants grow in damp, shady places and reproduce by releasing spores. Others, known as conifers, produce seeds that develop inside scaly structures called cones.



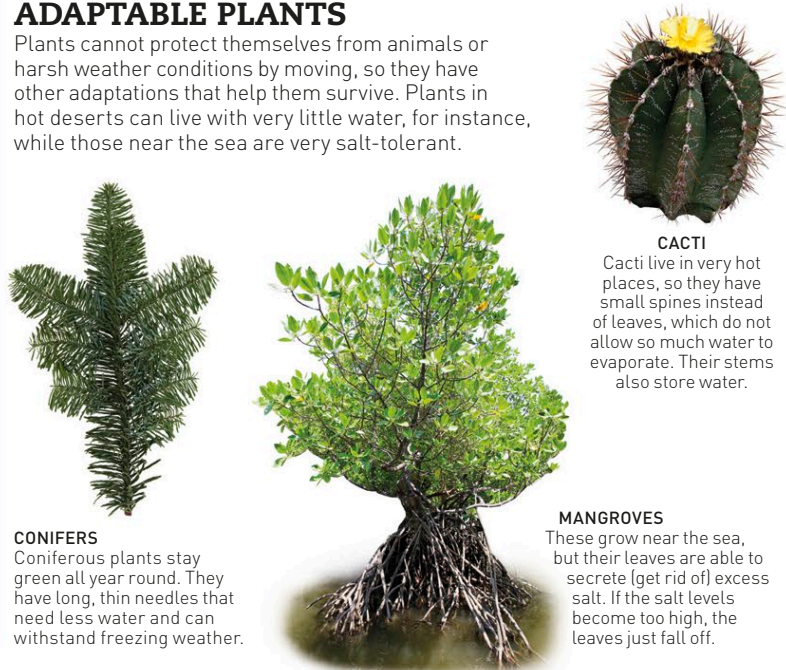
## FLOWERING PLANTS

These plants have flowers that produce pollen. The pollen is blown on the wind or carried by insects to other flowers of the same type, where it fertilizes the plant's seeds.



## ADAPTABLE PLANTS

Plants cannot protect themselves from animals or harsh weather conditions by moving, so they have other adaptations that help them survive. Plants in hot deserts can live with very little water, for instance, while those near the sea are very salt-tolerant.



## SEED DISPERSAL

Plants need to spread their seeds as far away from themselves as possible, so they do not end up overcrowded. There are different ways that seeds can be dispersed.



**BY BURSTING**  
When the seeds are ripe, they burst out, away from the parent plant.



**BY WIND**  
Some seeds have shapes that make them fly easily in the wind.



**BY WATER**  
Some fruits (seeds) are waterproof and can float, such as the coconut.



**BY ANIMALS**  
Seeds can be eaten and excreted or carried on animal coats.



**BY HUMANS**  
Humans discard seeds after eating fruit or carry them on their clothes.

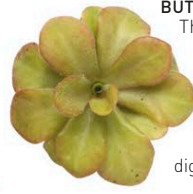


**SCIENTISTS THINK THAT SOME TYPES OF FERN HAVE BEEN ON EARTH FOR OVER 350 MILLION YEARS.**



## CARNIVOROUS PLANTS

Some plants grow in soil that does not have many nutrients, so they get additional nutrients from animal prey, such as insects. Many attract their prey using color and smell and then trap it. The plant's digestive juices break down the prey so it can be absorbed.



**COBRA LILY**  
The traps on this plant look like snake heads. It contains cells that give off light and attractive smells to tempt hungry insects.

**BUTTERWORT**  
This plant's leaves are covered with an insect-trapping sap. Small insects, such as gnats, get stuck, and their struggle releases the plant's digestive juices.

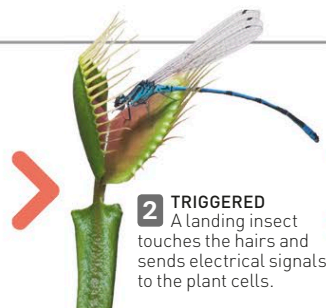
**PITCHER PLANT**  
This tropical plant has cups (pitchers) that hang from trees and contain water to attract prey. Thirsty insects fall in—and become plant food.

### CATCHING PREY

The Venus flytrap catches its insect prey very fast—it snaps shut in a tenth of a second. If an insect lands on the plant and touches sensory hairs, the plant snaps into action.



**1 PRIMED**  
The plant has sensory hairs on the inside, ready for its prey.



**2 TRIGGERED**  
A landing insect touches the hairs and sends electrical signals to the plant cells.



**3 SHUT**  
The plant lobes snap together, trapping the insect. Digestive juices are released.

## POISONOUS PLANTS

Some plants use poison as a protective device so that people and animals do not eat them. These plants are among the deadliest to humans.

- OLEANDER**  
The whole oleander plant is poisonous. Even smoke from burning oleander is highly toxic.
- WATER HEMLOCK**  
The most deadly plant in North America, a tiny dose of this plant can be lethal if eaten. One species also occurs in Europe.
- ROSARY PEA**  
These bright red seeds contain the most deadly plant poison known to humankind.
- DEADLY NIGHTSHADE**  
All parts of this plant contain deadly toxins. The roots are the most dangerous part.
- CASTOR BEAN**  
These contain ricin, one of the deadliest plant toxins. It is more toxic when inhaled than eaten.

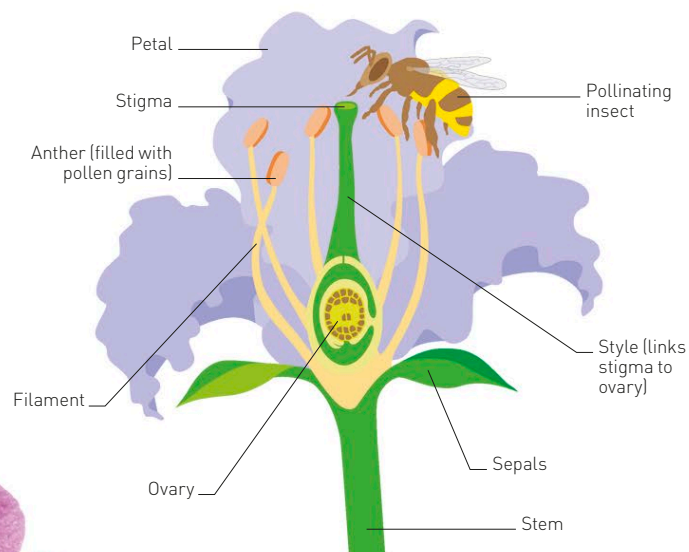


# Flowers

Flowers, often colorful and scented, play a vital role in a plant's life cycle. They contain organs that produce pollen and seeds. Pollen is taken from one flower to another in various ways. The flower receiving the pollen is fertilized (pollinated) and then forms seeds to make new plants.

## STRUCTURE OF A FLOWER

The parts of a flower are centered around the task of reproduction. Flower petals surround an ovary that produces eggs and a stigma that is ready to accept pollen. When eggs and pollen meet, they create seeds.



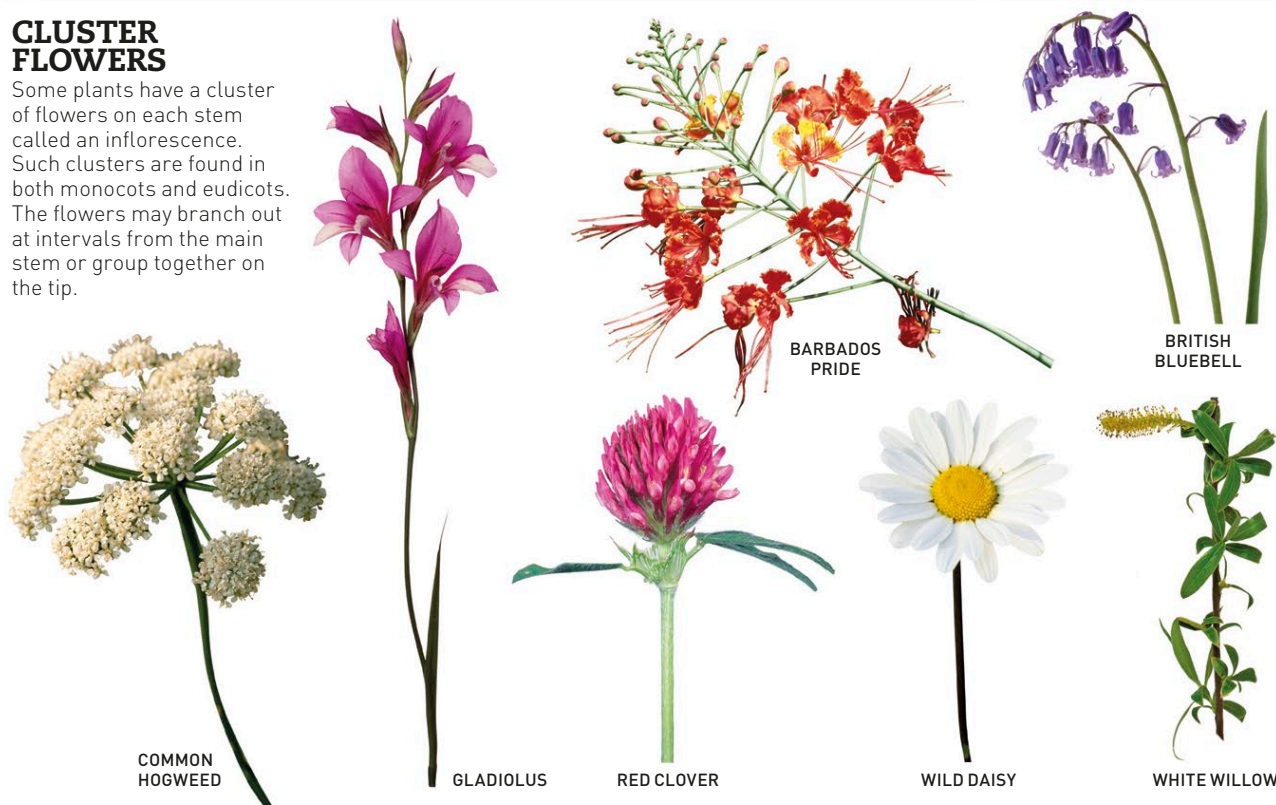
## MONOCOTS

This group of flowers has several features in common: their petals are always in multiples of three; they have one main stem, which has very few leaves; and their stems contain veins that run in parallel lines.



## CLUSTER FLOWERS

Some plants have a cluster of flowers on each stem called an inflorescence. Such clusters are found in both monocots and eudicots. The flowers may branch out at intervals from the main stem or group together on the tip.



## GREEN FLOWERS

Plants that use wind pollination often have green flowers, because they do not need to attract insects. The flowers also tend to be small and less easy to see. Their pollen-containing parts are positioned to catch the breeze.





## POLLINATION

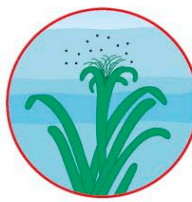
Flowers reproduce by pollination—pollen being taken from one flower to another. Some plants self-pollinate, but animals, wind, and water often play a part.



**ANIMAL**  
Many flowers contain nectar that attracts animals such as bees. While drinking the nectar, the animal gets coated with pollen, which it carries to other flowers.



**WIND**  
Some plants, such as grasses, rely on wind for pollination. They produce lots of pollen to increase the chances of it landing in the right places.



**WATER**  
A small number of aquatic plants are pollinated by water. Pollen is released into the water and carried to other plants by water currents.



**SELF**  
Some plants self-pollinate by either transferring pollen from the anther to the stigma of the same flower or to another flower on the same plant.

## FRUITS

Fruits are the parts of a plant that contain seeds. Some fruits change color and become juicy when ripe, which makes them attractive to animals. If a fruit is eaten, its seeds pass through the animal's digestive tract and are dispersed in its droppings. Some types of fruit have wings or hooks and are carried on the wind or stuck in an animal's fur.



**1 SEEDS AT BASE**  
After pollination, seeds form in this melon flower's ovary.



**2 OVARY SWELLS**  
The flower petals fall away and the ovary begins to swell.



**3 SMALL FRUIT**  
The skin hardens; the ovary is now a small fruit.



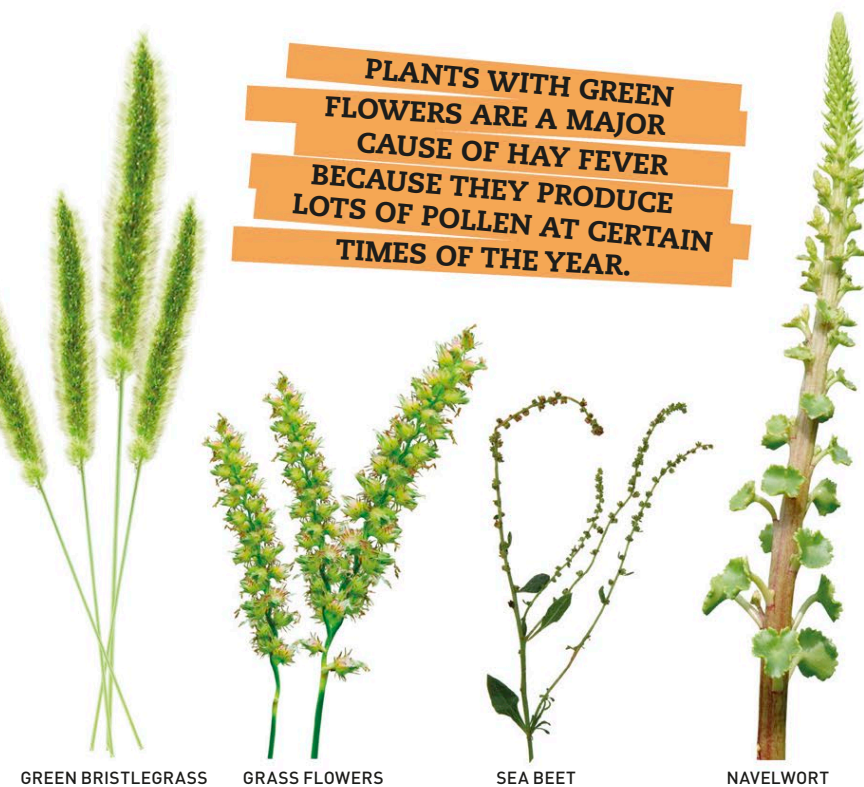
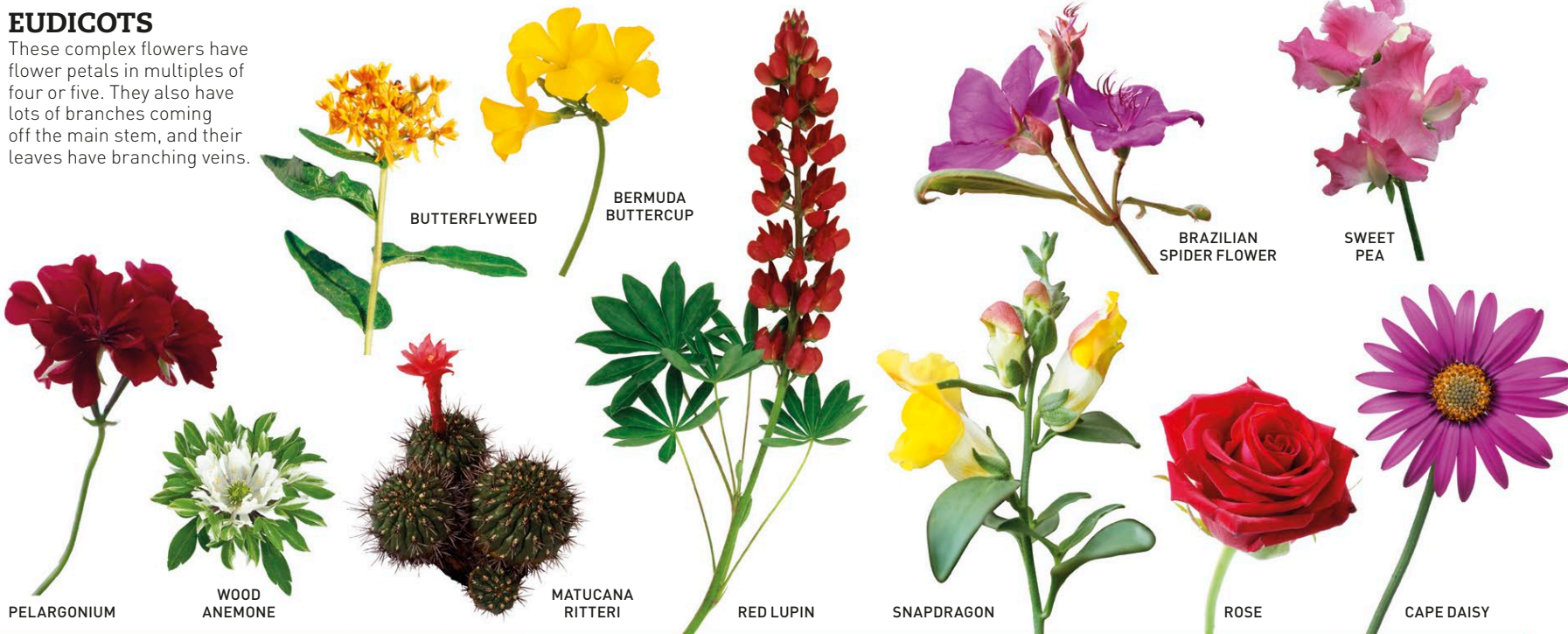
**4 RIPENING**  
Over the growing season, the fruit gets bigger and ripens.



**5 MATURE FRUIT**  
The melon is ripe. If an animal eats it, the seeds will be dispersed.

## EUDICOTS

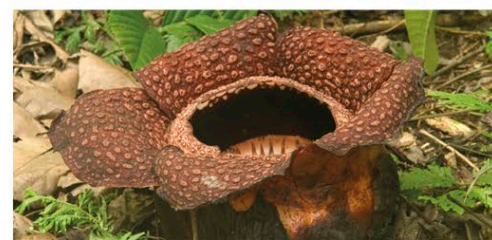
These complex flowers have flower petals in multiples of four or five. They also have lots of branches coming off the main stem, and their leaves have branching veins.



**PLANTS WITH GREEN FLOWERS ARE A MAJOR CAUSE OF HAY FEVER BECAUSE THEY PRODUCE LOTS OF POLLEN AT CERTAIN TIMES OF THE YEAR.**

## THE GREAT PRETENDERS

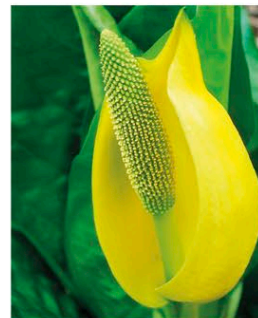
Some flowers have evolved in ways that would make them at home in fairy tales. Among them are flowers that look like insects. Others smell of bad meat or the foul scent sprayed by skunks. Such strange adaptations have a good reason—they are tricks to attract pollinators.



**RAFFLESIA**  
This is also known as the "corpse flower" because it smells like a rotten carcass. It has no roots or leaves and lives off other plants, taking their nutrients and water.



**BEE ORCHID**  
This flower has petals that look like a bee. Real bees are fooled into trying to mate with it, so they pick up and disperse the pollen.



**WESTERN SKUNK CABBAGE**  
The tiny flowers are surrounded by a vivid yellow structure called a "spathe." Some insects love the skunky smell of this plant.



**STINK LILY**  
The long black spike (spadix) on this plant stinks of rotten meat—which attracts flies hoping for a meal.

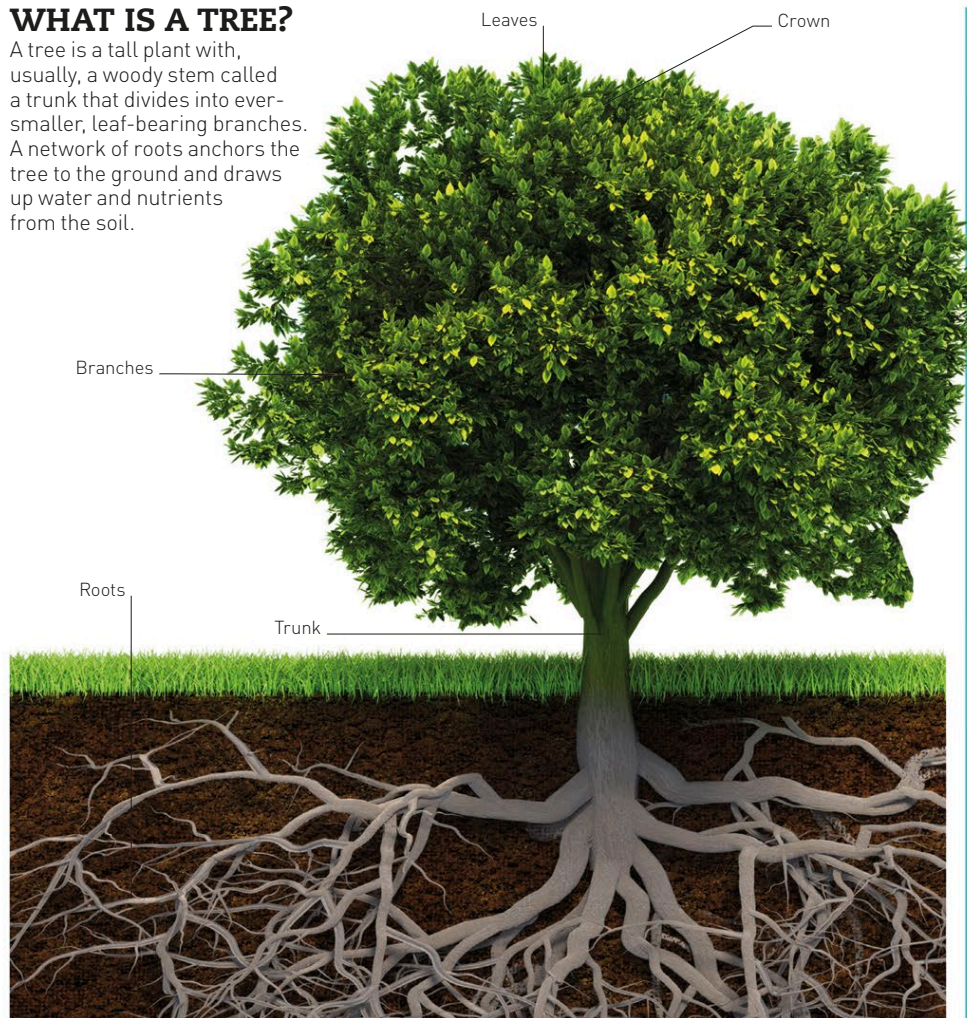


# Trees

The largest plants on Earth, trees have been here for millions of years. They are vital to the planet's survival. Their leaves absorb harmful substances from the atmosphere and produce oxygen. Trees keep the air moist, which helps create rainfall, and provide homes and food for wildlife.

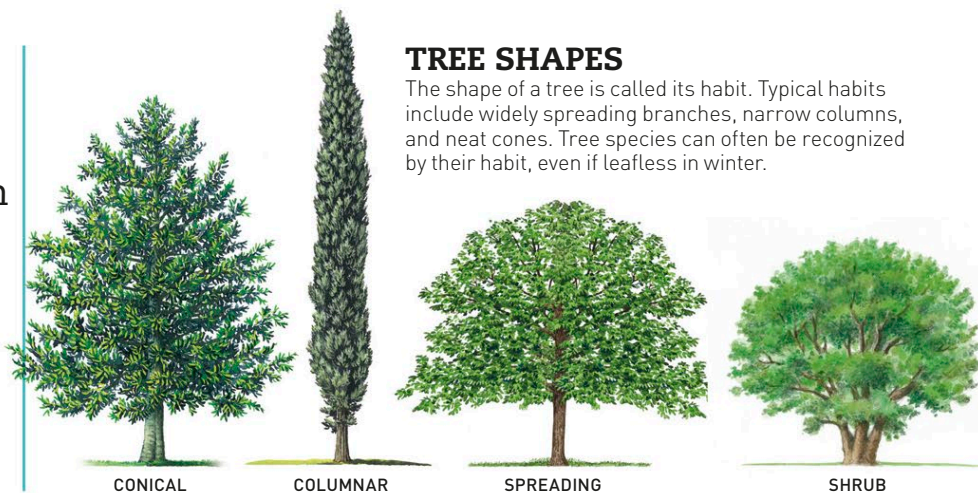
## WHAT IS A TREE?

A tree is a tall plant with, usually, a woody stem called a trunk that divides into ever-smaller, leaf-bearing branches. A network of roots anchors the tree to the ground and draws up water and nutrients from the soil.



## TREE SHAPES

The shape of a tree is called its habit. Typical habits include widely spreading branches, narrow columns, and neat cones. Tree species can often be recognized by their habit, even if leafless in winter.



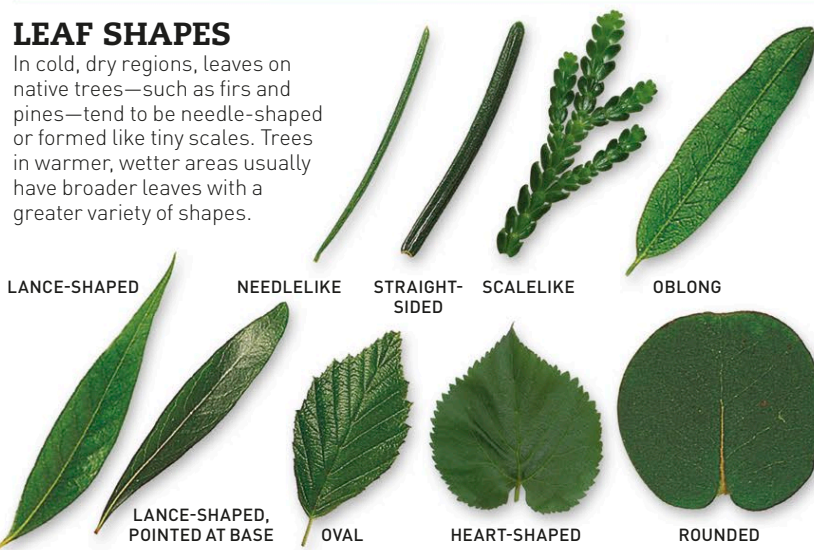
## TYPES OF BARK

Bark is the outer layer of a tree. It protects the trunk and branches from damage and keeps in water. The color and texture of bark, and the way it flakes or peels, can help with the identification of a tree. The appearance of bark can change as a tree gets older.



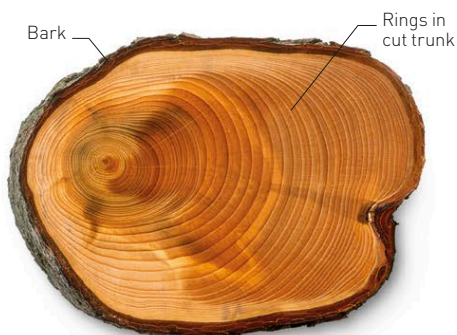
## LEAF SHAPES

In cold, dry regions, leaves on native trees—such as firs and pines—tend to be needle-shaped or formed like tiny scales. Trees in warmer, wetter areas usually have broader leaves with a greater variety of shapes.



## TREE RINGS

Every year that a tree grows, it adds a new layer of wood beneath its bark. If the tree is cut down, these layers can be seen as dark and light rings. By counting the dark rings, it is possible to work out the age of the tree.

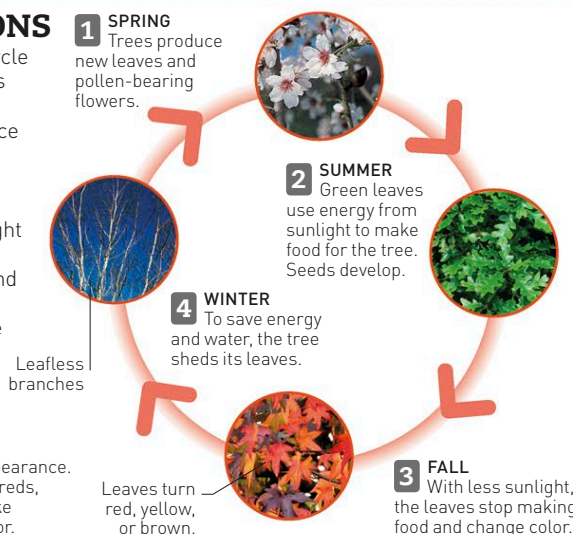


## FOUR SEASONS

Some trees have a cycle of growth that follows seasonal weather changes. They produce leaves and flowers in spring, then seeds through the summer. As the hours of daylight shorten in fall, the trees stop growing and drop their leaves. In winter, the trees have a period of rest.

### LEAF CHANGE

In fall, leaves change appearance. The green vanishes, and reds, yellows, and browns make woodlands glow with color.



## TALLEST TREES

The evergreen trees known as Coastal Redwoods grow taller than any other species of tree. They grow naturally only along the Pacific coast of northern California. The very tallest redwood is an amazing 380 ft (116 m) high. Named Hyperion, its exact location is secret.

**HYPERION REDWOOD**  
380 ft (116 m)





## DECIDUOUS TREES

Trees that lose all their leaves for part of the year—for example, oaks and beeches—are called deciduous. They have flat leaves of many shapes that are usually shed in cold or dry seasons. The tree remains bare until warmer weather returns, when new leaves grow. Deciduous trees are found in many regions of the world.



COMMON ALDER



SILVER BIRCH



COMMON HORNBEAM



SWEET CHESTNUT



COMMON BEECH



MANNA ASH



TAMARACK



SUGAR MAPLE



QUAKING ASPEN



CHERRY



WHITE WILLOW



ROWAN



ENGLISH ELM



WHITE MULBERRY



ENGLISH OAK



QUINCE



JUDAS TREE



COMMON FIG



TURPENTINE TREE

## EVERGREEN TREES

These trees have leaves all year round. Although old leaves fall off, they are constantly replaced by new ones. Evergreens include firs, pines, cedars, and spruces. Many grow in northern regions, where they thrive in harsh, cold climates.



SILVER FIR



GIANT FIR



MONKEY PUZZLE



YLANG YLANG



ITALIAN CYPRESS



NORWAY SPRUCE



BLUE SPRUCE



BLUE GUM



MAGELLAN'S BEECH



STRAWBERRY TREE



LEMON TREE



CEDAR OF LEBANON



WELLINGTONIA



COCOA TREE



CHINESE EVERGREEN  
MAGNOLIA



COMMON MANGO



COMMON JUNIPER



SCOTS PINE



COMMON YEW



EASTERN HEMLOCK

THE WORLD'S MOST  
ANCIENT TREE  
IS A BRISTLECONE  
PINE IN CALIFORNIA,  
DATED AT MORE THAN  
4,850 YEARS OLD.

## ANCIENT TREES

The first treelike plants that grew on Earth, about 380 million years ago, were spore trees. These reproduced not from seeds but from cells called spores on the underside of their leaves. The only spore trees living today are the tree ferns. Another ancient tree is the Ginkgo, a survivor from before the age of dinosaurs.



TREE FERNS



GINKGO

## BONSAI

The ancient oriental art of bonsai creates tiny replicas of large trees. Techniques such as wiring roots and branches stop the tree from reaching its full growth. Bonsai can be used on any type of tree to produce a miniature version small enough to keep in a pot.

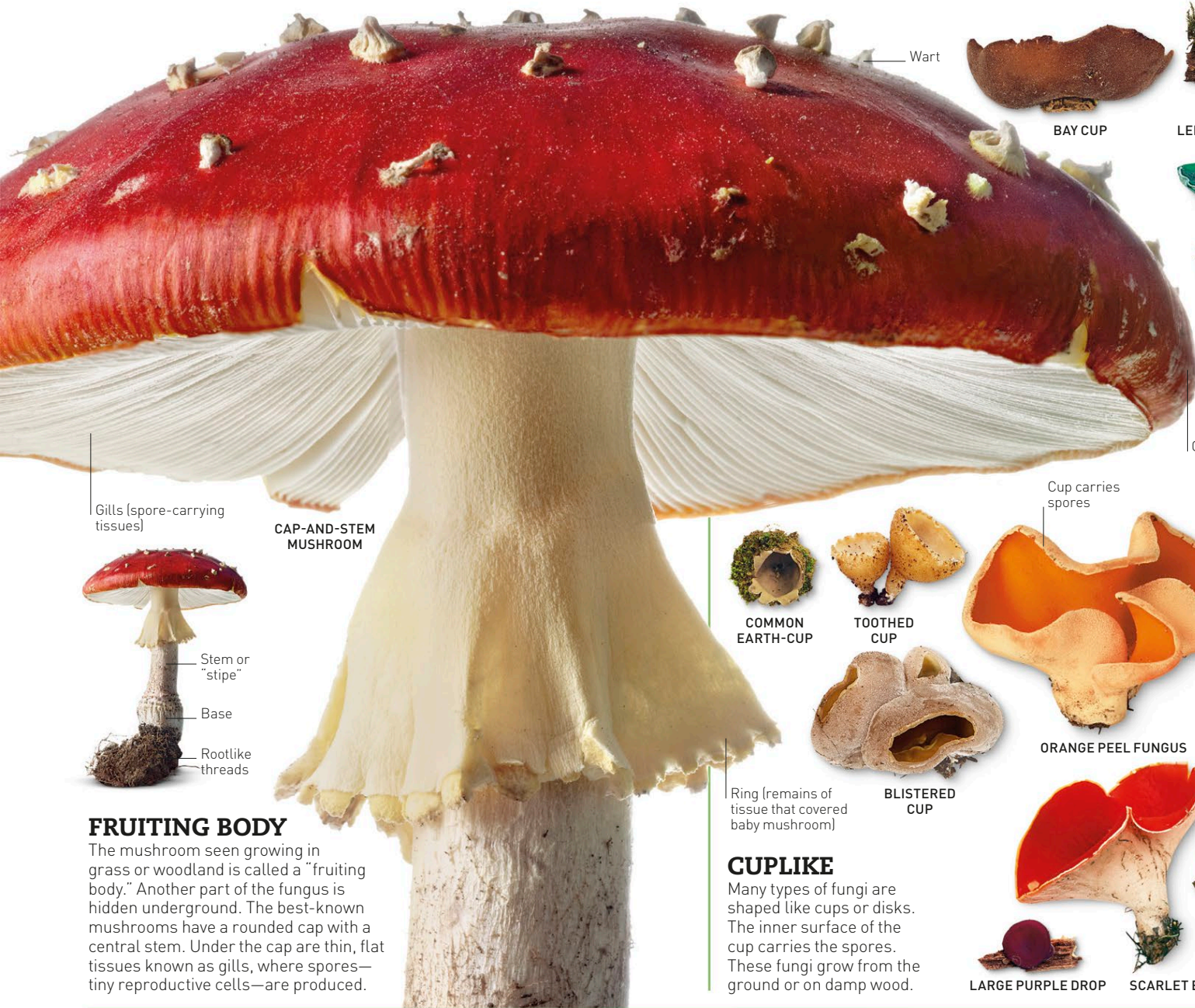


JAPANESE MAPLE



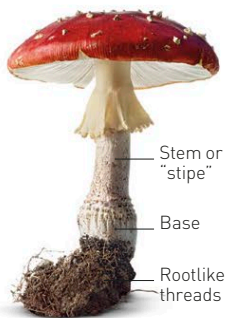
DWARF CRAB APPLE





Gills (spore-carrying tissues)

CAP-AND-STEM MUSHROOM



Stem or "stipe"  
Base  
Rootlike threads

## FRUITING BODY

The mushroom seen growing in grass or woodland is called a "fruiting body." Another part of the fungus is hidden underground. The best-known mushrooms have a rounded cap with a central stem. Under the cap are thin, flat tissues known as gills, where spores—tiny reproductive cells—are produced.

Wart

BAY CUP

LEMON DISCO

GREEN ELF CUP

YELLOWING CUP

Cap

LEMON PEEL FUNGUS

COMMON EARTH-CUP

TOOTHED CUP

Cup carries spores

Deeply cup-shaped fruiting body

ANEMONE CUP

JELLY EAR

Ring (remains of tissue that covered baby mushroom)

BLISTERED CUP

ORANGE PEEL FUNGUS

Spore-producing tissue

## CUPLIKE

Many types of fungi are shaped like cups or disks. The inner surface of the cup carries the spores. These fungi grow from the ground or on damp wood.

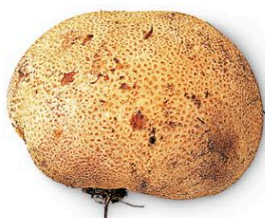
LARGE PURPLE DROP

SCARLET ELF CUP

BEECH JELLYDISC

## BALL-SHAPED

Some fungi are round like balls. They range in size from tiny ones clustering on stems to giants as large as a soccer ball. The type called puffballs split open to release the spores stored inside.



COMMON EARTHBALL



STUMP PUFFBALL



SPINY PUFFBALL



GRAY PUFFBALL



PESTLE-SHAPED PUFFBALL



CRAMP BALLS



MEADOW PUFFBALL



SUMMER TRUFFLE



GIANT PUFFBALL



RED CAGE

Spores sit on the inner surface

## CAP-AND-STEM

The most easily recognized fungi are the "umbrella" or cap-and-stem type. They come in all shapes and sizes. Some are small and spindly, while others have fat stems and thick, fleshy caps.



FALSE MOREL



SPLENDID WEBCAP



SCARLET WAXCAP



VIOLET WEBCAP



SICKENER



MEADOW WAXCAP



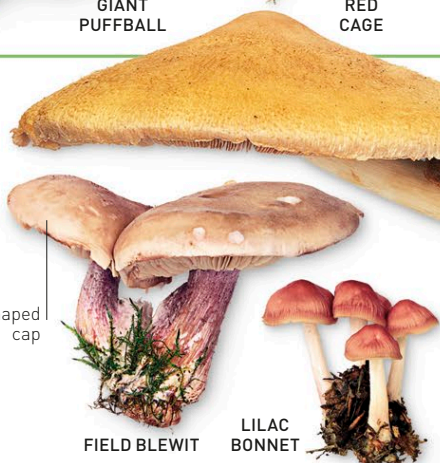
CONIFER TUFT



FLY AGARIC



PANTHERCAP



Bun-shaped cap

AMETHYST DECEIVER



FIELD BLEWIT

LILAC BONNET

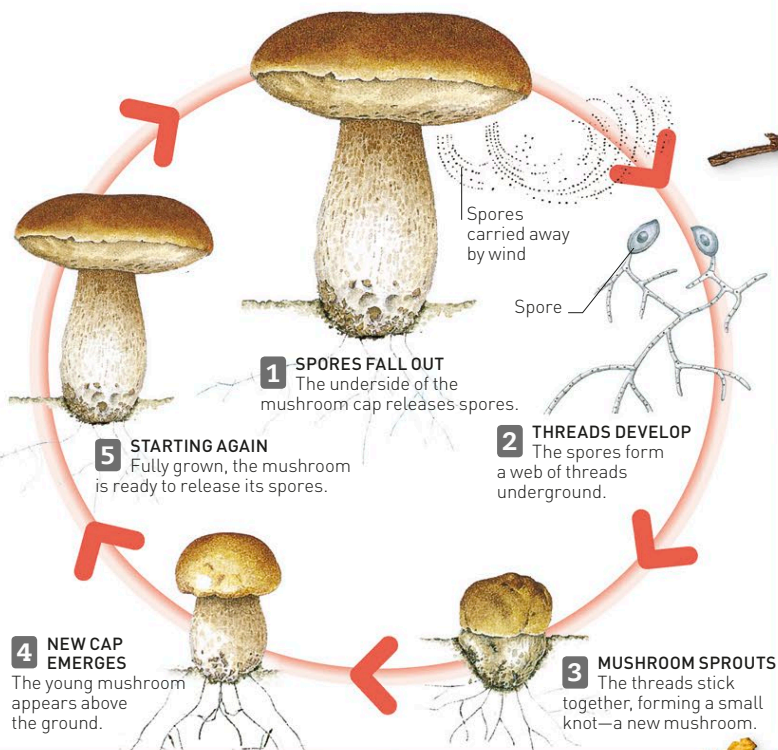


# Fungi

Although they look like plants, fungi are quite different and belong to a separate scientific group. They come in many shapes, including the familiar mushrooms, and all of them feed on organic matter. Some are edible, but others are deadly poisonous.

## LIFECYCLE OF A MUSHROOM

The real growth of a fungus takes place out of sight. Beneath the ground, a web of fine threads develops from the mushroom's spores (reproductive cells) and spreads to produce more mushrooms.



## WHERE FUNGI GROW

Finding and identifying fungi means knowing the right places to look. For example, some fungi grow by certain trees.



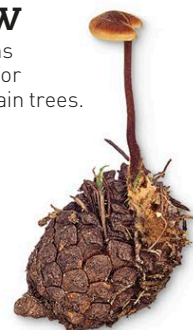
**FALLEN BRANCHES**  
The common brown cup mushroom grows on oak bark.



**LEAVES**  
Redleg club fungi appear on the ribs and stalks of ash, maple, or alder leaves.



**UNDER TREES**  
The hazel bolete mushroom grows in leaf beds under hazel and hornbeam trees.



**FIR CONES**  
The earpick fungus grows directly out of decaying fir cones.



**ON OTHER MUSHROOMS**  
Silky piggyback mushrooms grow on the rotting bodies of other fungi.

## DANGEROUS MUSHROOMS

Some poisonous mushrooms look very like the ones used in cooking. No one should pick a mushroom without being sure what type it is.



### DEATHCAP

One of the deadliest fungi in the world, the deathcap can be fatal if eaten.

### BROWN ROLLRIM

The poison in the rollrim can damage red blood cells and lead to kidney and liver failure.



### JEWELLED AMANITA

This cream-colored or yellow mushroom can cause sickness and stomach pains less than an hour after being eaten.

### FUNERAL BELL

Found on rotting wood, the yellowish-brown funeral bell contains a poison that causes liver damage and, without fast treatment, death.

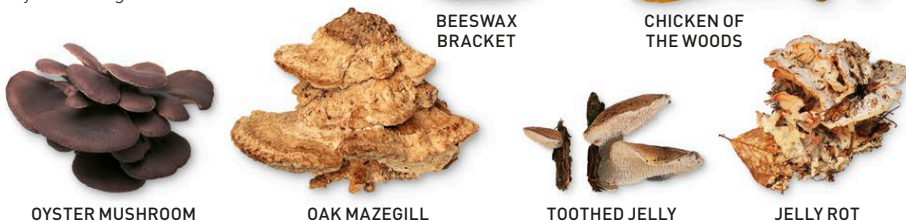
### DEADLY WEBCAP

This type is very dangerous because it looks like the edible chanterelle mushroom. If eaten, the deadly webcap damages the liver and kidneys.



## BRACKETLIKE

These types of fungi are found on trees or dead wood. They grow like shelves, sometimes forming row on top of row. Bracket fungi can eventually kill living trees by attacking their tissues.



BEESWAX BRACKET



CHICKEN OF THE WOODS



DWARF EARTHSTAR



DEVIL'S FINGERS



COLLARED EARTHSTAR

## STAR-SHAPED

In these fungi, the spores are held in a round case. To release the spores, the outer layer of the case splits open like a many-pointed star.



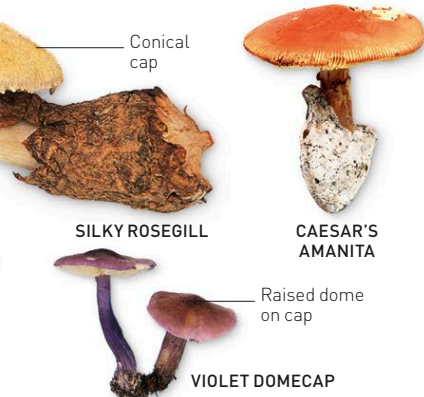
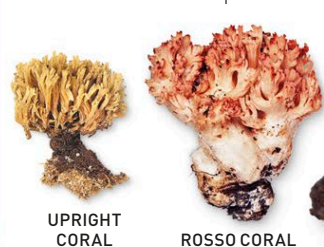
## CLUB-SHAPED

With their upright shapes and no noticeable caps, club fungi look very unlike typical mushrooms. Some types grow in clumps.



## CORAL-LIKE

Often brightly colored, the clustered, branching stalks of coral fungi look very similar to the corals found in tropical seas.





## SPIDERS

There are about 45,000 species of spiders. They have eight legs and most species have eight eyes. Typical spiders can live for up to one year, if they avoid disease and predators. Some big spiders, such as tarantulas, can live for up to 20 years.



CAVE SPIDER



NURSERY WEB SPIDER



DADDY LONG-LEGS SPIDER



NORTH AMERICAN TRAPDOOR SPIDER



GIANT HOUSE SPIDER



WATER SPIDER



BROWN JUMPING SPIDER



NORTHERN SPITTING SPIDER



NORTHERN BLACK WIDOW SPIDER



AMERICAN GOLDEN SILK ORB-WEAVER



FUNNEL-WEB SPIDER



CHACO TARANTULA



EUROPEAN WOLF SPIDER

# Spiders and scorpions



## SCORPIONS

A scorpion's body is encased in a tough shell-like covering. Claws near the head are used to seize prey and fight predators, while its tail ends in a venomous stinger.

Spiders and scorpions are arachnids— invertebrate animals with eight, jointed legs. They are different in many ways, but most obviously a scorpion has a venomous stinger in its tail, while a spider has venomous fangs.



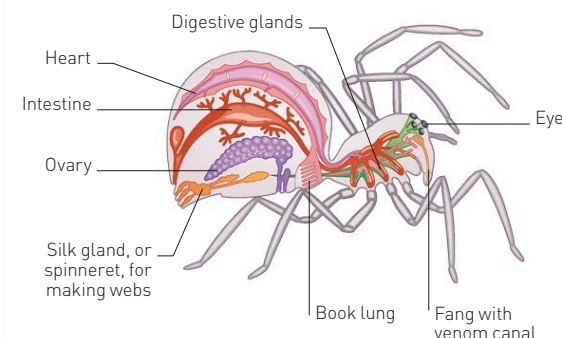
YELLOW THICK-TAIL SCORPION

IMPERIAL SCORPION

CHILEAN BURROWING SCORPION

## ANATOMY OF A SPIDER

A spider's body is divided into two parts. The front part includes the eyes, fangs, stomach, and legs, while the rear part contains the silk glands, known as spinnerets. Spiders have four pairs of legs and use the hairs on these to pick up smells, sounds, and vibrations.



## SCORPLINGS

Young scorpions develop inside their mother's body. After birth, they climb on to her back until their external skeleton molts for the first time.



Scorplings  
External skeleton will be shed five to seven times before adulthood.





CRABLIKE SPINY  
ORB-WEAVER



ORANGE  
BABOON  
TARANTULA



WHIP  
SPIDER



COMMON  
HARVESTMAN



BROAD-HEADED  
PSEUDOSCORPION



RAFT  
SPIDER

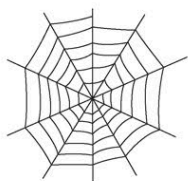
MEXICAN RED-KNEED  
TARANTULA

## OTHER ARACHNIDS

The arachnid group includes other animals such as mites, ticks, and harvestmen. They are often mistaken for insects, but they are not, mainly because they all have eight legs, not six, and two body segments instead of three.

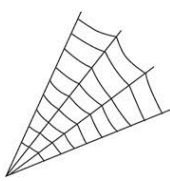
## WEB TYPES

Different species of spider produce different types of webs. Orb spiders produce the most widely recognized web.



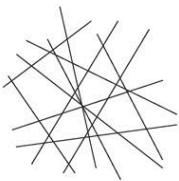
### ORB WEB

Spun by orb web spiders, this type of web needs repairing every day.



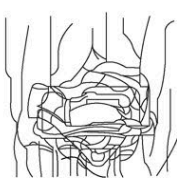
### TRIANGULAR WEB

This type is spun by nonvenomous cribellate orb-weaver spiders.



### COBWEB

Also known as a "tangled web," this type is made by house spiders.

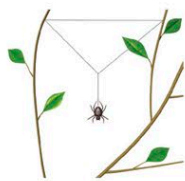


### FUNNEL-WEB

This tubular style is built by funnel-web spiders.

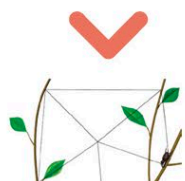
## BUILDING A WEB

Orb spiders produce a strong silk "thread" from their abdomen, which they use for spinning webs. The finished web is sticky, so that it can trap insects that pass by for the spider to eat.



### 1 FRAMEWORK

The spider lets out a thread, which catches on a twig. It then attaches the other end to another twig. Next, it attaches a looser thread to the same spot and then suspends itself from a third thread in the middle.



### 2 SPIRAL THREADS

Once the third thread is attached, the spider spins spiral threads to complete the web. These threads are not sticky.



### 3 STICKY THREADS

Finally, the spider replaces the spiral threads with sticky threads, ready to catch its prey. It then eats the nonsticky threads.

## SPIDER SIZES

The world's smallest spider, the Patu Digua, has a body about the size of a pin head. The largest spider, the Goliath Birdeater Tarantula, has a leg span of 11 in (28 cm).



PATU DIGUA  
SPIDER



GOLIATH BIRDEATER  
TARANTULA

## FEEDING

Spiders use fangs to kill their prey. Many also "spit" digestive fluids over the prey to turn it to liquid, then suck it up. All spiders eat insects, but some big spiders also eat lizards, frogs, and even fish.



## DANGEROUS SPIDERS

Only a small number of spiders are a danger to humans.

### BRAZILIAN WANDERING SPIDER

The world's most poisonous spider wanders across jungle floors at night in search of food.

### SYDNEY FUNNEL-WEB

When prey comes into contact with its web, this spider rushes out and delivers lots of bites very quickly.

### BROWN RECLUSE

Also known as "violin spiders," these have flesh-destroying bites, which create wounds that can take months to heal.

### BLACK WIDOW SPIDER

This spider is small, but its venomous bite can be very dangerous.

THE OLDEST WEB  
IS A 110-MILLION-  
YEAR-OLD FOSSIL.

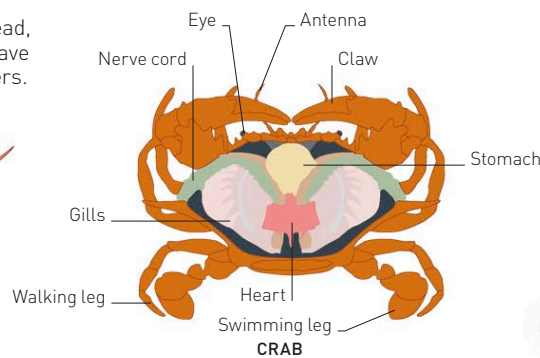
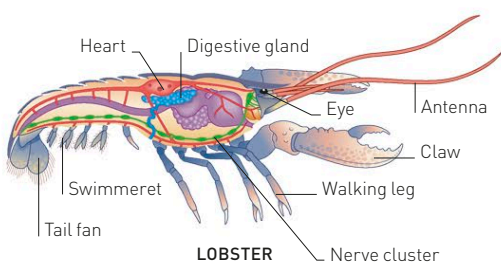


# Crustaceans

The animals called crustaceans are a varied group that includes crabs, lobsters, prawns, and shrimp. Most of them live in water. Among the few found on land are tiny woodlice. Crustaceans have an outer skeleton that does not grow when their bodies do, so they shed it regularly to allow a new, larger one to develop.

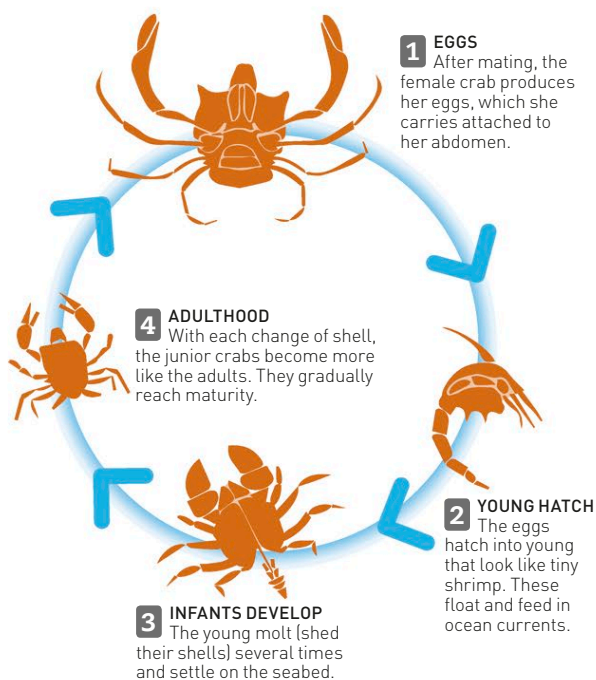
## THE BODY OF A CRUSTACEAN

Lobsters and crabs have three body regions: the head, the thorax or midsection, and the abdomen. They have five pairs of legs, which in some species form pincers.



## LIFECYCLE OF A CRAB

Like most crustaceans, newly hatched crabs look very different from their parents. They develop into adults through several stages. A female crab lays millions of eggs, of which only a handful survive.



## SURVIVAL TACTICS

Crabs are a tasty meal for many other sea creatures. They often dodge predators by hiding under rocks or in a tangle of seaweed. If cornered a long way from shelter, a crab uses different tactics to get out of trouble.

### MOCK ATTACK

The crab rears up and waves its pincers, trying to make itself look as large as possible.



### CROUCH

Another trick the crab may try is to crouch down low so that it is seen less easily by the waiting predator.



### ESCAPE

With luck, the crab confuses the attacker and has time to scuttle off to safety.



## DEADLY BUBBLE

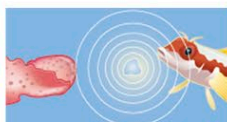
The 2-in (5-cm)-long pistol shrimp makes a big noise for its size. Meeting prey, the shrimp opens the larger of its claws and snaps it shut at lightning speed. The snap creates an air bubble, which bursts with a bang loud enough to stun the victim.



1 **CLAW OPENS**  
The shrimp opens its hinged claw wide.



2 **CLAW SHUTS**  
The claw snaps shut, creating a bubble.



3 **PREY STUNNED**  
The sound of the bubble bursting stuns the prey.

## CRABS

All but a few crabs live in the sea. Most of them have flat bodies and a wide shell. The soft-bellied hermit crabs protect themselves by living in the empty shells of other marine animals. Crabs move by walking sideways.



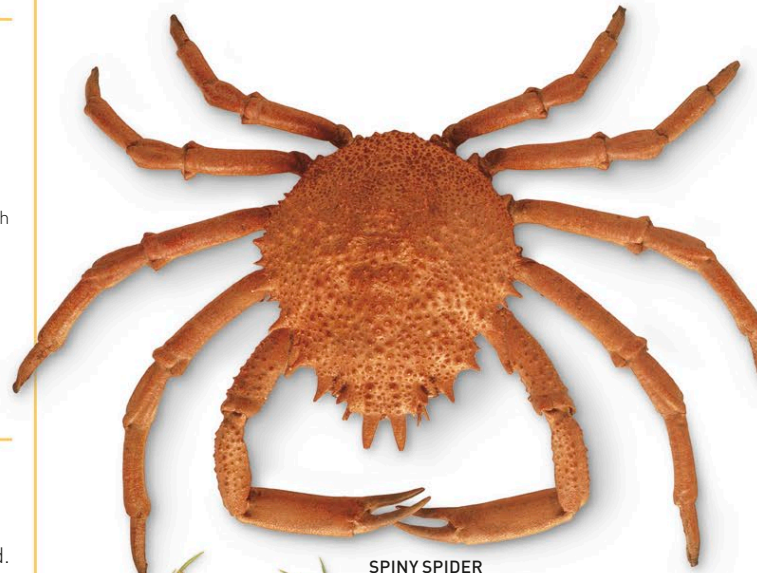
WARTY BOX CRAB



EDIBLE CRAB



SPLENDID ROUND CRAB



SPINY SPIDER CRAB



MASKED CRAB



GHOST CRAB

## LOBSTERS AND OTHER GROUPS

Like most crabs, lobsters live in the sea. These large animals have a hard upper shell and powerful tails. Smaller crustaceans include numerous shrimp, both marine and freshwater. Sea slaters and woodlice belong to a large group whose members are found on land, as well as in water.



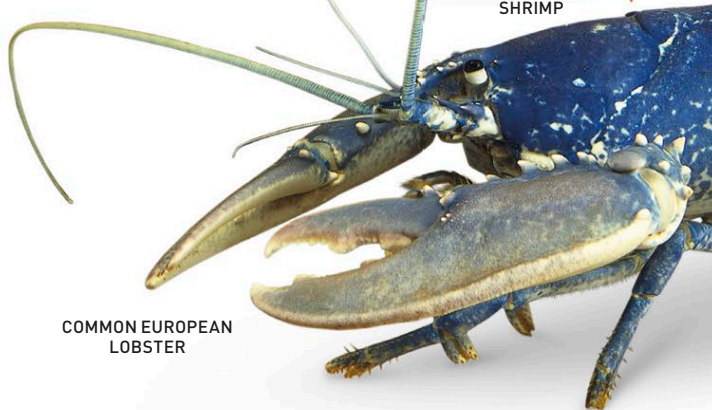
BROAD LOBSTER



VERNAL POOL TADPOLE SHRIMP



AESOP SHRIMP



COMMON EUROPEAN LOBSTER





RED LAND CRAB



ANEMONE HERMIT CRAB



COMMON HERMIT CRAB



DUNGENESS CRAB



VELVET SWIMMING CRAB



PANAMIC ARROW CRAB



PORCELAIN ANEMONE CRAB



RED REEF HERMIT CRAB



ORANGE FIDDLER CRAB



FURROWED CRAB



ATLANTIC BLUE CRAB



PEACOCK MANTIS SHRIMP



COMMON MARBLE SHRIMP



SCULPTURED SLIPPER LOBSTER



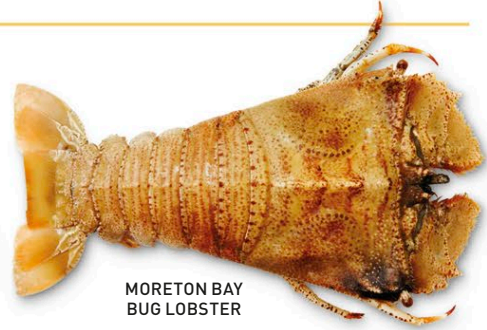
COMMON SHRIMP



HAIRY SQUAT LOBSTER



NORWAY LOBSTER



MORETON BAY BUG LOBSTER



STRIPED-LEG SPINY LOBSTER



SEA SLATER



ANTARCTIC KRILL



PILL WOODLOUSE



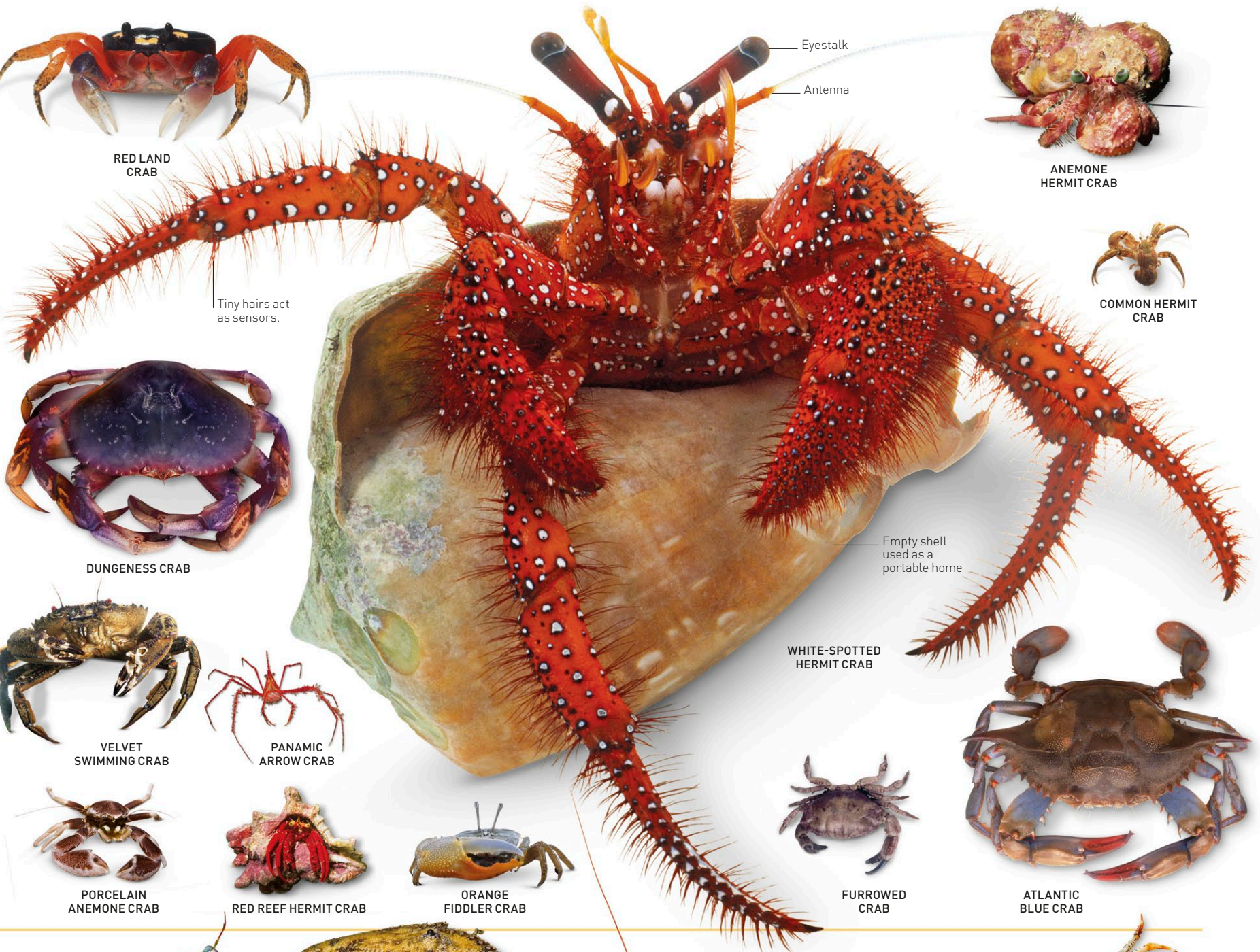
WHITE-CLAWED CRAYFISH



SPINY SQUAT LOBSTER



TIGER PRAWN



Tiny hairs act as sensors.

Eyestalk

Antenna

Empty shell used as a portable home

WHITE-SPOTTED HERMIT CRAB



## RECOGNIZING AN INSECT

Insects come in many forms. Most have wings, and there are other features that make them easier to recognize, too.



THREE BODY SEGMENTS



OFTEN HAVE WINGS



OUTER SKELETON



COMPOUND EYES



ANTENNAE



SIX JOINTED LEGS

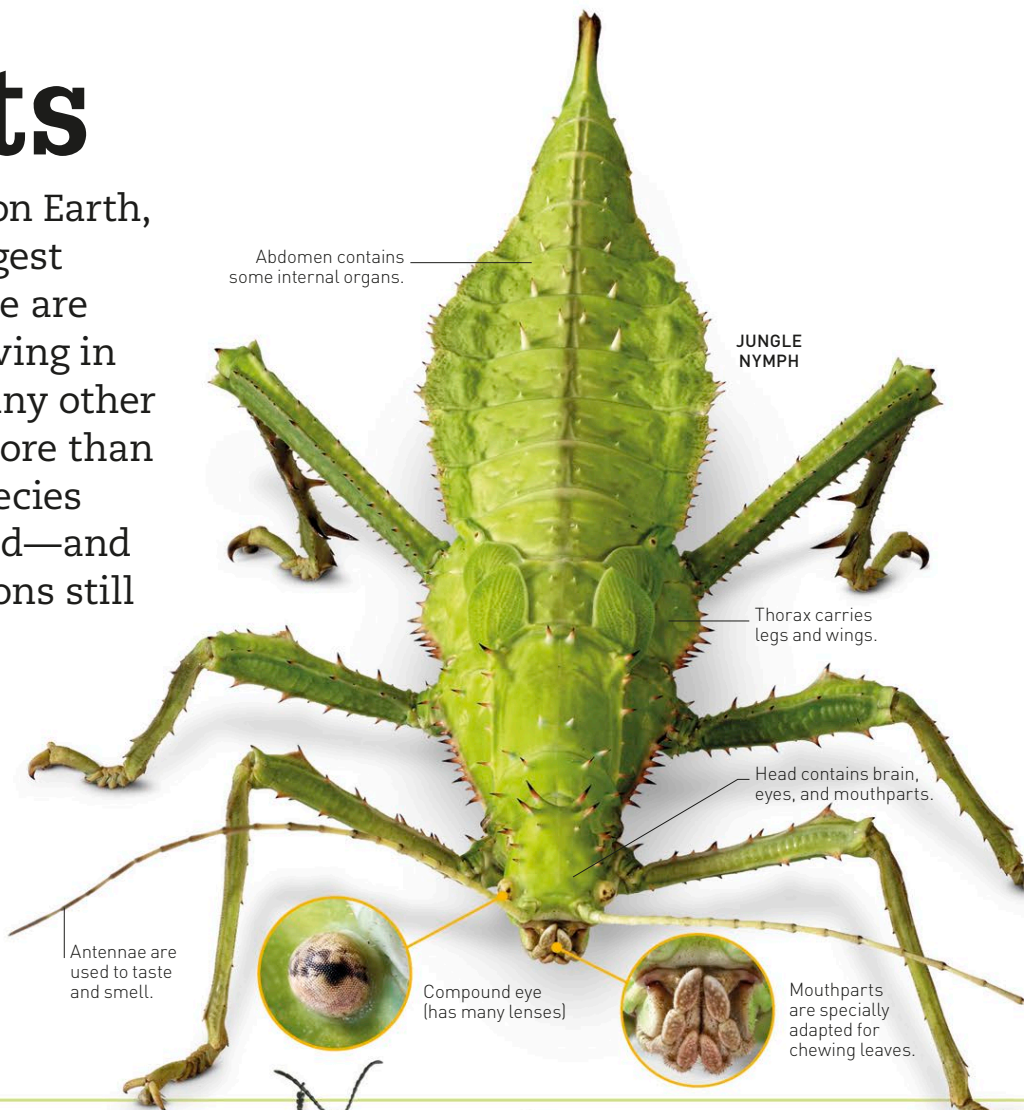
**INSECTS WERE THE FIRST ANIMALS TO FLY, 400 MILLION YEARS AGO.**

# Insects

Of all the animals on Earth, insects are the biggest success story. There are greater numbers living in more places than any other type of creature. More than a million insect species have been identified—and there may be millions still to discover.

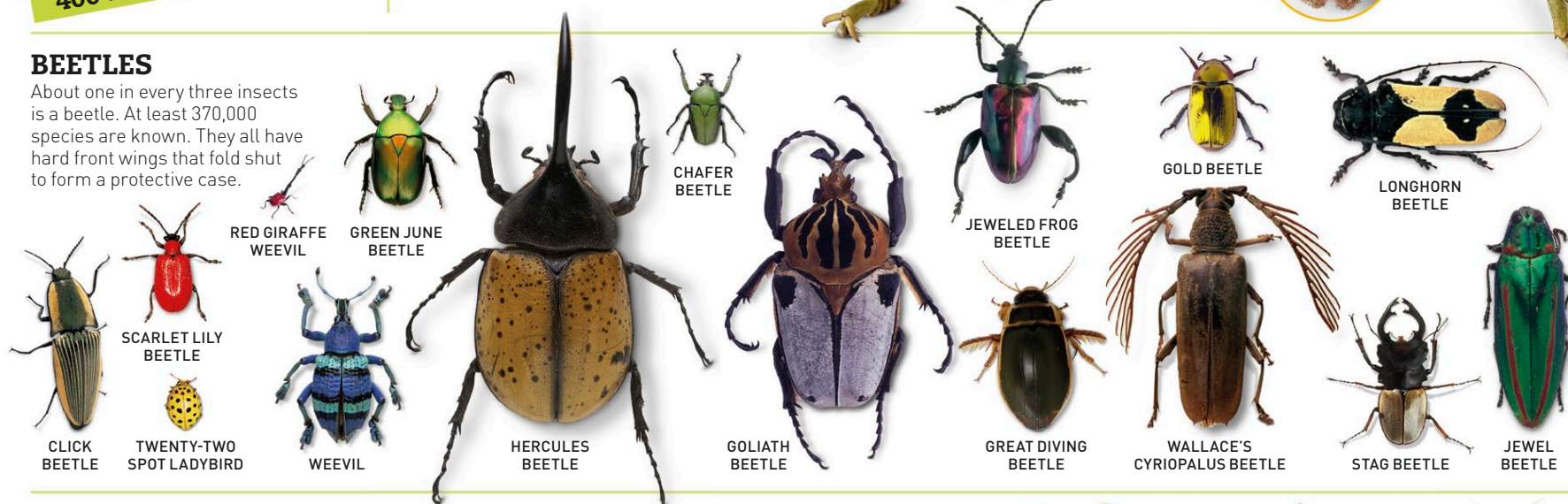
## THE BODY OF AN INSECT

Insects have three main body segments: the head; the thorax, or midsection, to which the legs and maybe wings are attached; and the abdomen or belly. All these parts are protected by a hard outer skeleton.



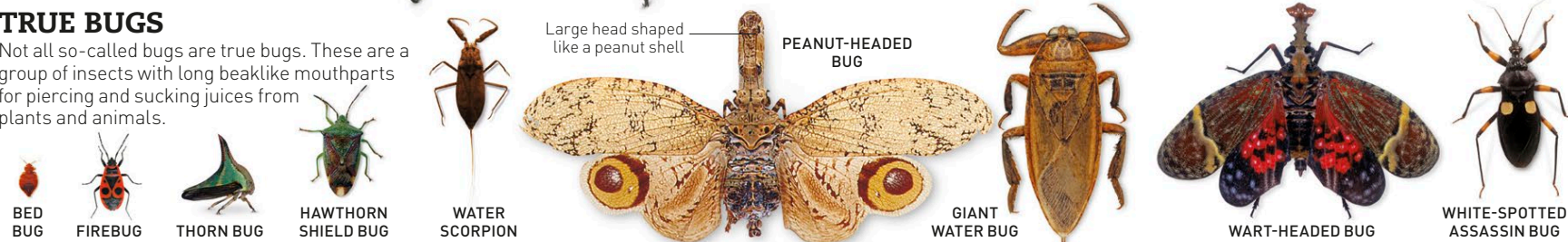
## BEETLES

About one in every three insects is a beetle. At least 370,000 species are known. They all have hard front wings that fold shut to form a protective case.



## TRUE BUGS

Not all so-called bugs are true bugs. These are a group of insects with long beaklike mouthparts for piercing and sucking juices from plants and animals.



## GRASSHOPPERS AND CRICKETS

A grasshopper makes its loud chirp by rubbing its hindlegs against its wings. Crickets "sing" by rubbing their wings together. Both types of insect fly and jump.





## ANTS, BEES, AND WASPS

These groups of insects include many that sting. Ants and nearly all types of bees and wasps live in organized colonies.



WOOD ANT



ARMY ANT



COMMON WASP



ASIAN CARPENTER BEE



TAWNY MINING BEE

## DRAGONFLIES AND DAMSELFLIES

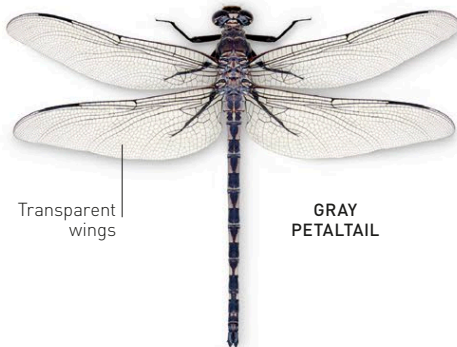
Strong muscles and large wings make these the flying aces of the insect world. They are skillful predators, darting through the air to catch other insects.



PLAINS CLUBTAIL



AZURE DAMSELFLY



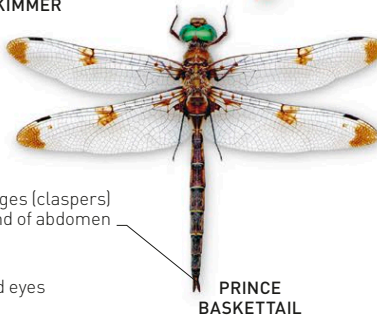
Transparent wings

GRAY PETALTAIL

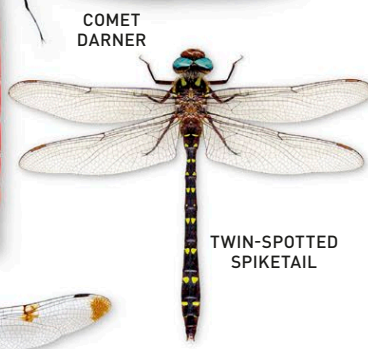


FLAME SKIMMER

Appendages (claspers) at end of abdomen



PRINCE BASKETTAIL



COMET DARTER

TWIN-SPOTTED SPIKETAIL



BROAD-BODIED CHASER



EMPEROR DRAGONFLY



SOUTHERN HAWKER DRAGONFLY



ILLINOIS RIVER CRUISER



BANDED DEMOISELLE



GIANT HAWKER



WHITE-LEGGED DAMSELFLY

## FLIES

True flies have just one functioning pair of wings. Although some types of flies are disease-carrying pests, many are useful as pollinators of plants.



BLUEBOTTLE



TIMBER FLY



HOUSE FLY



GIANT BLUE ROBBER FLY

## BUTTERFLIES AND MOTHS

Often colorful, butterflies are daytime flyers. Moths are usually duller and most fly at night. Both have tiny scales on their wings.



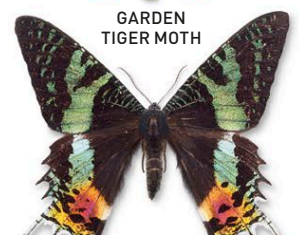
ORANGE OAKLEAF BUTTERFLY



MONARCH BUTTERFLY



GARDEN TIGER MOTH



MADAGASCAN SUNSET MOTH

## LIFECYCLE

All insects start life as an egg. Once they hatch, their bodies go through changes as they grow into adults. The lifecycle of the ladybird, shown here, is how many beetles develop.



**1 EGGS**  
The female may lay hundreds of eggs over the spring and early summer.



**2 LARVA**  
Each egg hatches into a larva (young, undeveloped insect).



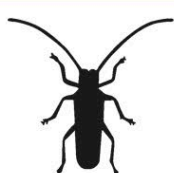
**3 SKIN CHANGES**  
The larva eats and grows, shedding its skin multiple times over several weeks.



**4 PUPA**  
When the larva is full size, its skin splits to reveal the pupa (nonfeeding stage).



**5 ADULT**  
Inside a tight wrapping, the pupa changes, and an adult ladybird emerges.



TITAN LONGHORN BEETLE  
6.5 IN (16.7 CM)



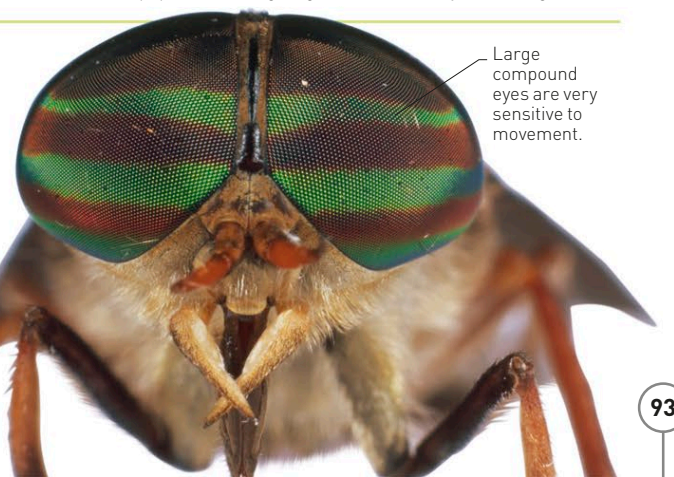
FAIRYFLY  
0.005 IN (0.139 MM)

## BIGGEST AND SMALLEST

One of the largest insects in the world is the South American Titan Longhorn Beetle, which can fill the palm of a hand. The tiniest insects are fairyflies, barely visible without a magnifying glass.

## ALL-AROUND VISION

Insects have compound eyes. While a human eye has one lens, a compound eye has hundreds or thousands of lenses. This allows insects to look in many directions at once.



Large compound eyes are very sensitive to movement.

HORSEFLY

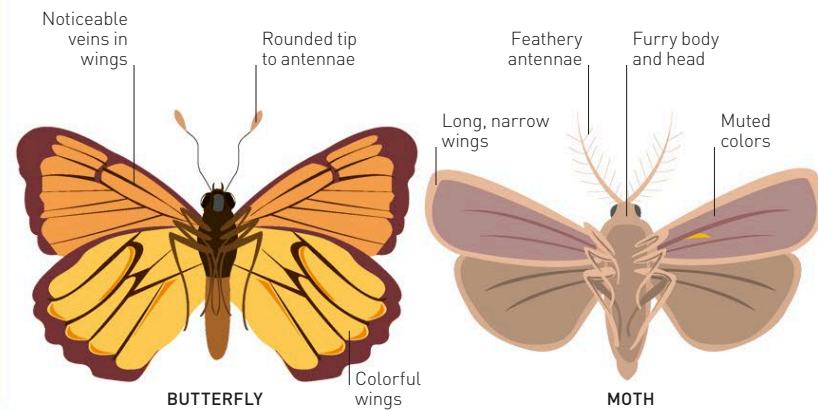


# Butterflies and moths

With their delicate shapes and often stunning colors, butterflies and moths are beautiful insects. Both have four wings covered in tiny scales that create a mosaic of exquisite patterns. Most butterflies and moths feed on nectar from flowers and are important for pollinating plants.

## WHAT'S THE DIFFERENCE?

Butterflies fly by day, and many are brightly colored. To hide, they fold their wings upright. Most moths fly at night and have duller coloring. They have furry bodies, and males have feathery antennae. When resting, moths either hold their wings apart or fold them close to the body.



## BUTTERFLIES

There are butterflies nearly everywhere in the world. The biggest wings and boldest patterns are seen mostly in species from tropical regions. A butterfly's colors not only attract mates, but also provide protection. To a predator, bright wings are a warning that the prey could be poisonous to eat.



LARGE COPPER



BROWN-VEINED WHITE



ORANGE-BARRED GIANT SULPHUR



IMPERIAL WHITE



LEAFWING



BLUE NIGHT BUTTERFLY



REGENT SKIPPER



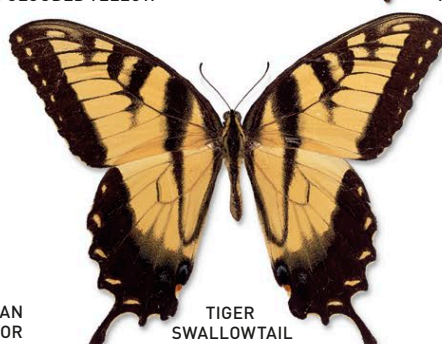
MOORLAND CLOUDED YELLOW



MECHANITIS MIMIC



BRAZILIAN DYNASTOR



TIGER SWALLOWTAIL



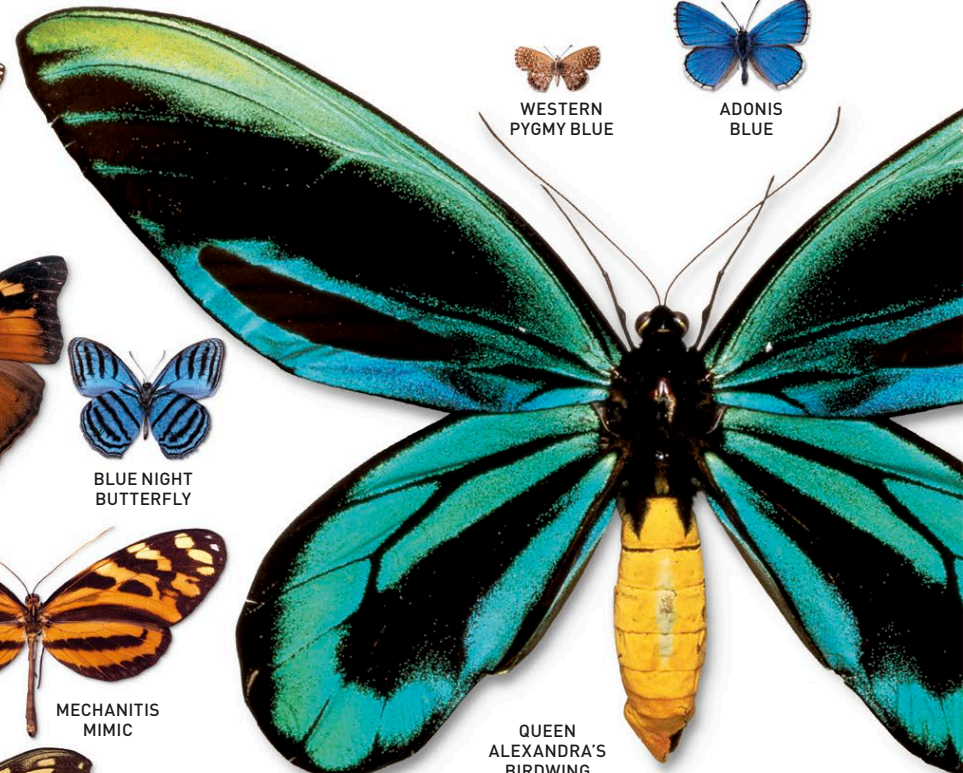
BLUE TRIANGLE



PEACOCK BUTTERFLY



APOLLO



QUEEN ALEXANDRA'S BIRDWING



WESTERN PYGMY BLUE



ADONIS BLUE

## MOTHS

There are many more moths than butterflies. Most are less eye-catching, but spectacular species do exist. The gigantic moon moths can have wingspans of up to 12 in (30 cm).



PROVENCE BURNET



MADAGASCAN SUNSET MOTH



INFANT MOTH



GOLDEN EMPEROR



ORNATE MOTH



SMOOTH EMERALD



ORIZABA SILKMOTH

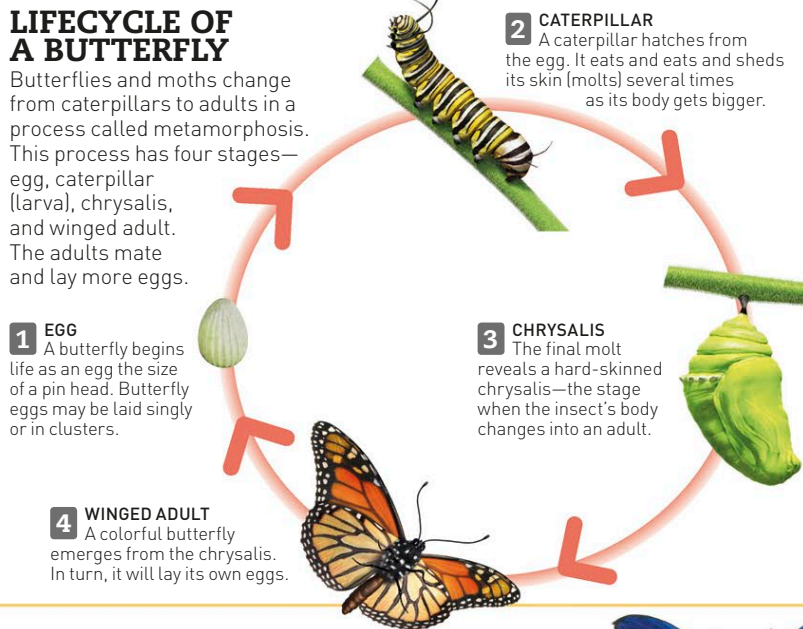


## LIFECYCLE OF A BUTTERFLY

Butterflies and moths change from caterpillars to adults in a process called metamorphosis. This process has four stages—egg, caterpillar (larva), chrysalis, and winged adult. The adults mate and lay more eggs.

**1 EGG**  
A butterfly begins life as an egg the size of a pin head. Butterfly eggs may be laid singly or in clusters.

**4 WINGED ADULT**  
A colorful butterfly emerges from the chrysalis. In turn, it will lay its own eggs.



**2 CATERPILLAR**  
A caterpillar hatches from the egg. It eats and eats and sheds its skin (molts) several times as its body gets bigger.

**3 CHRYSALIS**  
The final molt reveals a hard-skinned chrysalis—the stage when the insect's body changes into an adult.

## LARGEST AND SMALLEST

The female Queen Alexandra's birdwing is the world's biggest butterfly, with a wingspan of up to 11 in (28 cm). The Western pygmy blue has a wingspan of less than 0.5 in (2 cm), making it one of the world's smallest.



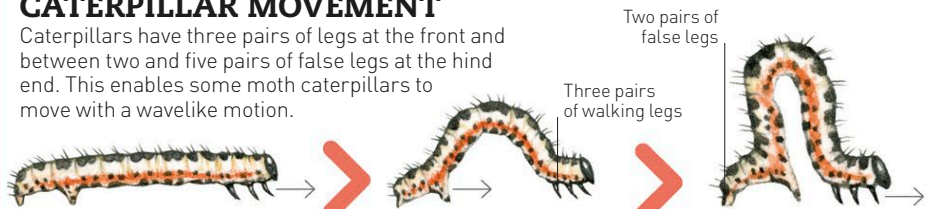
## CATERPILLAR MOVEMENT

Caterpillars have three pairs of legs at the front and between two and five pairs of false legs at the hind end. This enables some moth caterpillars to move with a wavelike motion.

**1 FRONT MOVES**  
The caterpillar moves its front part forward, leaving the rear anchored.

**2 REAR CATCHES UP**  
It draws its hind end forward while holding on with the front legs.

**3 FRONT MOVES AGAIN**  
It then moves its front again, gripping with the false legs at the back.



## CATERPILLARS

Different species of caterpillars vary greatly in appearance, but all are big eaters. Most feed on plants, often of one type only. Less usual foods include wool and the horns of dead cattle.



DEATH'S HEAD HAWK-MOTH



OAK LEAFROLLER



PUSS MOTH



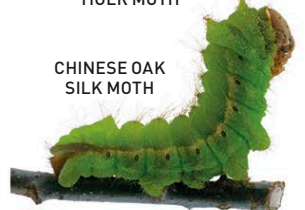
POSTMAN BUTTERFLY



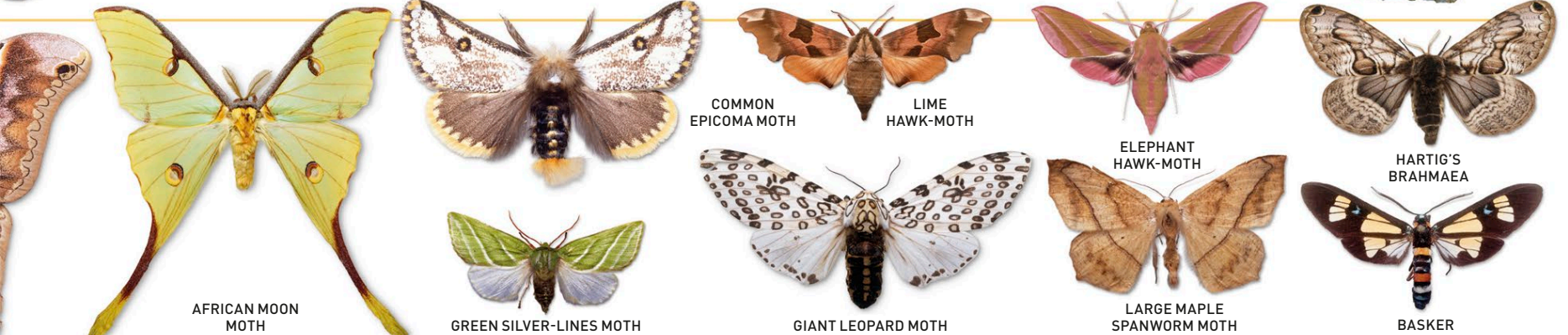
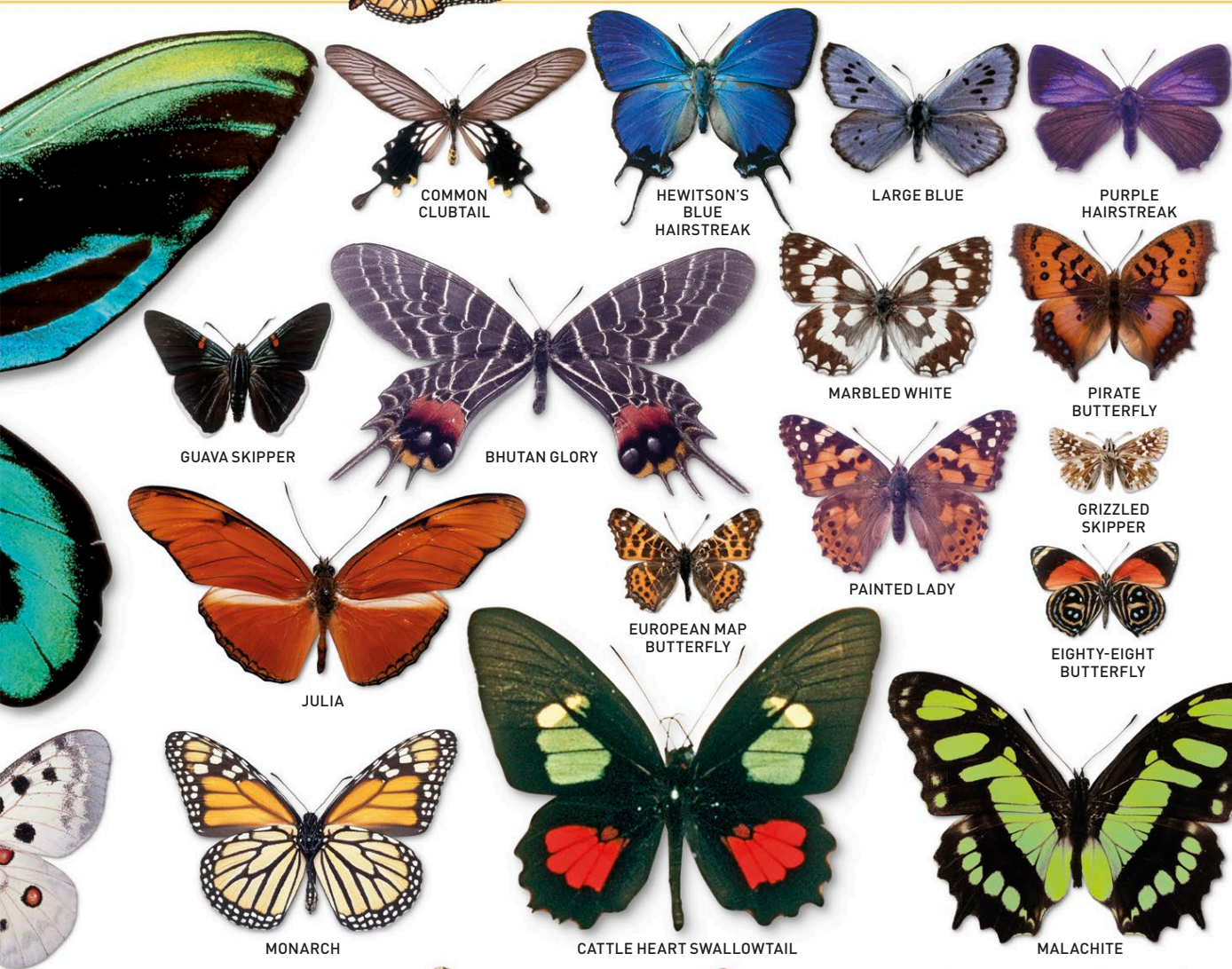
SWALLOWTAIL



TIGER MOTH



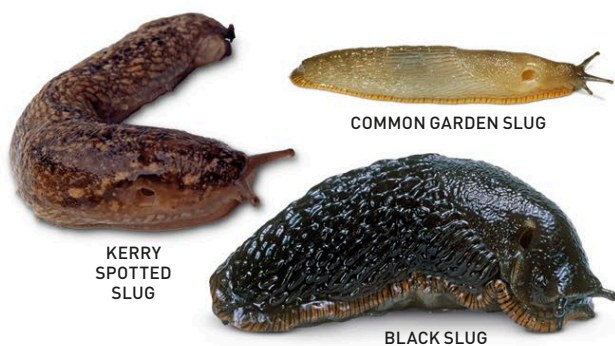
CHINESE OAK SILK MOTH





## LAND SLUGS

With no shell to retreat into, slugs have to hide, emerging at night to feed. Some live underground. Although seen as pests for devouring garden plants and farm crops, slugs play a useful part in breaking down rotting vegetation.



## SEA SLUGS

As wobbly as jelly and often as brightly colored, sea slugs creep over seabeds and corals. Some can swim in a clumsy fashion. They have feathery or spiky gills, or breathing organs, on their backs.



## LAND SNAILS

Among the best-known animals on Earth, land snails range from species no bigger than a pinhead to the giant African land snail, which can reach 15.5 in (30 cm) long and weigh up to 2 lb (900 g). Their shells are more than portable homes. The colors and patterns provide camouflage by blending into the snail's habitat.

**SOME TYPES OF SNAIL ARE HUNTERS THAT PREY ON WORMS, SLUGS, AND EVEN OTHER SNAILS.**

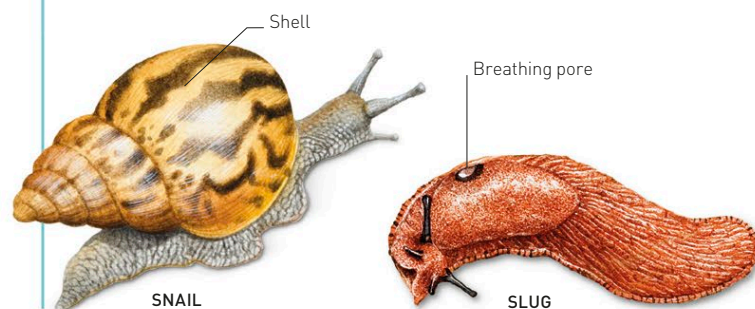


# Slugs and snails

Leaving pathways of shining slime made by their own bodies, land slugs and snails are familiar in damp places almost all over the world. Less often seen, except sometimes as aquarium pets, are slugs and snails that live in water. Many of these, especially species from warm oceans, are vividly colored or have fantastically shaped shells.

## WHAT'S THE DIFFERENCE?

The bodies of slugs and snails are very similar, but a snail can pull its body into a hard, chalky shell for protection or to stop itself losing vital moisture in dry weather. Some slugs have a tiny internal shell that stores calcium.







LETTUCE SEA SLUG

BLACK-MARGINED SEA SLUG

SPOTTED SEA HARE

VARIABLE NEON SEA SLUG

## AQUATIC SNAILS

Some of these snails live in the sea, and others in fresh water. Sea snails are often highly colorful. Many have spectacular spiraling shells, like the huge Triton's trumpet snail, a predator that injects poison into its prey.



DOG WHELK



APPLE SNAIL



GREAT POND SNAIL



RAMSHORN SNAIL

Shell up to 20 in (50 cm) long



COMMON WHELK



TRITON'S TRUMPET

## SURPRISING RELATIVES

The octopus seems an unlikely relative of slugs and snails, but it is in the same major scientific group—the mollusks. Many other animals, possibly just as unexpected, also belong to this group. Some of them are shown here.



GIANT CLAM



AUSTRALIAN GIANT CUTTLEFISH



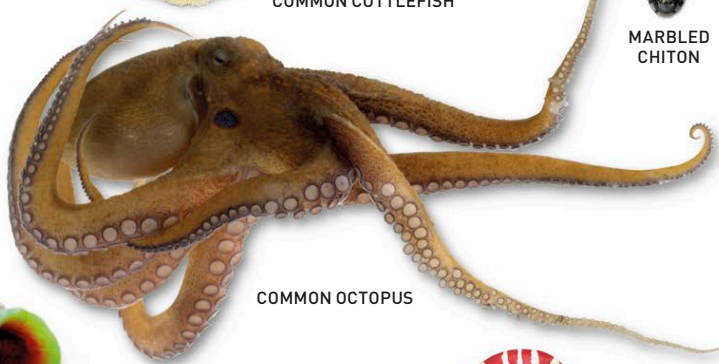
GEODUCK CLAM



COMMON CUTTLEFISH



PACIFIC THORNY OYSTER



COMMON OCTOPUS



MARbled CHITON



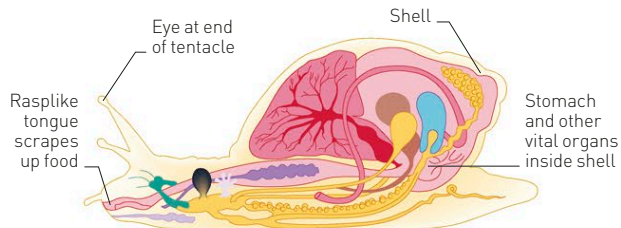
BIGFIN REEF SQUID



NAUTILUS

## BONELESS BODIES

Slugs and snails have no bones. Their soft bodies consist of a head, a central part containing the organs, and an underside, or "foot," that they use for moving. The head carries one or two pairs of tentacles that contain eyes and other sense organs.



## SHELL SHAPES

Most snails have spiral shells, which come in many shapes and sizes. More unusual types of shells usually belong to sea snails. Among the variations are elegantly twisted cones, irregular shapes bristling with spikes, and flat shells like caps.



CLUB SHAPE



SPINDLE SHAPE

PEAR SHAPE



IRREGULAR

CAP SHAPE



SPIRAL SHAPE

EGG SHAPE

## HABITATS

There are tens of thousands of different slugs and snails living in a wide variety of habitats. They are found on mountains and seabeds and in rivers, forests, and gardens.



**SEA**  
Many slugs and snails live on coral reefs and in warm seas. A few occur at great depths.



**FRESH WATER**  
Ponds, lakes, streams, and rivers are all common habitats for freshwater snails.

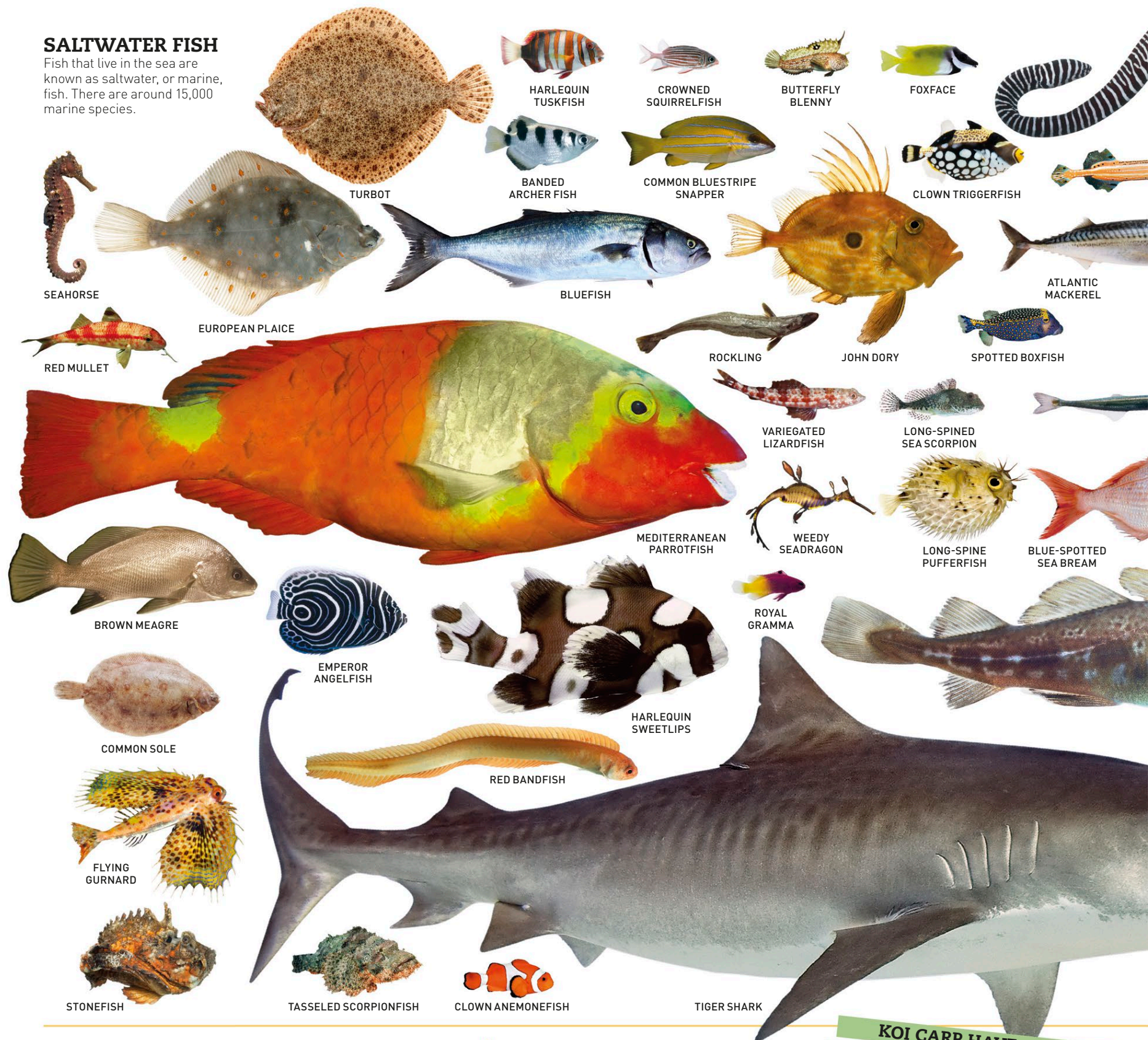


**LAND**  
Few snails can survive in a dry habitat. Most, like slugs, thrive only in damp places.



## SALTWATER FISH

Fish that live in the sea are known as saltwater, or marine, fish. There are around 15,000 marine species.

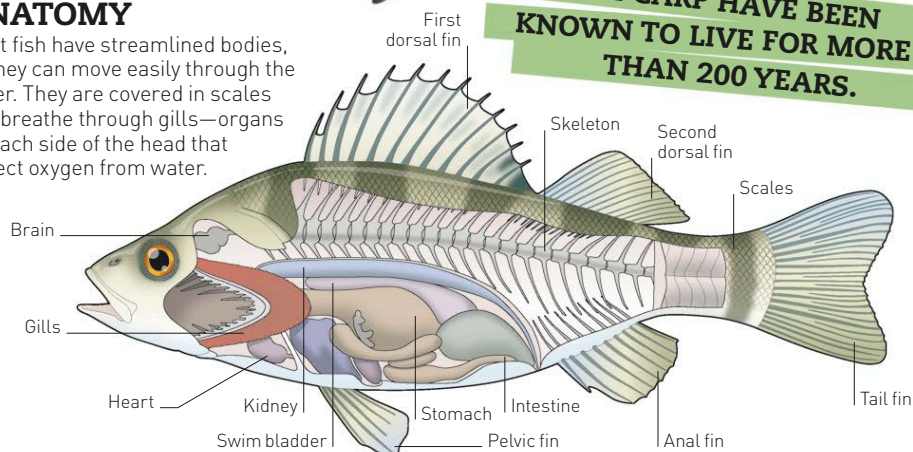


# Fish

Fish can be found in nearly every type of watery environment, from mountain streams to the deepest oceans. They range from 0.5 in (12 mm) to 53 ft (16 m) in length, and there are some 28,000 species.

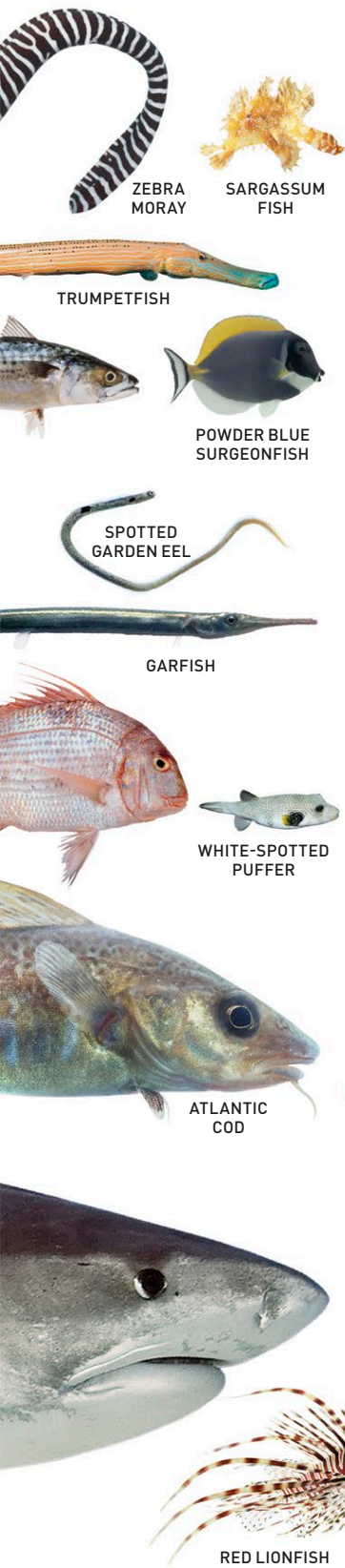
## ANATOMY

Most fish have streamlined bodies, so they can move easily through the water. They are covered in scales and breathe through gills—organs on each side of the head that collect oxygen from water.



**KOI CARP HAVE BEEN KNOWN TO LIVE FOR MORE THAN 200 YEARS.**





## FRESHWATER FISH

Around 13,000 fish species live in fresh (nonsalty) water in lakes, streams, rivers, and ponds. Some fish, known as euryhaline fish, can adapt to live in salty or fresh water.



## TYPES OF FISH

There are three main types of fish: jawless, bony, and cartilaginous. Bony species make up the highest number (27,000), then cartilaginous (970), and finally the jawless species (100).



### JAWLESS FISH

This is the oldest type of fish. They have no jaws or scales.



### BONY FISH

These are the only fish with a skeleton made of bone.



### CARTILAGINOUS FISH

These are similar to bony fish but have a skeleton made of cartilage.

## DEFENSE

Most fish do not have weapons (such as spines) on their bodies to defend themselves, so they do clever things to make themselves look bigger or disappear from view.



### SWIMMING IN GROUPS

A group of fish swimming in a school looks like one big fish to a predator.



### BURIED IN SAND

Flatfish can alter the color and pattern of their skin so they can hide by lying flat in the sand.



### HIDING IN ANEMONE

Clownfish hide in the stinging tentacles of sea anemones to avoid predators.



### BALLOONING UP

When threatened, porcupine fish inflate their bodies to make sharp spines stand up.

## CARING FATHERS

Fish don't usually take care of their young. However, for a few species, including the seahorse, the male carries the fertilized eggs until they hatch.



MALE SEAHORSE

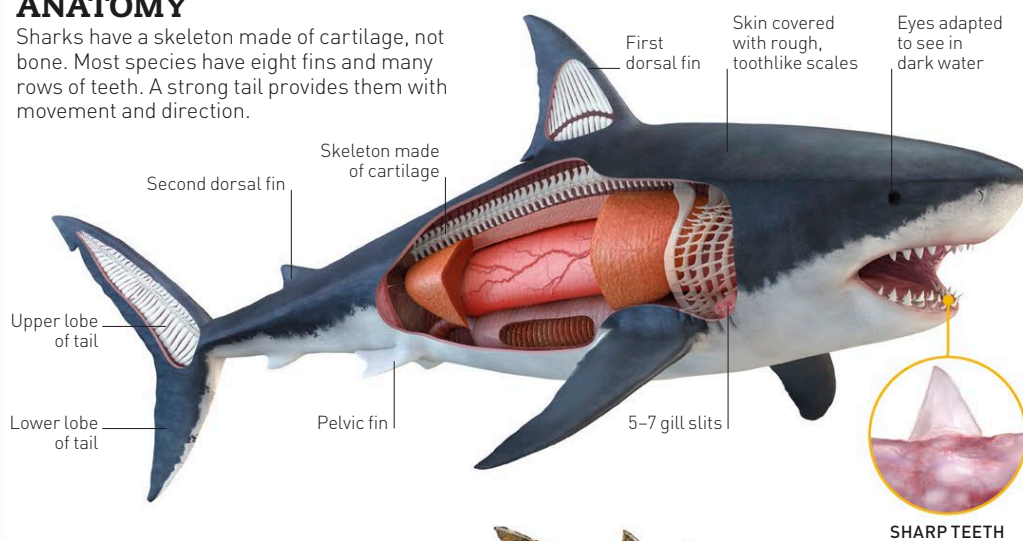


# Sharks

Sharks have prowled the oceans for 400 million years, which means they existed before the dinosaurs. In all that time, they have hardly changed at all, possibly because they are so perfectly suited to their environment. There are more than 500 different species of sharks.

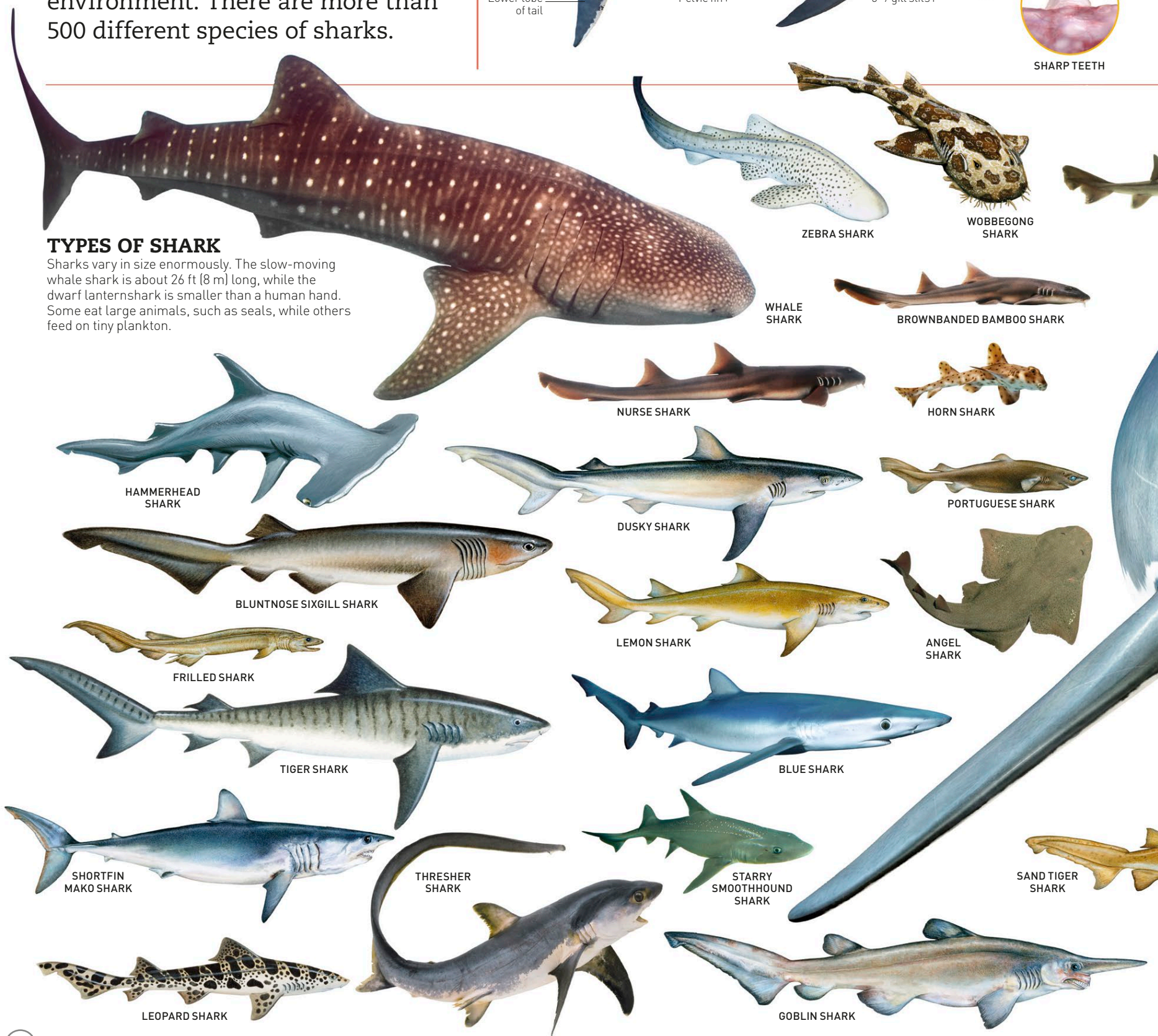
## ANATOMY

Sharks have a skeleton made of cartilage, not bone. Most species have eight fins and many rows of teeth. A strong tail provides them with movement and direction.



## TYPES OF SHARK

Sharks vary in size enormously. The slow-moving whale shark is about 26 ft (8 m) long, while the dwarf lanternshark is smaller than a human hand. Some eat large animals, such as seals, while others feed on tiny plankton.





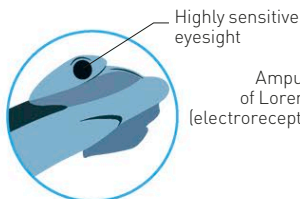
## SENSES

As well as having excellent eyesight, hearing, and sense of smell, sharks have an extra sense that humans do not have: electrical sensing. Special pores in their skin pick up electrical fields generated by other animals.



**SNOUT**

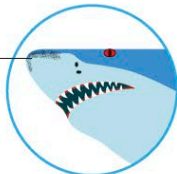
Two nasal cavities give the shark an acute sense of smell.



**EYES**

A shark's eyes are about 10 times more sensitive to light than human eyes.

Ampullae of Lorenzini (electroreceptors)

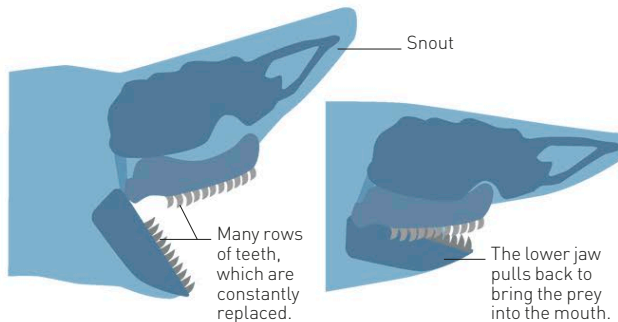


**ELECTRICAL SENSORS**

The snout contains cells that sharks use to "receive" electric signals from nearby creatures.

## LETHAL JAWS

To catch its prey, a great white shark lifts its snout, drops its upper jaw, sticks out its lower jaw, and takes a large bite. Sharks' teeth are sharp, often serrated, so they can rip through flesh easily.



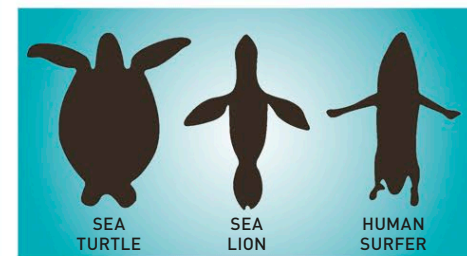
Snout

Many rows of teeth, which are constantly replaced.

The lower jaw pulls back to bring the prey into the mouth.

## MISTAKEN IDENTITY

Although there are around 500 shark species, only 25 have been known to attack humans. This may be because they mistake people for fish, seals, sea lions, or turtles.



SEA TURTLE

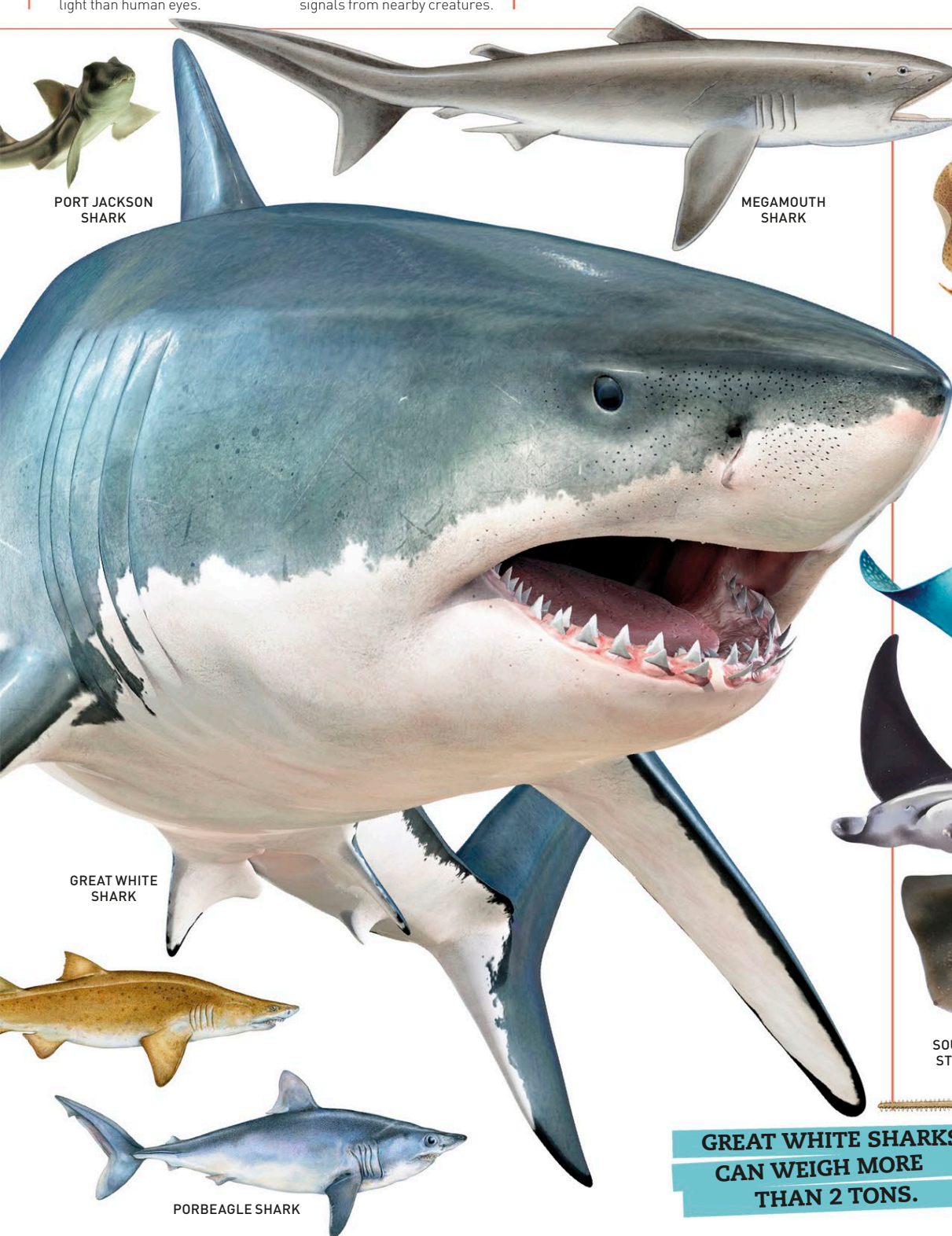
SEA LION

HUMAN SURFER

**SHARKS USUALLY LET GO AFTER EACH BITE THEY TAKE OUT OF THEIR PREY.**

## RELATIVES

Rays, skates, and sawfish are flattened fish that are related to sharks. They, too, have a skeleton made of cartilage. These fish have existed on Earth for at least 150 million years.



PORT JACKSON SHARK

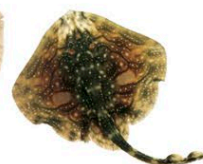
MEGAMOUTH SHARK

GREAT WHITE SHARK

PORBEAGLE SHARK



BLONDE RAY



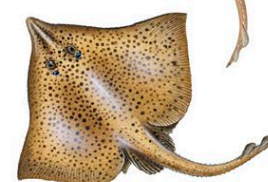
UNDULATE RAY



BIG SKATE



THORNBACK RAY



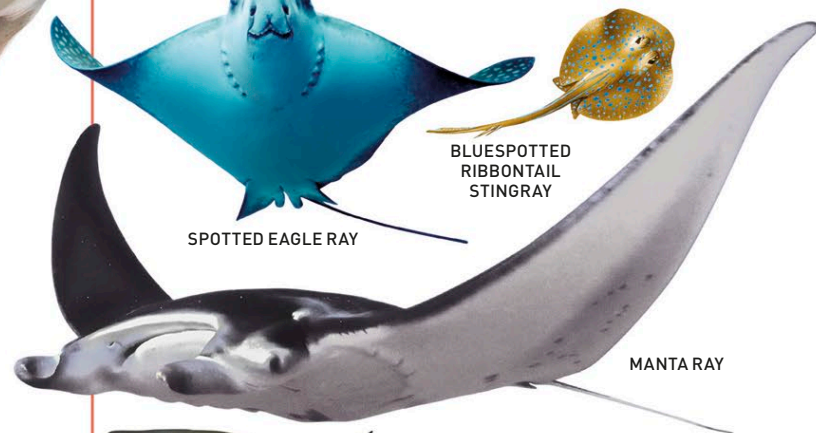
BARNDOR SKATE



SPOTTED EAGLE RAY



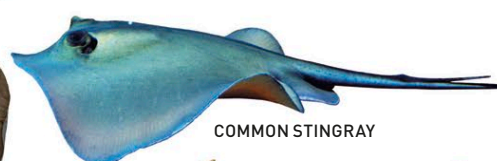
BLUESPOTTED RIBBONTAIL STINGRAY



MANTA RAY



SOUTHERN STINGRAY



COMMON STINGRAY



SMALLTOOTH SAWFISH



SPOTTED RATFISH

**GREAT WHITE SHARKS CAN WEIGH MORE THAN 2 TONS.**



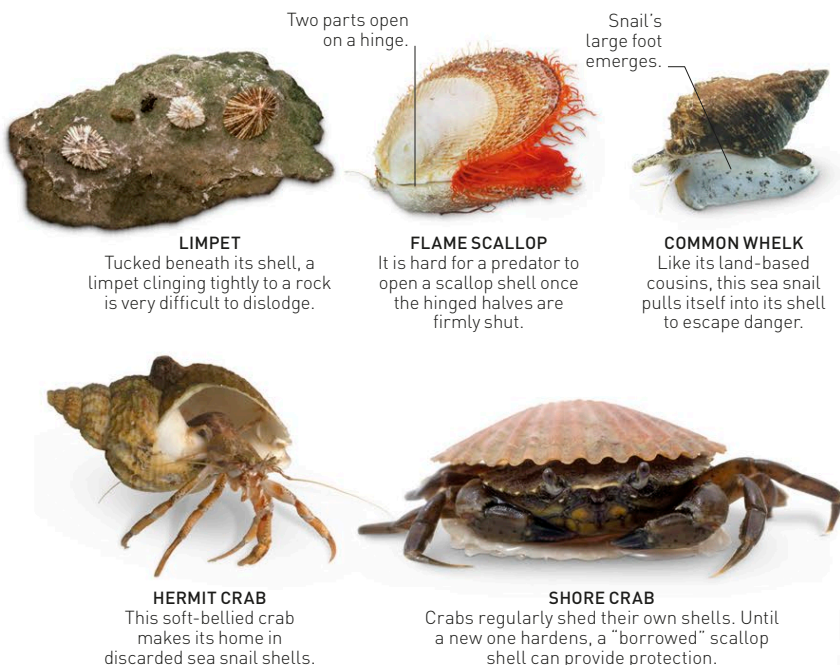
# Seashells

The shells that wash up on beaches are the empty homes of soft-bodied sea animals called mollusks. Shells come in amazing shapes and colors. Some have two joined halves, and others are in one piece, often a coil or a spiral. No two, even of the same type, are ever identical.

## WHO NEEDS A SHELL?

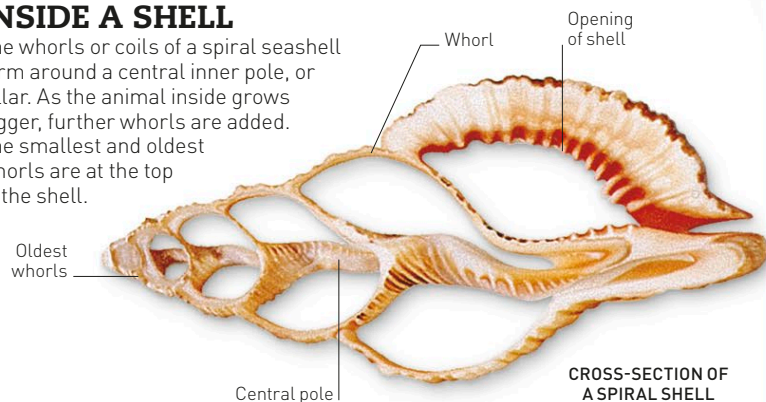
Mollusks have easily damaged bodies and are too slow moving to hurry away from danger. A rigid shell provides a safe place to retreat into or close up tightly when predators are around. Empty shells make useful shelters for other animals.

**THERE ARE MORE THAN 90,000 KNOWN SPECIES OF MOLLUSKS.**



## INSIDE A SHELL

The whorls or coils of a spiral seashell form around a central inner pole, or pillar. As the animal inside grows bigger, further whorls are added. The smallest and oldest whorls are at the top of the shell.



## SIZE COMPARISON

The biggest mollusks on Earth are the giant clams, which can weigh as much as 500 lb (227 kg). The smallest shells belong to some minute sea snails, several of which would fit on a thumbnail.



## HINGED SHELLS

Many mollusks—such as clams, scallops, and oysters—are bivalves. Their shells are divided into two parts called valves that are joined by a hinge. The animal opens the shell to feed and closes it to take refuge.



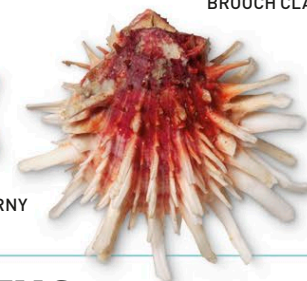
CHICKEN VENUS



AUSTRALIAN BROOCH CLAM



GIANT RAZOR SHELL



PACIFIC THORNY OYSTER



PEARL OYSTER

## SNAIL SHELLS

The largest group of seashells are those of the sea snails. These are endlessly varied in size, shape, and pattern. There are species that twist like corkscrews, while others coil or look like caps or shiny eggs. The animals that live in these shells creep slowly around on a large, fleshy foot.



COMMON EGG COWRIE



HUMPBACK COWRIE



EYED COWRIE



MAP COWRIE



TROSCHEL'S MUREX



SCARLET CONE



FEATHERED CONE



TRITON'S TRUMPET



SPOTTED TUN



MAPLE LEAF TRITON



ROBIN REDBREAST TRITON





BLOOD-STAINED  
SANGUIN



CRADLE  
DONAX



PURPLISH  
SEMELE



CAMP PITAR  
VENUS



PACIFIC FILE  
SHELL



ICELAND SCALLOP



QUEEN SCALLOP



COMMON  
MUSSEL



TWISTED WING  
OYSTER



GIANT  
COCKLE



ROYAL CLOAK  
SCALLOP



LION'S PAW  
SCALLOP



EUROPEAN  
CHINA LIMPET



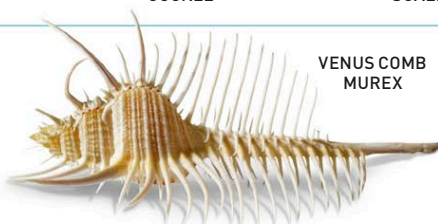
LISTER'S  
KEYHOLE  
LIMPET



CINNABAR  
LIMPET



PACIFIC  
SUGAR LIMPET



VENUS COMB  
MUREX



COMMON  
JANTHINA



PRECIOUS  
WENTLETRAP



CLEAR  
SUNDIAL



STARRY  
MOON



EPISCOPAL  
MITER



BLOODSUCKER  
MITER



SUPERIOR  
MITER



DENNISON'S  
MITER



LITTLE  
FOX MITER



BUTTERFLY  
MITER



PONTIFICAL  
MITER



MATCHLESS  
CONE



RAPA SNAIL



HOOPED  
WHELK



NORTH'S  
LONG  
WHELK



CLATHRATE  
DOG WHELK



GLANS DOG  
WHELK



PIMPLED  
DOG WHELK



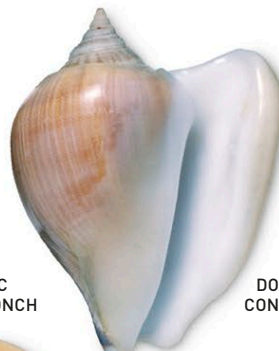
LIGHTNING  
WHELK



PINK  
CONCH



PACIFIC  
CROWN CONCH



DOG  
CONCH



BROAD  
PACIFIC  
CONCH

POWIS'S  
TIBIA



LESSER  
GIRDLED  
TRITON



ANGULAR  
TRITON



RED ABALONE



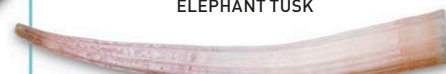
DONKEY'S EAR ABALONE

## TUSK SHELLS

These seashells are not often found on the beach. Most of them live buried beneath the sand in deep water.



ELEPHANT  
TUSK



EUROPEAN  
TUSK SHELL



BEAUTIFUL TUSK

## CHITONS

The shells of chitons are made of eight movable, overlapping sections. They are sometimes called coat-of-mail shells. Chitons live under rocks and stones near the shore.



WEST INDIAN  
CHITON



MARBLED CHITON

## CHAMBERED SHELLS

A few shells are divided inside into chambers. In the squidlike Nautilus, some chambers are gas-filled, which allows the shell to float. The chambered shell of the Spirula squid is inside the animal, not outside. The similar-looking Paper-nautilus "shell" is the empty egg case of an animal called an argonaut.



NAUTILUS



COMMON SPIRULA



PAPER-NAUTILUS



## FROGS AND TOADS

There are more than 6,300 species of frogs and toads in total. They live on every continent except Antarctica.



RED-EYED  
TREE FROG



BOULENGER'S  
ASIAN TREE TOAD



ORIENTAL  
FIRE-BELLIED TOAD



MEXICAN  
BURROWING TOAD



ORNATE HORNED TOAD



EUROPEAN  
TREE FROG



AMAZON  
MILK FROG



SPLENDID  
LEAF FROG



STRAWBERRY  
POISON-DART FROG



GREEN AND BLACK  
POISON-DART FROG



LEHMANN'S  
POISON-DART FROG



DYEING POISON  
FROG



YELLOW STRIPED  
POISON FROG



DUCK-BILLED  
TREE FROG



GREY FOAM-NEST  
TREE FROG



WHITE-LIPPED  
TREE FROG



WHITE'S  
TREE FROG



SPRING PEEPER



MALAGASY PAINTED  
MANTELLA



GOLDEN POISON  
FROG



YELLOW-HEADED  
POISON-DART FROG

## SALAMANDERS AND NEWTS

Salamanders look like lizards, with long bodies and tails. However, unlike lizards, salamanders have soft, moist skin.



OITA  
SALAMANDER



RED-BACKED  
SALAMANDER



FIRE  
SALAMANDER



AXOLOTL  
(MEXICAN SALAMANDER)

# Amphibians

Amphibians are cold-blooded vertebrates that typically start life in the water, where they breathe using gills. As adults, many develop lungs, allowing them to live on land. Frogs, toads, newts, and salamanders are all amphibians.

## FEATURES

Most amphibians share some key features. They start life as eggs and then aquatic larvae and need to live close to water as adults.



COLD-BLOODED



HAVE MOIST SKIN



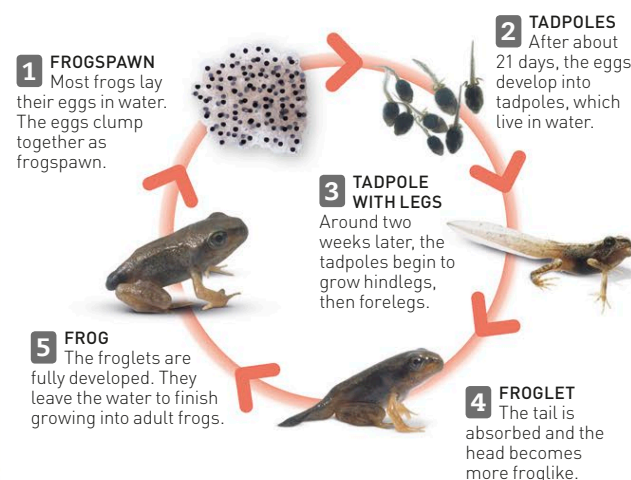
MANY HATCH  
AS TADPOLES



LAY EGGS TO  
REPRODUCE

## LIFECYCLE OF A FROG

Most frogs lay hundreds of eggs because many get eaten by predators. Those that survive undertake remarkable changes, becoming tadpoles and then frogs.







EUROPEAN  
GREEN TOAD



RAUCOUS TOAD



NATTERJACK TOAD



GREEN CLIMBING  
TOAD



AFRICAN SQUARE-  
MARKED TOAD



MAJORCAN  
MIDWIFE TOAD



EUROPEAN COMMON TOAD



CHILEAN RED-SPOTTED TOAD



AMERICAN TOAD



MARSH FROG



BANDED BULLFROG



WOOD FROG



TUNGARA FROG



EDIBLE FROG



GOLIATH  
FROG



PARADOXICAL FROG



PICKREL FROG



CANE TOAD



CROCODILE  
NEWT



SMOOTH NEWT



MARBLE NEWT

## CAECILIANS

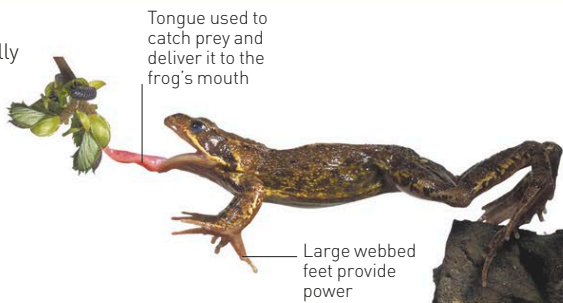
These limbless, wormlike amphibians are rarely seen. They live in soil, burrows, or underwater and use their sharp, curved teeth to catch worms.



ASIAN  
CAECILIAN

## HUNTING

A hunting frog usually sits still until it sees a bug or worm within range. Then it jumps or leans forward, catching its prey on its long, sticky tongue.

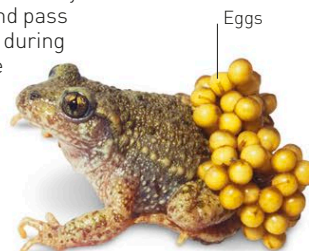


Tongue used to catch prey and deliver it to the frog's mouth

Large webbed feet provide power

## PARENTAL CARE

Female midwife toads lay strings of eggs and pass them to the male during mating. The male carries the eggs on his back until they are ready to hatch.



Eggs

## HOW FROGS SWIM

Most frogs propel themselves through water by pushing back against it with their webbed back feet. Their smaller forelimbs help them change direction.



**1 PULL**  
The frog pulls its back legs toward its body by contracting its thigh muscles.



**2 KICK**  
It pushes its forelimbs down to its sides as it begins to kick backward.



**3 STEER**  
As the legs finish the kick, the forelimbs reach forward to steer through the water.



## MOST TOXIC

The world's most poisonous frogs live in foliage and on the ground in the hot, damp forests of Central and South America.

### GOLDEN POISON-DART FROG

One of the most toxic animals on Earth, this frog only carries about 1 mg of poison, but that is enough to kill 10 humans. It lives in Colombia and stores poison in its skin.

### BLACK-LEGGED DART FROG

A cousin of the golden poison-dart frog, this frog is also found in Colombia. Its poison is used on the tips of hunting darts.

### PHANTASMAL POISON FROG

This bright red and white frog lives in Ecuador. It is tiny—only 0.4–1.6 in (1–4 cm)—but deadly. Despite its size, it carries enough toxin to kill a human.

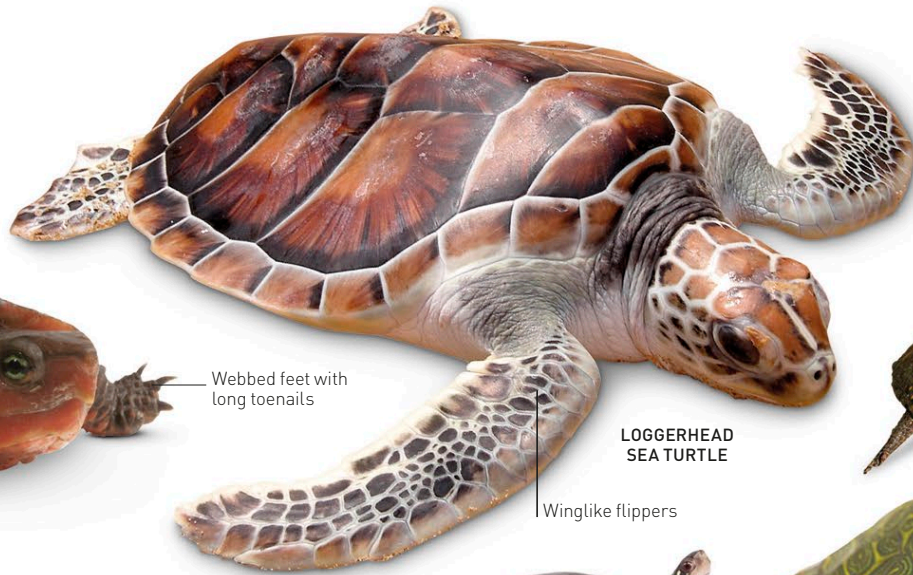


## TURTLES

Most turtles spend nearly all their lives in water. For a few species, this is the ocean, but there are also freshwater turtles, some of which are called terrapins. With streamlined shells and webbed feet or flippers, turtles are well made for swimming and diving.



BIG-HEADED TURTLE



LOGGERHEAD  
SEA TURTLE



BLANDING TURTLE



COMMON  
SNAPPING TURTLE



MISSISSIPPI  
MAP TURTLE



SPOTTED  
TURTLE



NORTHERN  
RED-BELLIED TURTLE

## TORTOISES

These slow-moving land-dwellers have strong shells, often with a high dome that is difficult for predators to bite. They have short, bent legs and strong, stumpy feet.

**GALÁPAGOS TORTOISES, THE LARGEST IN THE WORLD, CAN GROW UP TO 4 FT (1.2 M) LONG AND WEIGH UP TO 595 LB (270 KG).**



DESERT TORTOISE



RED-FOOTED  
TORTOISE



SPUR-THIGGED  
TORTOISE



HORSEFIELD  
TORTOISE



ELONGATED  
TORTOISE



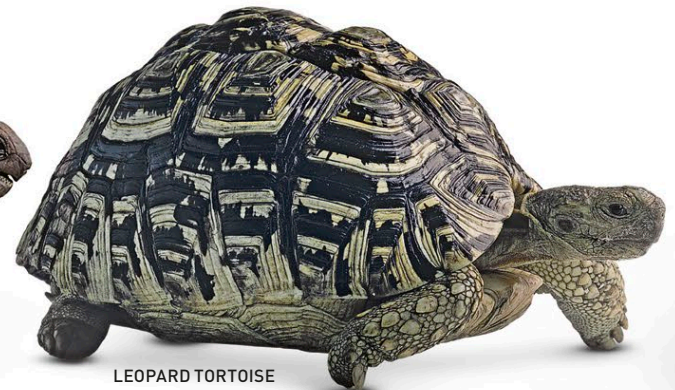
SERRATED HINGE-  
BACK TORTOISE



PANCAKE  
TORTOISE



GALÁPAGOS TORTOISE



LEOPARD TORTOISE

# Turtles and tortoises

There were turtles and tortoises on Earth even before the dinosaurs. They all belong to the same scientific group. The main difference between them is that turtles live in water and tortoises on land. All have shells and lay eggs.

## INSIDE THE SHELL

Turtles and tortoises have an unusual skeleton. Their ribs, spine, and some other bones form part of the shell. In nearly all species, the shell has a bony inner layer covered by thin plates of keratin, the same material as human fingernails.







COMMON SNAKE-NECKED TURTLE



YELLOW SLIDER



WEST AFRICAN BLACK TURTLE



RED-EARED SLIDER



POND TERRAPIN



CHINESE SOFT-SHELLED TURTLE



COMMON MUSK TURTLE

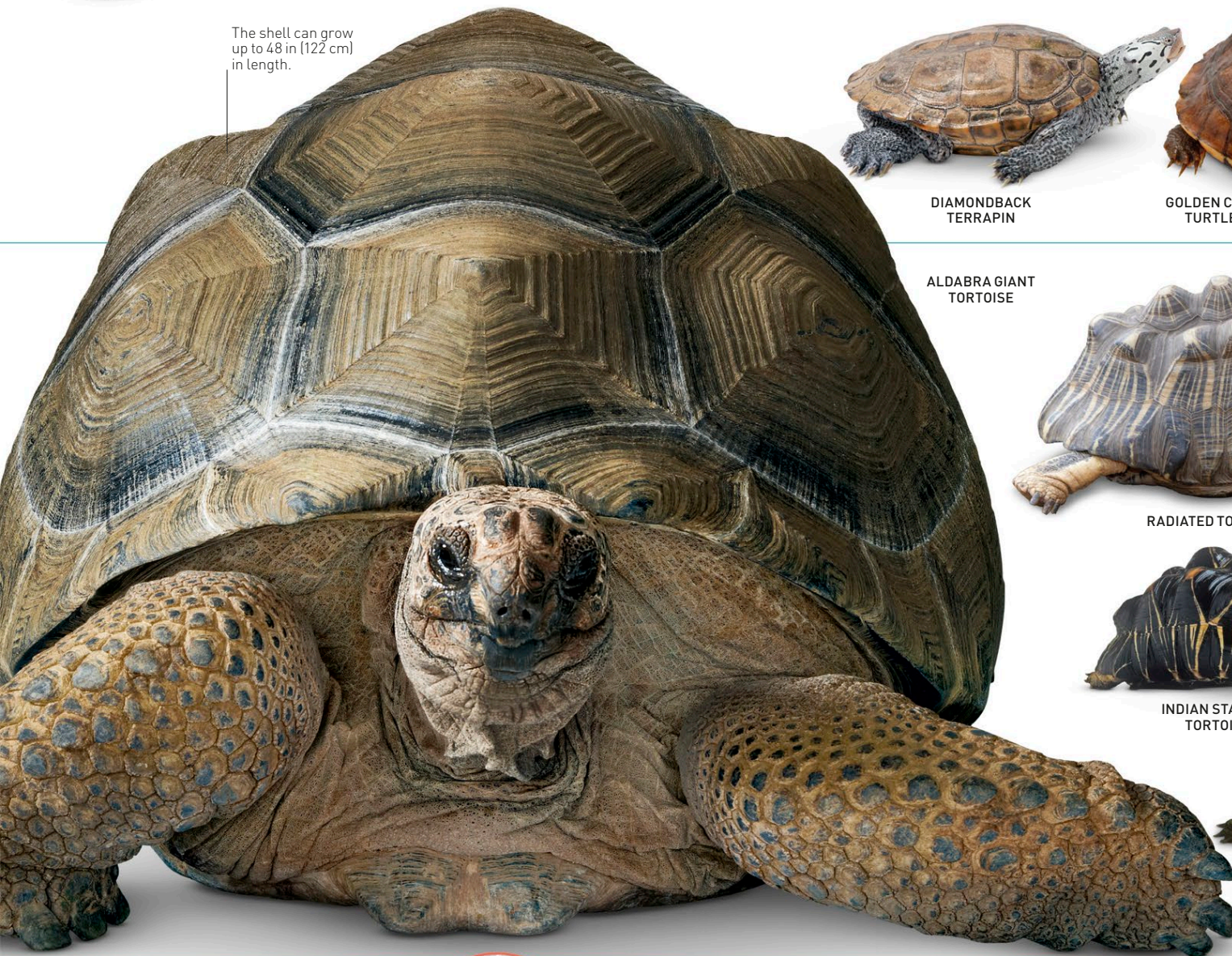


LITTLE PAINTED TURTLE



WOOD TURTLE

The shell can grow up to 48 in (122 cm) in length.

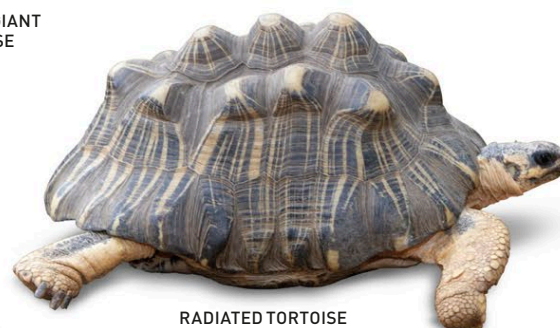


DIAMONDBACK TERRAPIN



GOLDEN COIN TURTLE

ALDABRA GIANT TORTOISE



RADIATED TORTOISE



INDIAN STARRED TORTOISE



HERMANN'S TORTOISE

## LIFECYCLE OF A TURTLE

All sea turtles come ashore to lay their eggs. They visit the same nesting beaches year after year. Depending on the species, the female may lay 50–200 eggs.

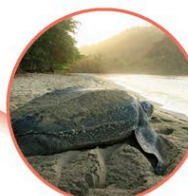
### 1 LAYING EGGS

The female lays her soft-shelled eggs in a scraped-out nesting chamber.



### 4 RETURN JOURNEY

Between 25 and 50 years of age, the adults make their first egg-laying trip back to the beach where they hatched.



### 2 HATCHLINGS HEAD OUT

The newly hatched babies dig their way out of the nest and crawl to the sea.



### 3 OCEAN LIFE

The young turtles spend many years entirely at sea, eating and growing.



## HIDING FROM DANGER

Tortoises move too slowly to run away from their natural predators, which include ravens, foxes, and dogs. Fortunately, they carry their own hiding place, which often keeps them safe until the danger has passed.



### 1 DETECTS A THREAT

A tortoise has a keen sense of smell that tells it when a likely predator is lurking nearby.



### 2 RETREATS INTO SHELL

Pulling in its legs and long, flexible neck, the tortoise disappears right into its shell. It is safe from the predator.

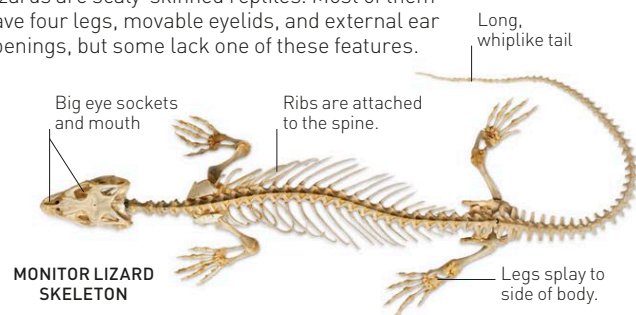


# Lizards

With more than 6,000 species, lizards are the largest group of reptiles on Earth. They are cold-blooded animals that live on every continent except Antarctica. Lizards are useful predators of insect pests.

## ANATOMY

Lizards are scaly-skinned reptiles. Most of them have four legs, movable eyelids, and external ear openings, but some lack one of these features.



## GECKOS

These small lizards have about 500,000 hairs on each foot that provide them with good adhesion for climbing smooth surfaces. They eat spiders and mosquitoes. Some make a clicking noise that sounds like "gecko."



TURQUOISE DWARF GECKO



LEOPARD GECKO



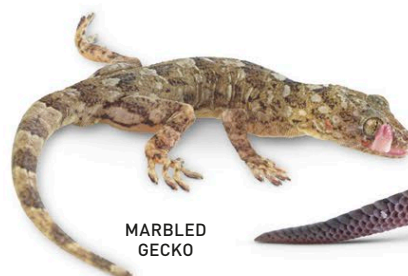
RING-TAILED GECKO



KUHL'S FLYING GECKO



TOKAY



MARBLED GECKO



WONDER GECKO



PALM GECKO



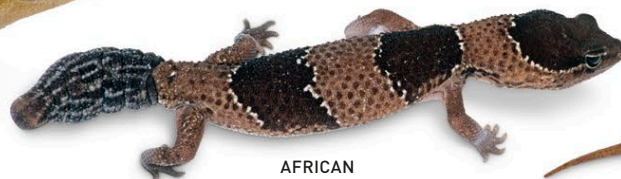
CRESTED GECKO



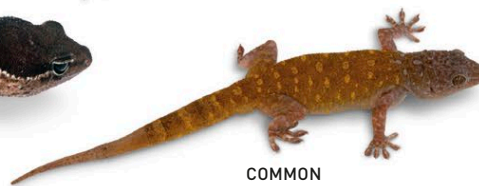
MEDITERRANEAN GECKO



MADAGASCAR DAY GECKO



AFRICAN FAT-TAILED GECKO



COMMON HOUSE GECKO



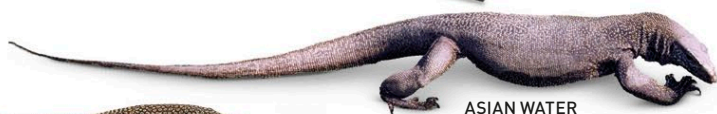
WESTERN BANDED GECKO

## MONITOR LIZARDS

These large lizards are strong, powerful, and fast swimmers. They have a forked tongue that can detect scent in the air and water. The largest lizard on Earth, the Komodo dragon, is a monitor lizard.



DUMERIL'S MONITOR LIZARD



ASIAN WATER MONITOR



SPINY-TAILED MONITOR LIZARD



GREEN TREE MONITOR LIZARD

SAVANNA MONITOR LIZARD



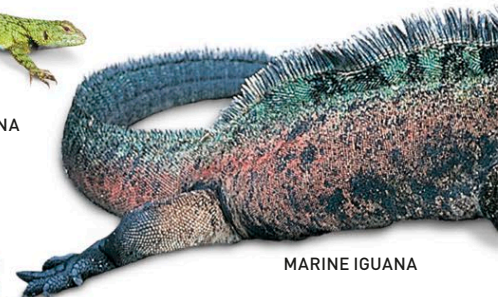
KOMODO DRAGON

## IGUANAS

Iguanas live in the tropical rainforests and deserts of the Americas, Fiji, and Madagascar. They can use their long tails like a whip for defense. The Marine iguana is the only lizard that finds food in the sea, where it eats seaweed.



GREEN SPINY IGUANA



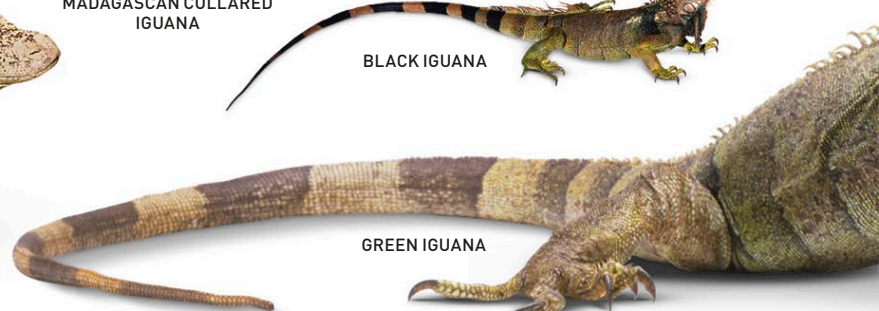
MARINE IGUANA



MADAGASCAR COLLARED IGUANA



BLACK IGUANA



GREEN IGUANA



## A NEW TAIL

Some lizards can detach their tails to escape from or deter a predator. After the tail has fallen off, the area heals like a wound. After about 10 days, a new tail begins to grow.

**A LIZARD'S DETACHED TAIL GOES ON MOVING FOR A WHILE TO DISTRACT THE PREDATOR.**



**1 TAIL FALLS OFF**  
The lizard detaches the end of its tail when attacked or threatened. The point of breakage begins to heal.

**2 GROWING BACK**  
Within 10 days or so, a new tail starts growing. By about day 25, the new tail is strong enough for the lizard to flick it.

**3 NEW FOR OLD**  
After about 60 days, the new tail is complete. It is not exactly the same as the original tail, as it uses cartilage instead of bone.

## SIZE COMPARISON

The world's smallest lizard fits on a fingernail. The biggest weighs about 154 lb (70 kg) and can hunt down large animals.

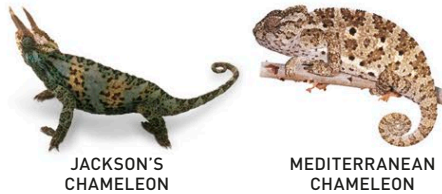


**BRITISH VIRGIN ISLAND DWARF GECKO**  
0.75 in (18 mm) long

**KOMODO DRAGON**  
10 ft (3.1 m) long

## CHAMELEONS

Chameleons mainly live in trees. They have long tongues for catching insects and protruding eyes that move independently of one another. The chameleon can swivel each eye around to look at two different things at once.



JACKSON'S CHAMELEON

MEDITERRANEAN CHAMELEON

### COLOR CHANGE

Chameleons have special skin cells containing tiny sacs of different colored pigments. The lizard's changing moods—such as excitement turning to fear—cause changes in its body that emphasize different colors.



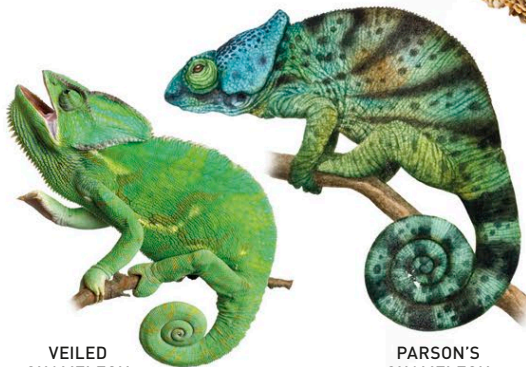
### PANTHER CHAMELEON

A calm chameleon is usually a pale green color. When it wants to show off to a possible mate, the chameleon may display all sorts of colors at once.

Protruding eyes that move in different directions



GIANT SPINY CHAMELEON



VEILED CHAMELEON

PARSON'S CHAMELEON

Two groups of toes on each foot help the chameleon hang on to the branch.

PANTHER CHAMELEON

## LEGLESS LIZARDS

These lizards look like snakes but can be distinguished from them by several features. Unlike snakes, they have eyelids, external ear openings, and a tail that can break off if the lizard is attacked by a predator.



SLOW WORM



EUROPEAN GLASS LIZARD



SLENDER GLASS LIZARD

## SKINKS

Skinks have very long, rounded bodies and pointed heads. Their legs are short or even absent, and they like to burrow into soft, sandy ground. They eat snails, slugs, and insects.



FIVE-LINED SKINK

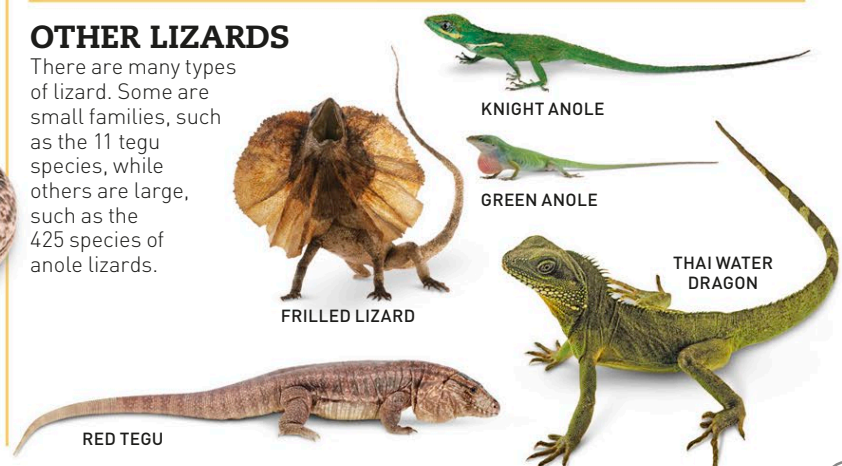
SANDFISH SKINK

PERCIVAL'S LANCE SKINK

FIRE SKINK

## OTHER LIZARDS

There are many types of lizard. Some are small families, such as the 11 tegu species, while others are large, such as the 425 species of anole lizards.



KNIGHT ANOLE

GREEN ANOLE

FRILLED LIZARD

RED TEGU

THAI WATER DRAGON



# Snakes

There are several thousand different types of snake. Most of them are not venomous or dangerous to people, and many are beautiful, with bright colors and patterns. All snakes swallow their prey whole.

## WHAT MAKES A SNAKE?

Snakes are cold-blooded and need outside heat, like the Sun, to keep warm. A snake smells with its tongue and "hears" by picking up vibrations.



LIDLESS EYES



COLD-BLOODED



NO EARS



FORKED TONGUE

## COLUBRIDS

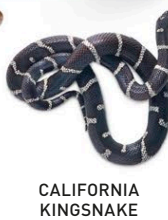
With their diverse colors and sizes, the colubrids make up a very large group. Few of them are venomous. Some kill by constriction.



EASTERN PINE SNAKE



DIADEM SNAKE



CALIFORNIA KINGSNAKE



LAVENDER STRIPED KINGSNAKE



RED CORNSNAKE

## VIPERS

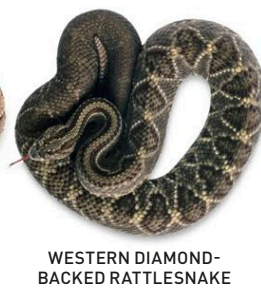
Found in nearly all countries, vipers are venomous. They have squat bodies and broad heads. Some have infrared sensors under their eyes that help them hunt in the dark.



MALAYAN PIT VIPER



GABOON VIPER



WESTERN DIAMOND-BACKED RATTLESNAKE



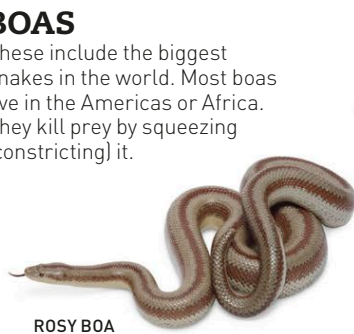
TAYLOR'S CANTIL VIPER



FER-DE-LANCE

## BOAS

These include the biggest snakes in the world. Most boas live in the Americas or Africa. They kill prey by squeezing (constricting) it.



ROSY BOA



COOK'S TREE BOA



RUBBER BOA



RAINBOW BOA



EAST AFRICAN SAND BOA

## COBRAS AND RELATIVES

All cobras are venomous. Some have very fast-acting poisons strong enough to kill large animals or a human.



EGYPTIAN COBRA



ALBINO MONOCLED COBRA



CENTRAL AMERICAN CORAL SNAKE



RED SPITTING COBRA



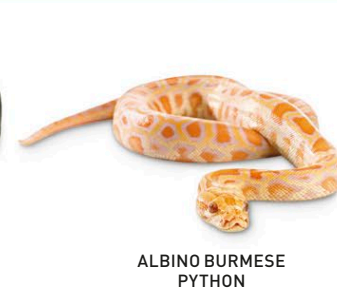
KING COBRA

## PYTHONS

These constricting snakes, which are often very big, come from Asia and Africa. Some types are popular as pets.



BURMESE PYTHON



ALBINO BURMESE PYTHON

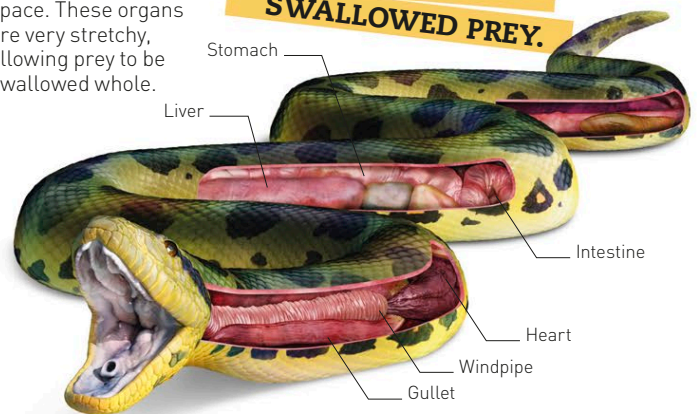


SPOTTED PYTHON

## INSIDE A SNAKE

A snake's internal organs are adapted to fit in a long, narrow space. These organs are very stretchy, allowing prey to be swallowed whole.

A SNAKE'S HEART CAN SHIFT AROUND TO AVOID INJURY FROM SWALLOWED PREY.







## MOST DEADLY

Many people die from snake bites. These five snakes are among the most venomous.

### ○ FER-DE-LANCE

The most feared snake in South America, it tends to live dangerously close to humans.

### ○ PUFF ADDER

Thick-bodied and slow, this African viper blows up its body and hisses if it feels threatened.

### ○ AUSTRALIAN TAIPAN

Anyone bitten by this taipan needs immediate medical treatment.

### ○ KING COBRA

This long snake is found in India and Southeast Asia. Just one of its bites could kill an elephant.

### ○ BLACK MAMBA

The fast-moving mamba is responsible for many human deaths in its native Africa.

## THE BIG SQUEEZE

A constrictor, like a python or boa, catches its prey by striking fast and seizing the animal with its sharp teeth. Then the snake wraps its body around the victim and suffocates it by gradually tightening its coils.



**1 GETTING A GRIP**  
The snake squeezes its victim to death.



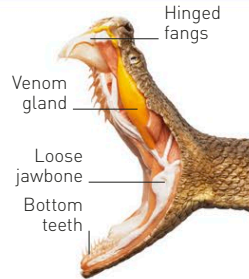
**2 HEAD FIRST**  
Its prey held head first, the snake is ready to eat.



**3 SWALLOWING DOWN**  
Mouth open wide, the snake gulps down its meal.

## A POISONOUS BITE

Venomous snakes have hollow fangs through which poison is squirted from glands in their mouth. The fangs of vipers move forward on a hinge when the snake bites its victim.



## COLOSSAL CONSTRICTOR

A 60-million-year-old fossil of a monster snake was found in Colombia. Named *Titanoboa*, it was 50 ft (15 m) long and weighed 2,500 lb (1,130 kg).

*Titanoboa*:  
Length 50 ft (15 m)

5 ft 9 in (1.8 m)  
tall human



YELLOW RATSNAKE



RUTHVEN'S  
KINGSNAKE



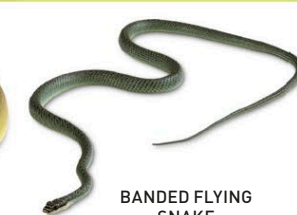
CALIFORNIA MOUNTAIN  
KINGSNAKE



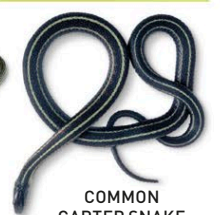
BROWN  
TREESNAKE



ROUGH GREEN SNAKE



BANDED FLYING  
SNAKE



COMMON  
GARTER SNAKE



HORNED  
DESERT VIPER



ORSINI'S VIPER



PRAIRIE RATTLESNAKE



COPPERHEAD



PUFF ADDER



COMMON ADDER



ASP VIPER



GREEN  
ANACONDA



PARAGUAYAN  
ANACONDA



COMMON BOA



DUMERIL'S  
BOA



CALABAR GROUND BOA

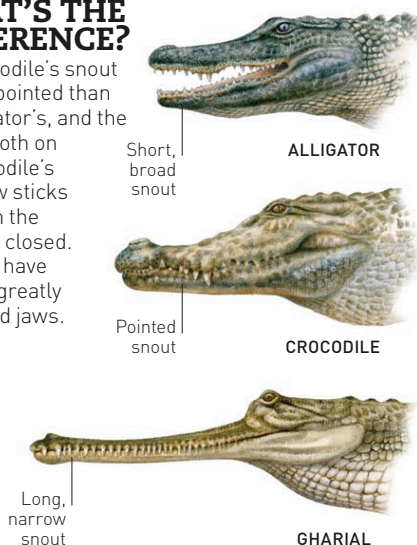
**AFTER A LARGE MEAL, A BOA  
MAY NOT EAT AGAIN FOR  
WEEKS OR EVEN MONTHS.**





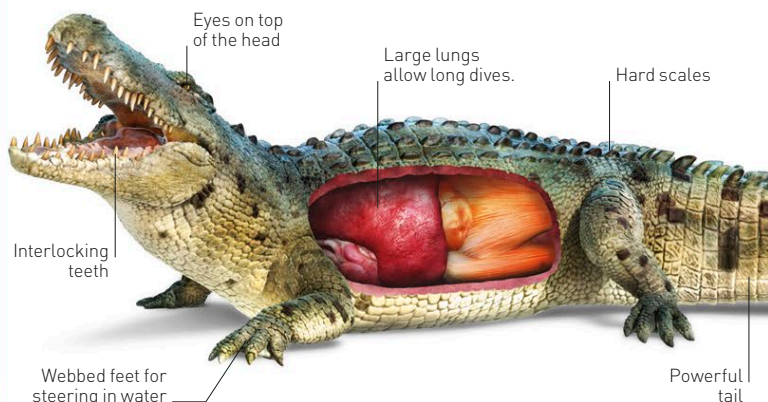
## WHAT'S THE DIFFERENCE?

The crocodile's snout is more pointed than the alligator's, and the fourth tooth on the crocodile's lower jaw sticks out when the mouth is closed. Gharials have narrow, greatly elongated jaws.



## ARMORED BODY

A crocodilian's long body and tail are covered in tough scales. The short legs allow limited movement on land. With eyes, ears, and nostrils on top of its head, a crocodilian can hunt while almost fully underwater. The lungs hold enough oxygen for a 15-minute dive.



## PARENTING

Eggs are laid in a nest built and fiercely guarded by the female. After the eggs have hatched, the mother usually remains with her young for a time to protect them.

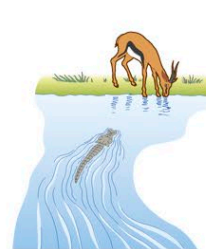


# Crocodiles and alligators

Crocodylians—crocodiles, alligators, and gharials—have been around since the time of the dinosaurs. They use stealth to ambush prey and their ferocious jaws to kill. These reptiles live partly in water and partly on land.

## SURPRISE AMBUSH

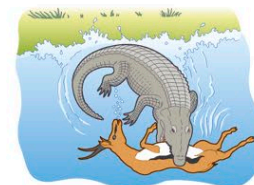
Feeding on fish, birds, reptiles, and mammals, crocodilians are masters of the surprise attack. Small prey is swallowed whole, but larger animals must first be drowned before they can be eaten.



**1 WAITS**  
With just eyes, ears, and tip of snout above the water, a crocodile waits almost motionless for unsuspecting prey to come near.



**2 LUNGES**  
Without warning, the crocodile launches itself from the water and seizes its victim with powerful jaws that snap shut around the animal.



**3 KILLS**  
With a strong grip on its prey, the crocodile dives down beneath the water and waits for the animal to drown.

## CROCODILES

Found in tropical regions, these reptiles occupy both freshwater and saltwater habitats. The two largest and most dangerous species are the saltwater crocodile and the Nile crocodile.



WITH THE STRONGEST BITE OF ANY LIVING CREATURE, A MALE SALTWATER CROCODILE CAN CRUSH A BUFFALO'S SKULL.







## GHARIALS

The Indian gharial lives only in the rivers of India and Nepal. Its long jaws are ideal for catching fish. Unlike other crocodilians, the female does not carry her young, but she does give them some care.

GHARIAL

## ALLIGATORS

Apart from the rare Chinese alligator, alligators are found only in the US. Their close relatives, the caimans, live in Central and South America. All these creatures live in freshwater swamps and rivers and feed on fish, birds, and mammals.



AMERICAN ALLIGATOR



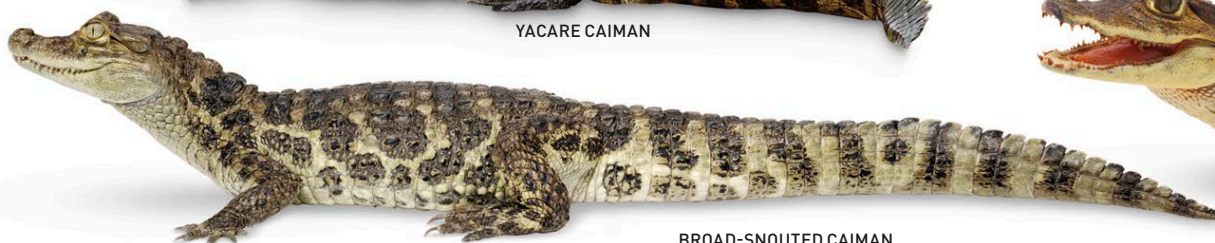
CUVIER'S DWARF CAIMAN



YACARE CAIMAN



CHINESE ALLIGATOR



BROAD-SNOUTED CAIMAN



SPECTACLED CAIMAN



CUBAN CROCODILE



DWARF CROCODILE

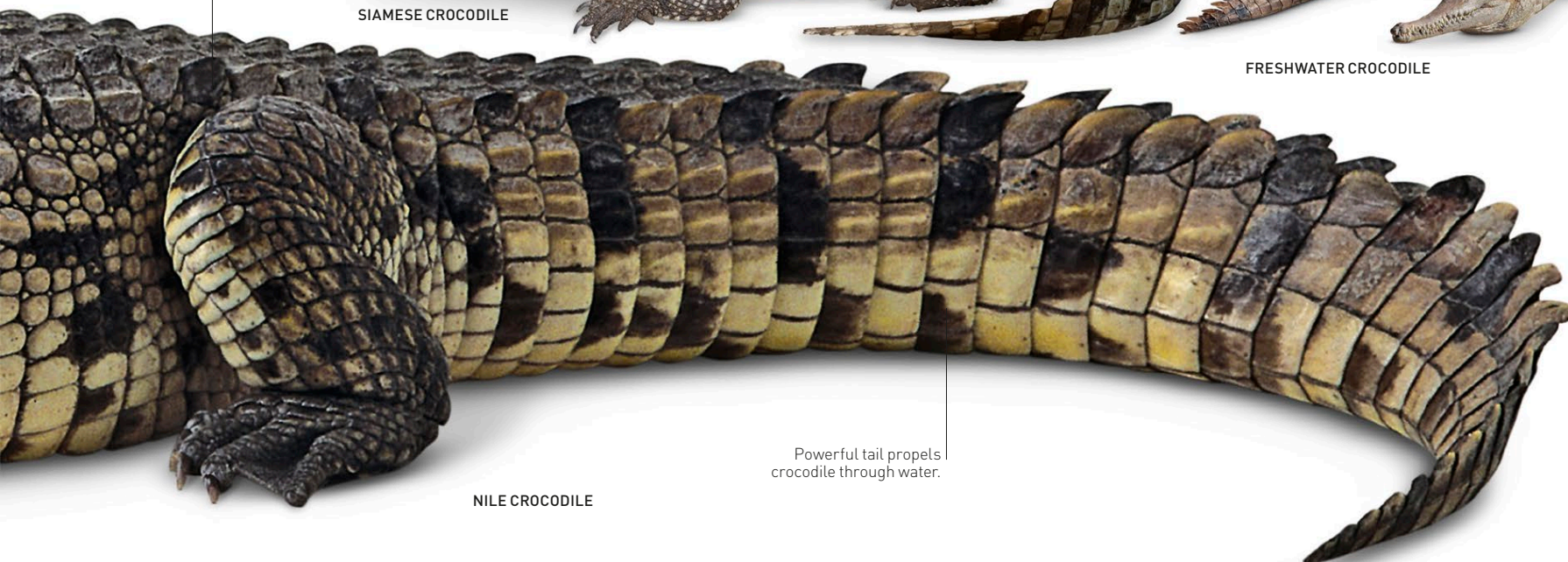


SIAMESE CROCODILE



FRESHWATER CROCODILE

Large scales armored with bony deposits



NILE CROCODILE

Powerful tail propels crocodile through water.



# Eggs

The young of many animals develop inside eggs, which provide protection and food. All birds and most fish and insects are egg-layers. Others include reptiles, frogs and toads, slugs and snails, and even a few mammals.

## EGG SHAPES

Most commonly, bird eggs are oval-shaped. Seabirds nesting on cliffs lay pear-shaped eggs, which roll in a circle but not off an edge. A few birds, including some owls, lay round eggs.



**OVAL**  
Typical shape for most birds' eggs.



**PEAR-SHAPED**  
Unlikely to roll right off a bare ledge.



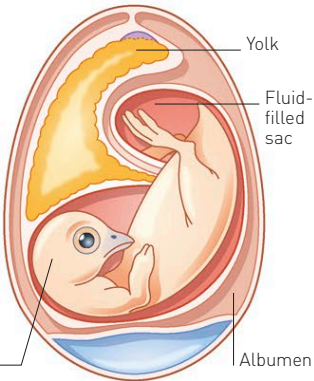
**SPHERICAL**  
Usually laid by birds that build deep nests.



**CONICAL**  
These eggs pack closely in the nest for equal warmth.

## INSIDE AN EGG

The developing bird, which is known as the "embryo," is cushioned inside a sac, or bag, full of fluid. The yellow yolk provides the embryo with most of its food, but the albumen, or "white," also gives it protein and water.

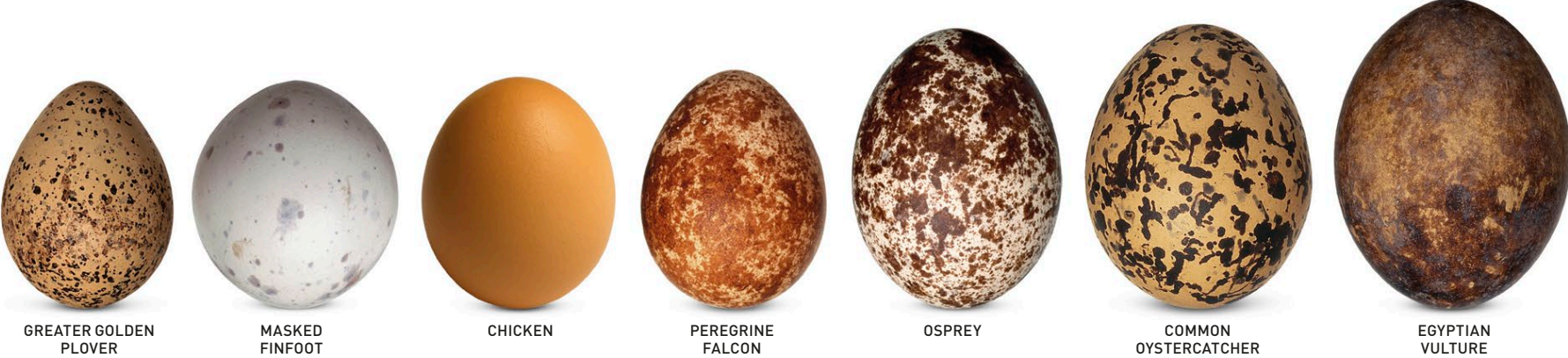
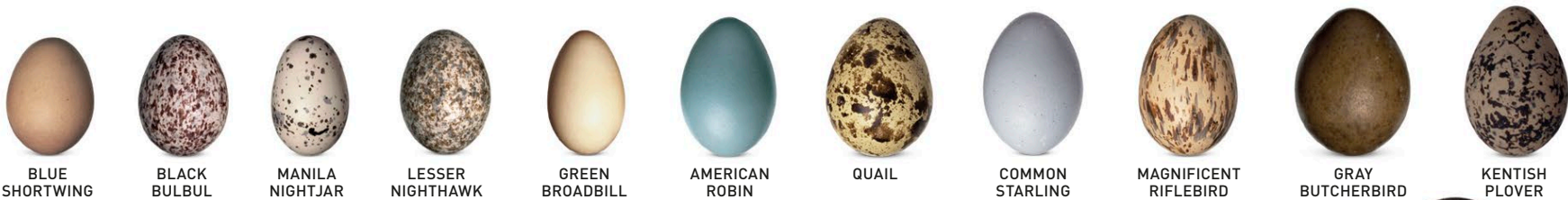


Embryo (developing bird) Yolk Fluid-filled sac Albumen

CHICKEN EMBRYO INSIDE EGG

## BIRD EGGS

Eggs come in lots of different colors and patterns, which may help camouflage them from predators. The colors partly depend on the diet of the bird. If it eats plenty of calcium—which it might get from foods such as insects—it produces a lighter, whiter egg.





## INCUBATING AN EGG

An embryo inside an egg cannot develop without warmth. Parent birds provide this by sitting on their eggs until the chicks hatch out. The process is called incubation. A mother hen such as this one will sit for 21 days.

HEN INCUBATING HER EGGS



## HATCHING OUT

The pictures below show a Japanese quail hatching out of its egg. First, the emerging chick starts chipping away at the shell with its beak. Eventually, the shell cracks apart and the chick kicks itself free of the egg.



**1 STARTING TO HATCH**  
The young chick starts chipping through the shell.

**2 CRACKING OPEN**  
The shell cracks open and falls into two parts.

**3 KICKING FREE**  
Using its legs and body, the chick struggles out.

**4 HATCHED**  
The exhausted chick rests for a while after hatching.

**SOME BIRD SPECIES LEAVE THEIR EGGS TO HATCH UNDER HUGE HEAPS OF VEGETATION.**



DUNNOCK



ANDEAN SPARROW



COMMON KINGFISHER



RICHARD'S PIPIT



CUCKOO SHRIKE



COMMON CUCKOO



GREEN WOOD-HOOPOE



HAWFINCH



JUNGLE CROW



RINGED PLOVER



JACKDAW



GUIRA CUCKOO



BARN OWL



CHIMANGO



NORTHERN LAPWING



GRAY TINAMOU



SOUTHERN CASSOWARY



OSTRICH

## REPTILE EGGS

Most reptiles lay eggs. Crocodiles and tortoises have hard-shelled eggs—like birds' eggs—while the eggs of turtles, snakes, and lizards are soft and leathery.



AFRICAN DWARF CROCODILE



SPUR-THIGHED TORTOISE



GALÁPAGOS GIANT TORTOISE



NILE MONITOR LIZARD



GRASS SNAKE



RAT SNAKE



AFRICAN HOUSE SNAKE

## OTHER EGGS

Fish, insects, and slugs are among other egg-layers. Most produce very tiny eggs in large numbers. In some species, such as the dogfish, the eggs are held in a protective case.



GOLDFISH



RAINBOW TROUT



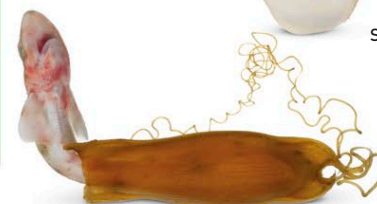
CHINESE OAK SILK MOTH CATERPILLAR



OWL BUTTERFLY CATERPILLAR



SLUG



LESSER SPOTTED DOGFISH



# Birds

Birds occupy almost every kind of habitat around the world—from hot deserts to the icy polar regions. Of the 10,200 species, some are larger than people, while others are barely bigger than bees. All birds have feathers, and most of them can fly.

## WHAT IS A BIRD?

Any animal that has feathers is a bird. All birds have wings, even those species that cannot fly. Most birds also have very good eyesight and hearing.



**EGGS**  
Birds reproduce by laying eggs, and many build nests.



**FEATHERS**  
These enable flight and also provide warmth.



**FLIGHT**  
While most birds can fly, some only walk.



**WARM-BLOODED**  
Like mammals, birds create their own body heat.



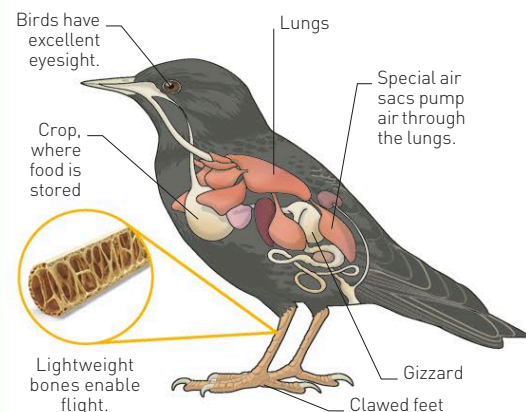
**TOOTHLESS BEAK**  
Having no teeth, birds grind their food in a "gizzard."



**CLAWED FEET**  
Feet and claws come in many different shapes.

## INSIDE A BIRD

Birds have strong yet lightweight skeletons and large chest muscles to power their wings. Flying burns energy and needs a lot of oxygen. Birds have a series of air sacs in their body to keep up the flow of oxygen through their lungs.



## FLIGHTLESS BIRDS

The largest of all birds, ostriches are too heavy to fly. They escape predators by running on strong legs. Other flightless birds include the chicken-sized kiwis. Their tiny wings are invisible beneath their thick plumage.



KIWI

OSTRICH

**OSTRICHES CAN SPRINT FASTER THAN MOST HORSES CAN GALLOP, REACHING SPEEDS OF UP TO 43 MPH (70 KPH).**

## GAME BIRDS

Some of these birds are hunted for food or sport. Most are ground-dwellers, taking flight only to escape from danger. They have strong feet and toes for scraping the ground to find food, and they can run fast.



## CUCKOOS AND TURACOS

Turacos live only in Africa, whereas cuckoos are more widespread. Some cuckoo species trick other birds into raising their chicks by laying eggs in their nests.



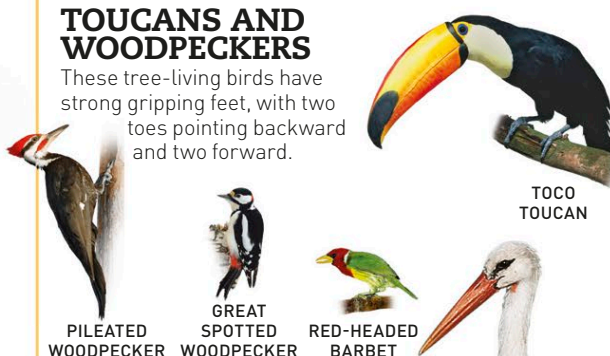
## OWLS

These night hunters have forward-facing eyes and see well in poor light. Fringed feathers allow owls to fly without making a sound.



## TOUCANS AND WOODPECKERS

These tree-living birds have strong gripping feet, with two toes pointing backward and two forward.



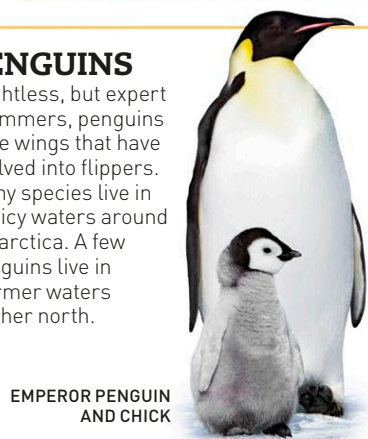
## BIRDS OF PREY

Eagles, hawks, and falcons are all birds of prey. These swift predators have three things in common: hooked beaks, long talons, and superb eyesight.



## PENGUINS

Flightless, but expert swimmers, penguins have wings that have evolved into flippers. Many species live in the icy waters around Antarctica. A few penguins live in warmer waters farther north.



## STORKS, IBISES, AND HERONS

These wading birds stalk prey in shallow waters. Storks and herons make lightning strikes for fish and insects, while ibises probe in mud and under plants.



## PELICANS

The long-beaked pelicans, and their relatives the gannets, are fisheaters. Pelicans scoop up their catch in a large throat pouch.





## BEAK VARIETY

A bird's beak reflects its diet. For example, the spoonbill sweeps its beak through water like a shovel to locate food. The sharp beak of a woodpecker is perfect for chiseling off tree bark to reach insects.



**SWEEPING IN WATER**



**CATCHING FLYING INSECTS**



**PICKING UP SURFACE PREY**



**TEARING MEAT**



**CUTTING FRUIT**



**CHISELING WOOD**



**STABBING AND SPEARING PREY**



**PROBING MUD AND SAND**



**MULTI-PURPOSE**

## BABY BIRDS

Most birds lay their eggs in a nest. The newly hatched young of some birds need constant feeding by their parents, but they grow very quickly. Once baby birds have mastered flying, they leave the nest for good.



### 1 EGGS

Most birds sit on their eggs to keep them at the right temperature.



### 2 HATCHLINGS

Blind and naked, the young of songbirds rely on their parents for food.



### 3 FIVE-DAY-OLD CHICKS

Now called "nestlings." Their eyes open and small "pin" feathers develop.



### 4 NINE-DAY-OLD CHICKS

The nestlings are now nearly feathered and their eyes are wide open.



### 5 READY TO FLEDGE

At two weeks, the fledglings are ready to leave the nest and learn to fly.

## PIGEONS AND DOVES

With their round bodies, small bobbing heads, and short beaks, pigeons and doves are easily recognized.



**MOURNING DOVE**



**SPECKLED PIGEON**



**SOUTHERN CROWNED PIGEON**

## PARROTS AND COCKATOOS

These vibrantly colored tropical birds are well known for their intelligence.



**OLIVE-HEADED LORIKEET**



**RED-FAN PARROT**

### BLUE-CROWNED HANGING PARROTS



## HUMMINGBIRDS AND SWIFTS

The tiny, acrobatic hummingbirds are among the smallest of all bird species. Swifts, known for their speed, can be recognized by their very short legs and small feet.



**BRAZILIAN RUBY**



**LUCIFER HUMMINGBIRD**



**WHITE-THROATED SWIFT**

## KINGFISHERS

Brightly colored kingfishers and their relatives are mostly "sit-and-wait" predators, swooping down from perches to snatch prey.



**PIED KINGFISHER**



**LAUGHING KOOKABURRA**



**JAMAICAN TODY**



**WHITE-THROATED BEE-EATER**

## DUCKS, GEESE, AND SWANS

Found across the world, these water birds have webbed feet and flattened beaks. Nearly all species nest on or beside the water.



**BLACK SWAN**



**BAR-HEADED GOOSE**



**KING EIDER DUCK**



**PLUMED WHISTLING DUCK**



**BAIKAL TEAL**



**LONG-TAILED DUCK**

## CRANES

Graceful cranes and their many relatives live in both dry and wet habitats. Cranes perform impressive courtship displays.



**CORNCRAKE**



**AMERICAN COOT**



**LITTLE BUSTARD**



**GRAY-CROWNED CRANE**



**PURPLE GALLINULE**

## WADERS, GULLS, AND AUKS

Auks, such as puffins, are sea swimmers, while gulls hunt on the wing. Waders feed along muddy shores.



**HEERMANN'S GULL**



**EURASIAN OYSTERCATCHER**



**PIED AVOCET**



**ATLANTIC PUFFIN**



**COMMON REDSHANK**

## PERCHING BIRDS

Most birds are perching birds—their clawed feet can grip even very slender branches. Many species are songbirds.



**BARN SWALLOW**



**EASTERN YELLOW ROBIN**



**LESSER BIRD OF PARADISE**



**EURASIAN SKYLARK**



**YELLOW WARBLER**



**DUNCOCK**



**WRENTIT**

**PARROTS CAN COPY MANY SOUNDS, INCLUDING HUMAN WORDS AND LAUGHTER.**



# Birds of prey

Also known as “raptors,” birds of prey have exceptional vision; grasping talons; and a sharp, hooked beak. Found on every continent apart from Antarctica, these spectacular hunters are divided into day-flying raptors and night-flying raptors, or owls.

## WHAT MAKES A BIRD A RAPTOR?

Day-flying raptors in particular have excellent eyesight that allows them to spot prey from a distance and to calculate exactly when to strike. Many owls rely more on their keen hearing. Strong feet and talons are a raptor's main tools of attack, while the hooked beak is used for tearing meat.



**CURVED BEAK**  
Powerful beaks can pierce prey, rip off skin, and tear flesh into chunks.



**KEEN EYESIGHT**  
Large, forward-facing eyes enable raptors to detect and capture their prey.

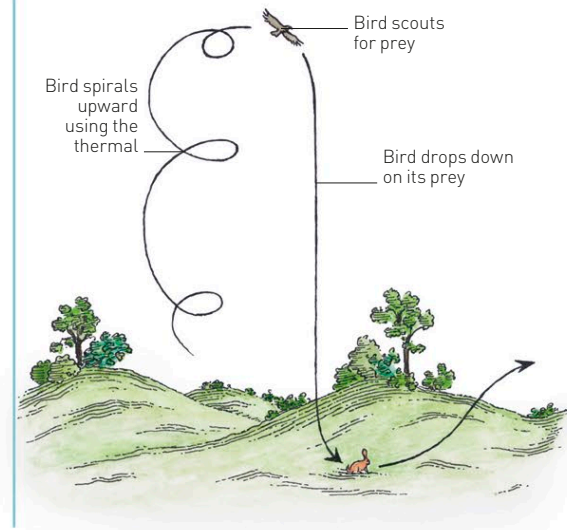


**KILLING FEET**  
Long, curved talons are designed to grasp prey such as rabbits.

**AN EAGLE'S VISION IS AT LEAST FOUR TIMES MORE POWERFUL THAN THAT OF A HUMAN.**

## SOARING HIGH

The broad wings of some hawks and eagles allow them to soar high in the sky on rising warm air currents called thermals. Using little energy, they can glide for long periods while searching for prey.



## DAY-FLYING RAPTOR

As well as airborne hunters such as hawks, eagles, and falcons, this group also includes the largely ground-dwelling secretary bird. Vultures, such as the Andean Condor, rarely kill prey and instead feed on dead animals.





## OWL PELLETS

Owls usually swallow their prey whole. They are unable to digest fur and bones, so they bring up pellets containing these undigested remains. The tawny owl pellet below reveals that the owl had dined on voles.

### INSIDE A PELLETT

All the bones shown here came from inside a single owl pellet.



WHOLE PELLETT



VOLE SKULLS



LOWER JAWBONES



CURVED RIBS



VERTEBRAE



LEG BONES



HIP BONES



FRONT-LIMB BONES



SHOULDER BLADES



SNAIL KITE



MISSISSIPPI KITE



WHITE-TAILED KITE



LANNER FALCON



AMERICAN KESTREL



AFRICAN PYGMY FALCON



COMMON KESTREL



CRESTED CARACARA



STRIATED CARACARA



SECRETARY BIRD

Diet includes snakes

Powerful legs are used to stamp on prey.

## OWLS

Most owls are nocturnal, although some hunt at dawn and dusk. Only a very few are active in the daytime. Owls have superb hearing, and they can see well in the dark. Flying silently on softly feathered wings, owls use stealth rather than speed to hunt their prey.



GREAT GRAY OWL



URAL OWL



BENGAL EAGLE OWL



GREAT HORNED OWL



BARN OWL



BUFFY FISH OWL



SNOWY OWL



BURROWING OWLS



SPECTACLED OWL



NORTHERN HAWK OWL



SHORT-EARED OWL



LONG-EARED OWL



BLACK-AND-WHITE OWL



TAWNY OWL



FERRUGINOUS PYGMY OWL



EASTERN SCREECH OWL



SOUTHERN WHITE-FACED OWL



BOOBK OWL



COLLARED SCOPS OWL



EURASIAN SCOPS OWL



CUBAN PYGMY OWL



NORTHERN SAW-WHET OWL



ELF OWL



TROPICAL SCREECH OWL



# Feathers

Birds have spread to every continent on Earth, partly because of their ability to fly. Feathers play a vital role in their flight and help birds stay warm, attract mates, and be camouflaged. Feathers come in many shapes and sizes and have different functions.

## WHAT ARE FEATHERS FOR?

Feathers allow flight, keep birds warm, provide camouflage, and help attract a mate. In many nesting birds, an area of feathers molts to allow more heat to pass from the mother bird to the eggs.



**FLIGHT**  
Stiff wing and tail feathers aid flight.



**TEMPERATURE CONTROL**  
Downy base of feather traps air for warmth.



**ATTRACTION**  
Bright colors can help attract a mate.



**CAMOUFLAGE**  
Patterns help bird blend into background.

## TYPES OF FEATHER

Birds have two main types of feather: down feathers for warmth and contour feathers for flight. The feathers grow in areas called tracts, with bare skin in between. The bare areas are hidden by the feathers.

**PRIMARIES**  
These are flight feathers, attached to the front section of the wing.

**TAIL FEATHERS**  
These are for balance, braking, and elevating in flight.

## GAME BIRDS

Game birds spend most of their time on the ground, preferring to walk rather than fly. Their flight feathers have a very pronounced curve, or camber, to provide explosive lift and quick bursts of flight.



## PARROTS AND COCKATOOS

Parrots use their brightly colored feathers to attract the opposite sex. The vivid colors may also help disguise these birds against the vibrant green of the forests where they live.



## TOUCANS AND WOODPECKERS

Woodpeckers and toucans do not have any soft down feathers, even when they are chicks.



## BIRDS OF PREY

There are two types of birds of prey: falconlike birds that are active in the daytime and owls that are active at night. Some can soar for hours to look for food, while others achieve great speed when they dive down to catch their prey.

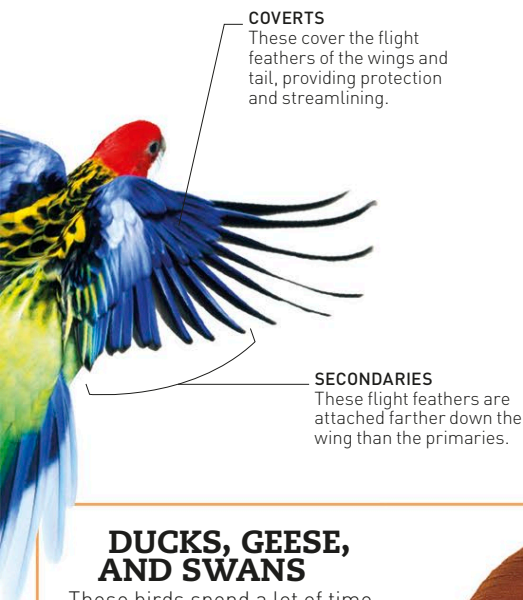


## COLORFUL DISPLAY

Male peacocks have amazingly colorful tail covert feathers that spread up and around into a fan shape behind them when they want to attract a mate. The females choose a mate depending on how many eye spots are on his tail—the more the better.

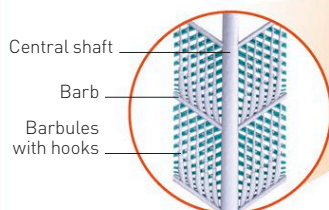




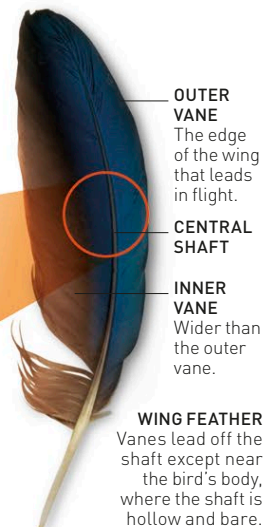


## FEATHER STRUCTURE

Contour feathers have stiff shafts in the center, with vanes on either side. The vanes are made up of thin branches called barbs. These have smaller branches of barbules with hooks that hold it all together.



**CLOSE-UP**  
This complex but strong structure holds the feather together.



**WING FEATHER**  
Vaness lead off the shaft except near the bird's body, where the shaft is hollow and bare.

## HOW BIRDS FLY

A bird uses strong breast muscles to flap its wings and fly. As it flaps them, it increases lift, which moves the bird forward and upward.



**STAYING UP**  
Once in the air, the bird's wings allow it to glide, soar, change direction, and slow down to land.

## DUCKS, GEESE, AND SWANS

These birds spend a lot of time in water, so their feathers are covered with an oily substance that keeps them waterproof.



MALLARD DUCK

WOOD DUCK

LOVEBIRD

MANDARIN DUCK

**THE BIRD WITH THE MOST FEATHERS IS THE WHISTLING SWAN: IT HAS UP TO 25,000 FEATHERS IN WINTER.**

## SHOREBIRDS, SEABIRDS, AND WADING BIRDS

These birds have feathers that help with waterproofing and warmth. They tend to have dark feathers on their backs and white ones on their chests to provide camouflage.



CURLEW

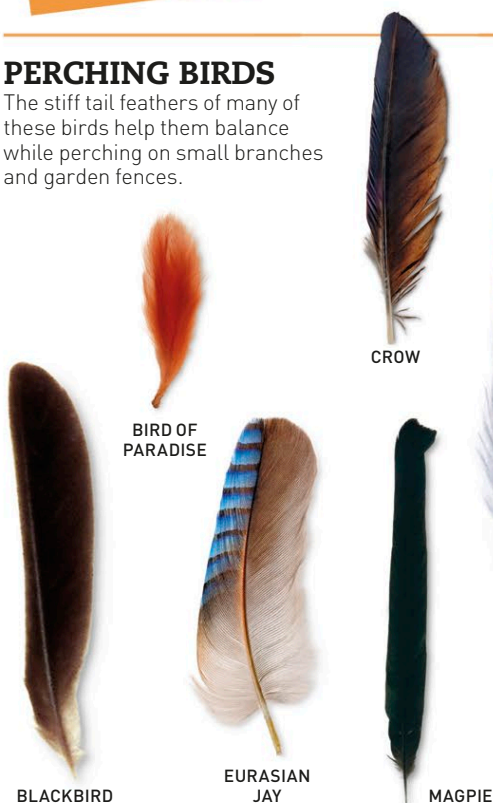
GULL

FLAMINGO

STORK

## PERCHING BIRDS

The stiff tail feathers of many of these birds help them balance while perching on small branches and garden fences.



BLACKBIRD

EURASIAN JAY

MAGPIE

CROW

BIRD OF PARADISE

**INSULATION**  
At the base of a flight feather is an area of downy, looser barbs. These help keep birds warm.



BLUE JAY

ROOK

## OTHER BIRDS

There are many families of birds. Each family has feathers suited to its habits and lifestyle. Doves and pigeons create a white powder called feather dust to keep their feathers waterproof, unlike kingfishers, which use preening oil for waterproofing their feathers. Ostriches don't fly, so they don't have any contour feathers, only soft down feathers.



ROCK DOVE

PIGEON

WHITE-THROATED KINGFISHER

OSTRICH



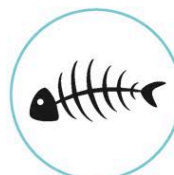
# Animal journeys

Every year, some animals travel huge distances from one area to another. This is known as “migration” and may involve groups numbering millions. Such journeys are undertaken to ensure a species’ survival.

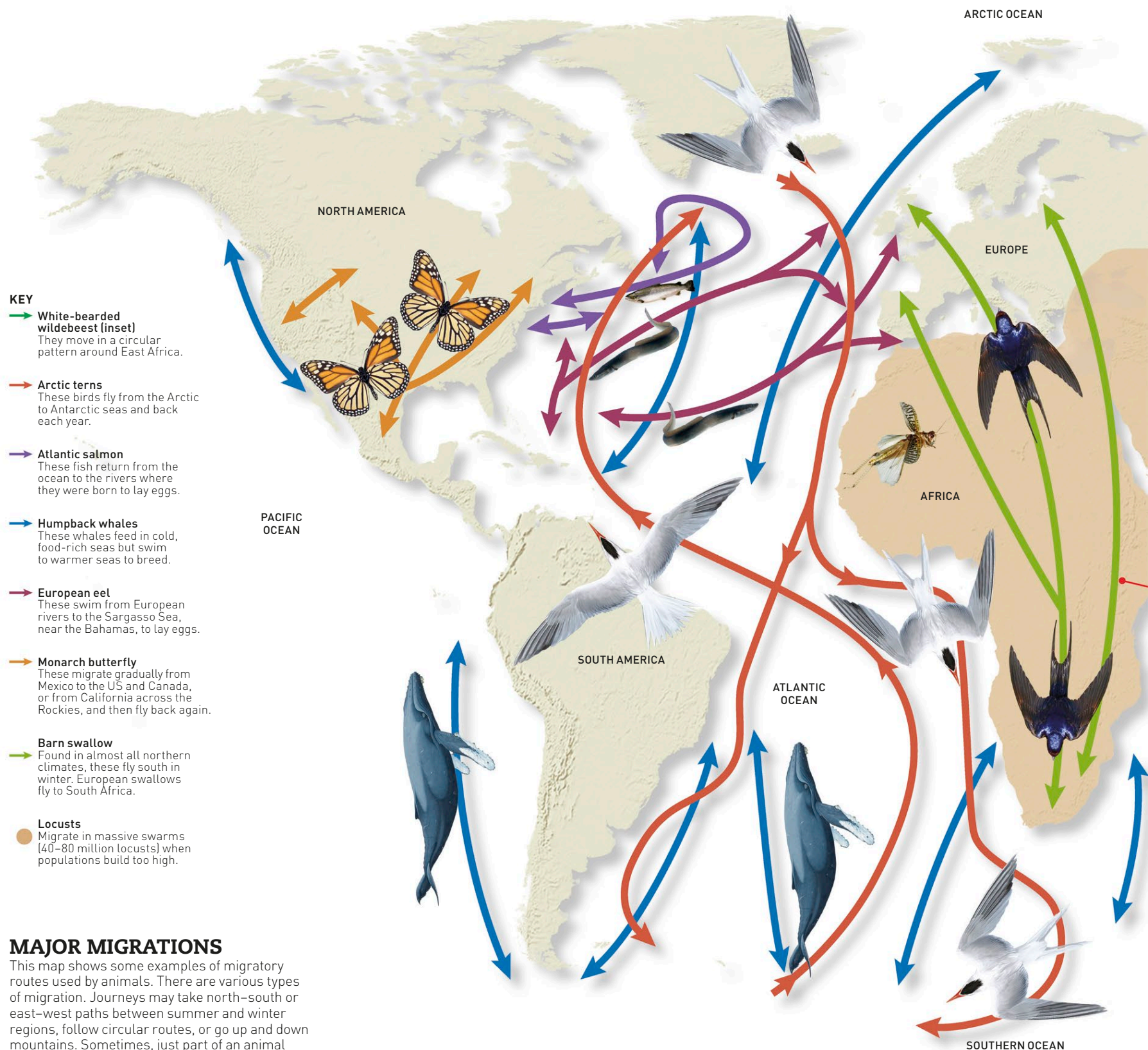
## WHY ANIMALS MIGRATE

Animals take long and sometimes dangerous migratory journeys when instinct tells them to move. Usually, they are seeking food, a mate, better weather, and safe places to rear their young.

**WALRUSES ALWAYS MIGRATE IN SEPARATE MALE AND FEMALE GROUPS.**



**FOR FOOD**  
Many animals migrate from one place to another during the year in search of food, as supplies in one place run out.







#### FOR REPRODUCTION

Animals may migrate to find a mate, lay eggs, give birth, and raise their young.



#### TO AVOID EXTREME WEATHER

In harsh wintry conditions, animals may move to areas where there is more food and warmer weather.



#### TO AVOID OVERCROWDING

When a population gets too big, animals may make a mass move. Locusts are one example.

## BIRD MIGRATION

Bird migration takes place in spring and late fall. The movement is triggered by changes in hours of daylight and temperature. Many migrating birds fly in V-shaped formations. The journey can last weeks or even months.

#### GETTING READY

Birds release a hormone to help them store fat in the weeks before they migrate.



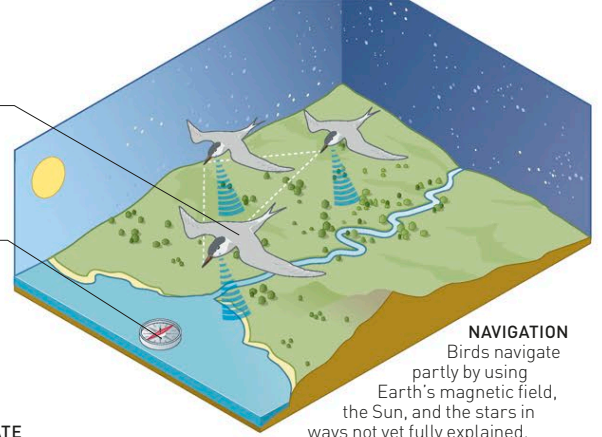
NORMAL BODY FAT



READY TO MIGRATE

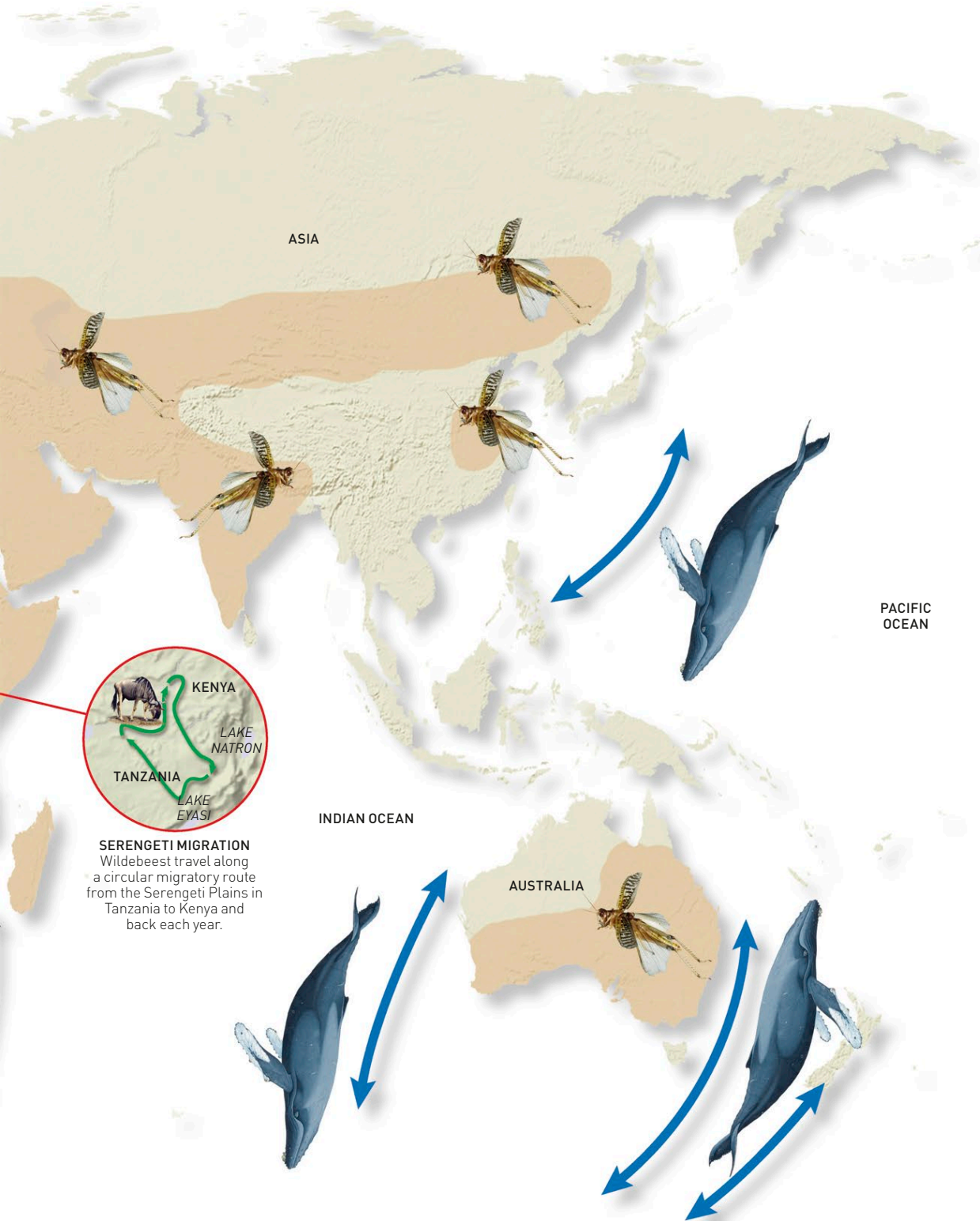
Height depends on wind patterns and landforms.

The Sun and stars help set the course.



#### NAVIGATION

Birds navigate partly by using Earth's magnetic field, the Sun, and the stars in ways not yet fully explained.



ASIA

PACIFIC OCEAN

INDIAN OCEAN

AUSTRALIA

KENYA

LAKE NATRON

TANZANIA

LAKE EYASI

#### SERENGETI MIGRATION

Wildebeest travel along a circular migratory route from the Serengeti Plains in Tanzania to Kenya and back each year.



INCA TERN

Migration ring

## TRACKING MIGRATION

Scientists can track migrating animals by attaching ultra-light radio transmitters to them in various ways, such as on their legs. The little radios send signals to satellites in space, building maps of the animals' movements. Birds are also given leg rings with unique numbers that are used to track movement.

## RECORD MIGRATIONS

When animals migrate, they can travel astonishing distances, often without stopping for food or drink. Here are some world-record holders.

#### ARCTIC TERN

Longest round trip: 44,000 miles (71,000 km)

This tiny bird migrates farther than any other animal in the world, zigzagging between Greenland and Antarctica.



#### BAR-TAILED GODWIT

Longest nonstop flight: 7,145 miles (11,500 km)

One of these shorebirds covered this distance in eight days without a break for food.

#### LEATHERBACK TURTLE

Longest recorded aquatic journey: 12,774 miles (20,558 km)

These travel across the Pacific Ocean to the beach where they were born.



#### WHITE-BEARED WILDEBEEST

Largest land migration: 1.3 million wildebeest

Vast herds can travel 1,000 miles (1,610 km) in a year.



#### BAR-HEADED GOOSE

Highest journey: 23,9170 ft (7,290 m)

Flying at extreme altitude, these birds fly with only 10 percent of the oxygen found at sea level. They have been tracked flying for 17 hours without stopping.

#### DESERT LOCUST

Largest air migration: 69 billion locusts in one swarm

In 2004, the swarm crossed Morocco and devastated crops in parts of northwest Africa.



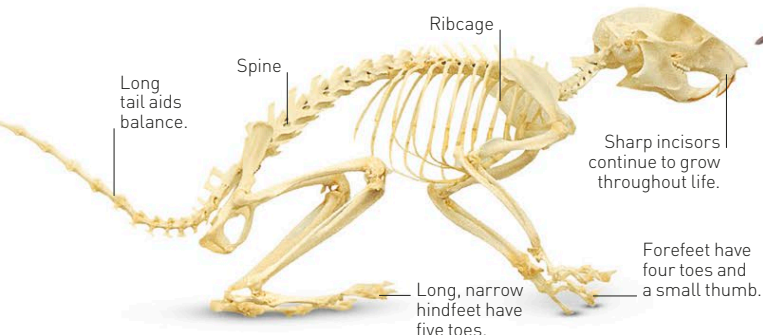


# Rodents

There are few places in the world where rodents cannot live. Mostly small, these animals fit themselves into many different habitats and often flourish in huge numbers. Rodents' front teeth keep growing to compensate for the way they wear down as the animals feed.

## WHAT MAKES A RODENT?

A compact body, long whiskers, and a long tail are common rodent features, although there are many variations in this big group. Rodents' teeth make them different from other animals. They have four sharp front teeth, or incisors, and just a few molars at the back of the mouth.



SQUIRREL SKELETON

## SUITABLE BODIES

Many rodents have special body adaptations to suit their various lifestyles. These include extra-flexible joints in the feet for climbing trees, protruding teeth for digging and tunneling, and webbed toes for swimming.



### CLIMBERS

Swiveling joints in their ankles make squirrels one of the few mammals that can climb head first down a tree.



### BURROWERS

Mole-rats dig with their sticking-out front teeth and push the soil behind them with their wide, flat hindfeet.

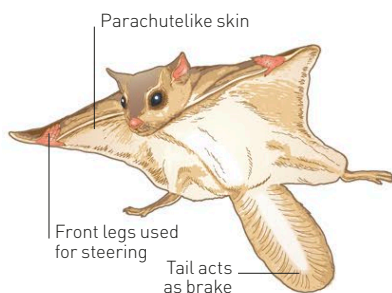


### SWIMMERS

Beavers have webbed feet and a flat tail that is used as a rudder. Thick underfur keeps them warm in water.

## HOW SQUIRRELS "FLY"

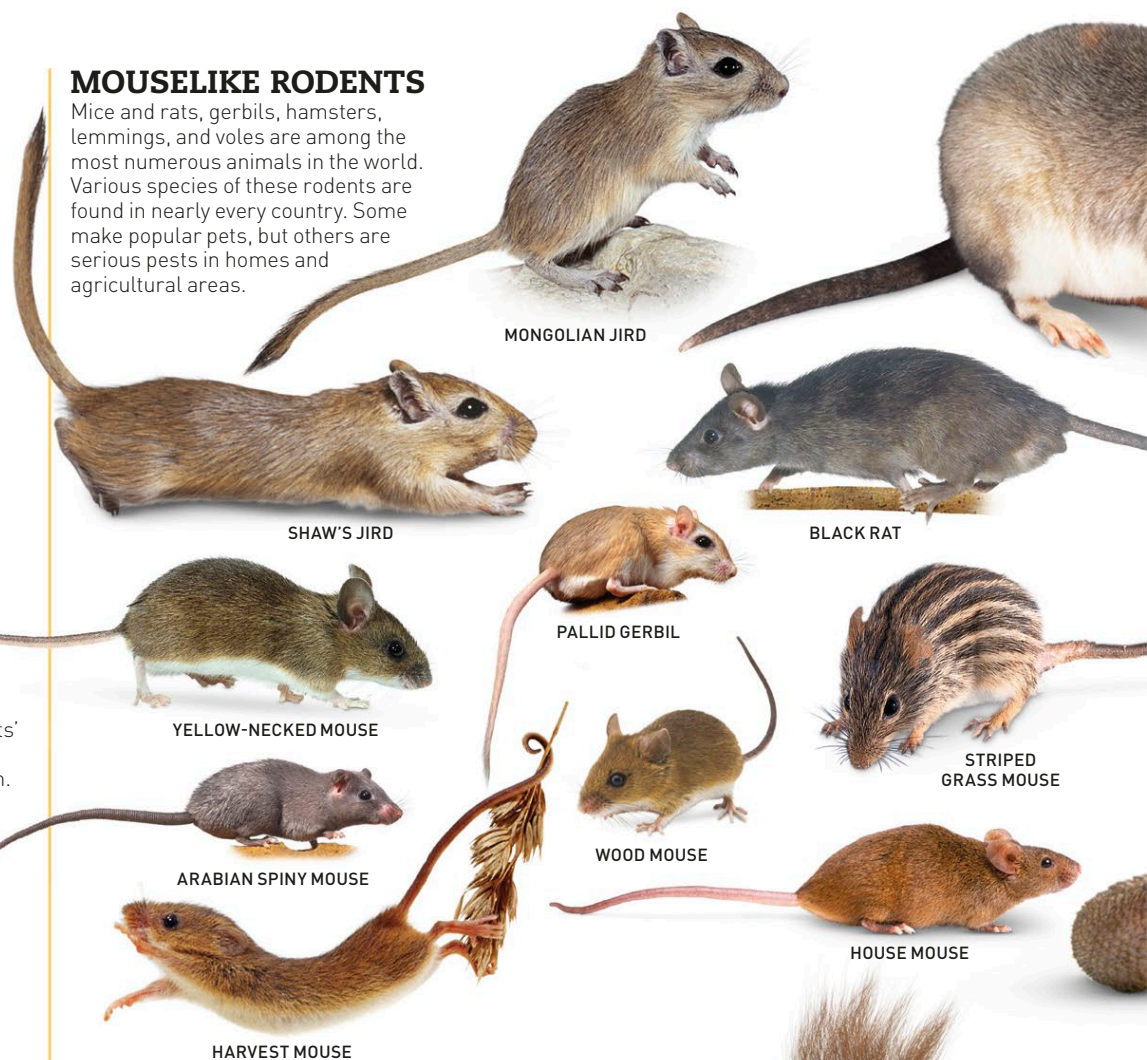
The rodent group includes the flying squirrels. As they move between trees, these animals travel through the air in what appears to be real flight. In fact, they are gliders. A flying squirrel has thin, loose skin between its legs that spreads out like a parachute to keep it aloft. To steer in midair, the squirrel moves its front legs. When preparing to land, it raises its fluffy tail as a brake.



**A FLYING SQUIRREL CAN GLIDE FOR UP TO 165 FT (50 M).**

## MOUSELIKE RODENTS

Mice and rats, gerbils, hamsters, lemmings, and voles are among the most numerous animals in the world. Various species of these rodents are found in nearly every country. Some make popular pets, but others are serious pests in homes and agricultural areas.



## SQUIRREL-LIKE RODENTS

Squirrels and their relatives have cylindrical bodies and thick fur, and most have bushy tails and big eyes. They are found throughout the world in habitats from rainforest, to semiarid desert, to big cities. Some live in trees, while others live on the ground.



## CAVYLIKE RODENTS

The best known of these rodents is the guinea pig, or cavy. It has a big head, sturdy body, short tail, and slender legs, which are common features among this varied group. Cavy relatives include porcupines, the capybara—the biggest rodent in the world—and the almost blind naked mole-rat, which lives underground.







MALAGASY  
GIANT RAT

STRIPED DWARF  
HAMSTER

COMMON HAMSTERS

ROBOROVSKY'S  
DESERT HAMSTER

GOLDEN HAMSTER

SYRIAN HAMSTER

NORWEGIAN  
LEMMING

MUSKRAT

ORKNEY VOLE

BANK VOLE

FOREST  
DORMOUSE

HAZEL  
DORMOUSE

COMMON VOLE

AFRICAN  
DORMOUSE

BROWN RAT

SOUTH AFRICAN  
GROUND SQUIRREL

NORTHERN  
FLYING SQUIRREL

HARRIS'S ANTELOPE  
SQUIRREL

EASTERN  
CHIPMUNKS

HOPÍ  
CHIPMUNK

RED BUSH  
SQUIRREL

YELLOW-BELLIED  
MARMOT

BLACK-TAILED PRAIRIE DOG

NAKED  
MOLE-RAT

CHINCHILLA

MARA

CRESTED  
PORCUPINE

CAPYBARA

## BEAVERS

There are two species of beavers: North American and Eurasian. Both are river-dwellers. They create waterways for their own purposes by building dams out of branches, mud, and stones.

EURASIAN BEAVER



# Monkeys and apes

Like humans, monkeys and apes are primates. They use their hands as we do, placing their thumbs against their fingers to grasp things. Monkeys and apes have good vision and large brains for their size. A tail helps identify which animals are which: most monkeys have tails, apes do not.

## MOVING AROUND

Some apes, such as gorillas, spend a lot of time on the ground, while others are skilled climbers and leapers. Monkeys scamper and run on all fours, using their tails for balance or as a fifth limb.



**ON TWO FEET**  
Apes are able to walk on their hindlimbs for short periods of time.



**ON FOUR FEET**  
Monkeys move on all fours, and their limbs are of roughly equal length.



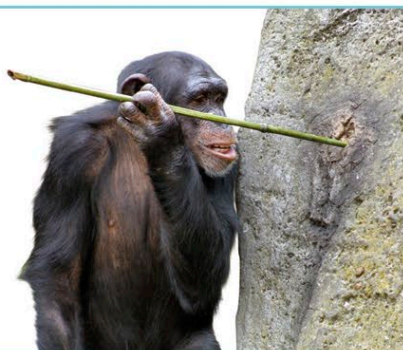
**KNUCKLE-WALK**  
Gorillas and chimpanzees put their weight on the knuckles of their forelimbs.



**SWINGING**  
Some apes use their long arms to swing from branch to branch.

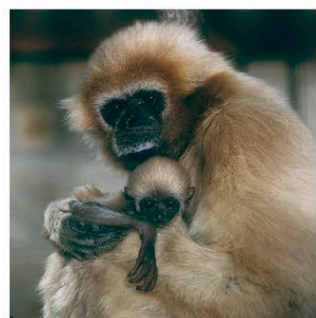
## TOOL USE

Apes are intelligent and can make and use tools. Chimpanzees have been observed using rocks to crack nuts and making "sponges" from leaves and moss to collect water. They also push sticks into termite mounds and trees to "fish" for insects.



## GROUP BEHAVIOR

Most apes and monkeys live in groups, which helps keep them safe from predators. They communicate with each other by using body language and sounds. Chimpanzees even work together to hunt and then share the food among the group.



**CARE OF YOUNG**

Monkeys and apes have one to two infants at a time and may devote years to rearing their offspring.

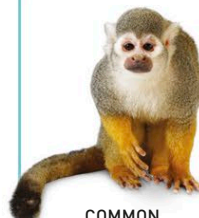


**SOCIAL LIFE**

Grooming is important not only for cleaning fur, but also for bonding between group members.

## MONKEYS

New World monkeys live in South and Central American rainforests. They have fairly broad noses with nostrils that open sideways. Many have gripping tails. Old World monkeys live in Asia and Africa. They have narrower noses than New World monkeys and downward-pointing nostrils. Most are tree-dwellers, although baboons live mainly on the ground.



**COMMON SQUIRREL MONKEY**



**GOLDEN LION TAMARIN**



**COTTON-TOP TAMARIN**



**WEEPER CAPUCHIN**



**NORTHERN NIGHT MONKEY**



**COMMON MARMOSET**



**PYGMY MARMOSET**



**RED HOWLER MONKEY**



**GRAY WOOLLY MONKEY**



**PIG-TAILED MACAQUE**



**BARBARY MACAQUE**

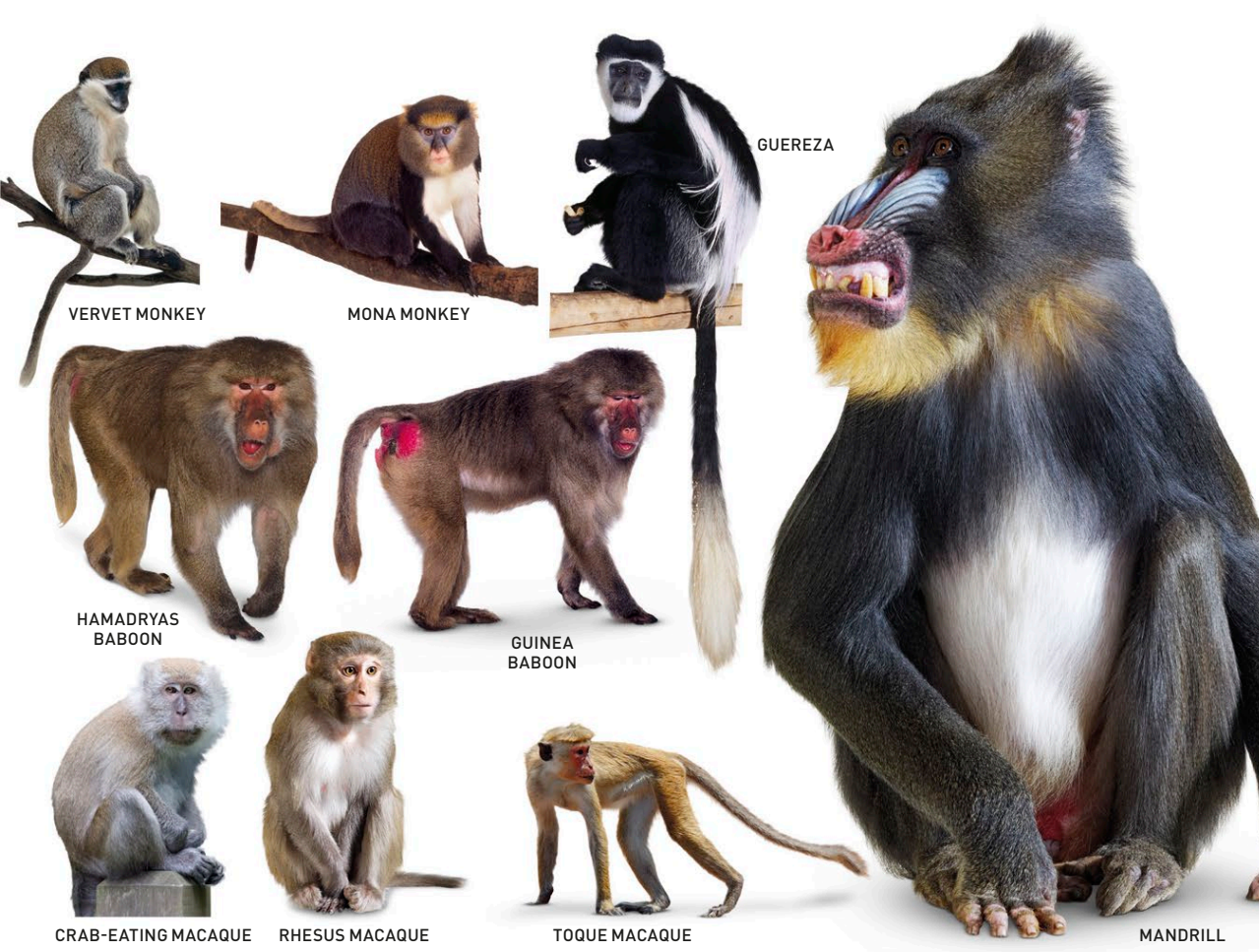
## APES

Found in Africa and Southeast Asia, apes have a more upright body posture than monkeys and do not have a tail. Gorillas, chimpanzees, orangutans, and humans are all "great apes," while gibbons are "lesser apes."



**BORNEAN ORANGUTAN**





## OTHER PRIMATES

Many other species belong to the order of primates. Lemurs are found only on the African island of Madagascar. Other relatives of apes and monkeys include galagos, bandros, and bushbabies, which are all nocturnal.





# Wild cats

Sleek, stealthy, patient, and intelligent, wild cats are natural killers. Most of them hunt on their own, using their claws and teeth to catch, stab, and cut up their prey. They are athletic, with supple, muscular bodies that are well adapted to running, climbing, leaping, and even swimming. They live in various habitats across Africa, Asia, Europe, and the Americas.

## CONSERVATION

The threats to wild cats vary according to where they live, but the main ones are poaching and the loss of their habitat. Most of the big cats are now vulnerable or endangered.

### KEY

- Critically endangered
- Endangered
- Vulnerable
- Near threatened
- Least concern

■ AMUR LEOPARD

■ AMUR TIGER

■ INDOCHINESE CLOUDED LEOPARD

■ ASIATIC LION

■ SNOW LEOPARD

■ DIARD'S CLOUDED LEOPARD

■ BENGAL TIGER

■ AFRICAN LION

■ JAGUAR

## SMALL WILD CATS

More than three-quarters of the world's wild cats are classified as "small." The 30 different species have adapted to their environments—their colors help them blend in. Domestic cats were derived from the North African wildcat.



SERVAL



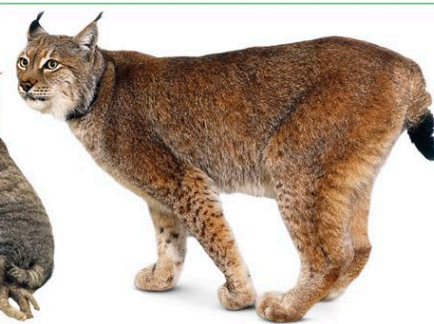
GEOFFROY'S CAT



IBERIAN LYNX



EUROPEAN WILDCAT



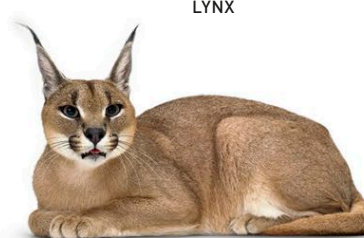
EURASIAN LYNX



FISHING CAT



COLOCOLO



CARACAL

## BIG CATS

Lions, tigers, jaguars, and leopards are classed as big cats. They all live alone, except for lions, which live in a big group known as a pride. The largest cats in the world are the Bengal and Amur tigers, which can weigh the same as 100 domestic cats.



LION



LIONESS



CLOUDED LEOPARD



## BUILT FOR SPEED

The cheetah is the fastest land mammal on Earth—it can run at 70 mph (113 kph). Strong muscles, large lungs, and a large heart mean it can take in lots of oxygen very fast, so it accelerates very quickly. It has to rest after about 20–60 seconds.

**A CHEETAH CAN  
CLOSE IN ON ITS  
PREY IN JUST  
60 SECONDS.**



### 1 STARTING LEAP

A cheetah can run fast over short distances only. It stalks its prey until it is very close, then suddenly rushes out of cover.



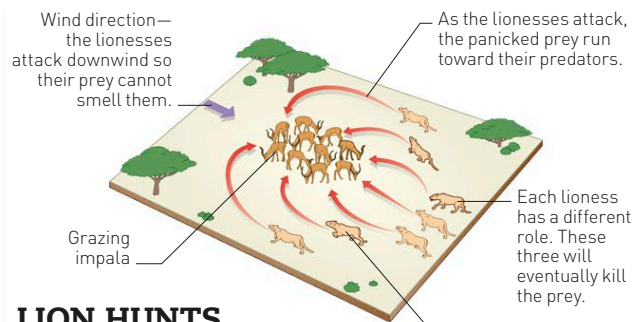
### 2 STRAIGHTENING OUT

The cheetah's unusually long and flexible spine means it can cover 23–26 ft (7–8 m) in one single stride.



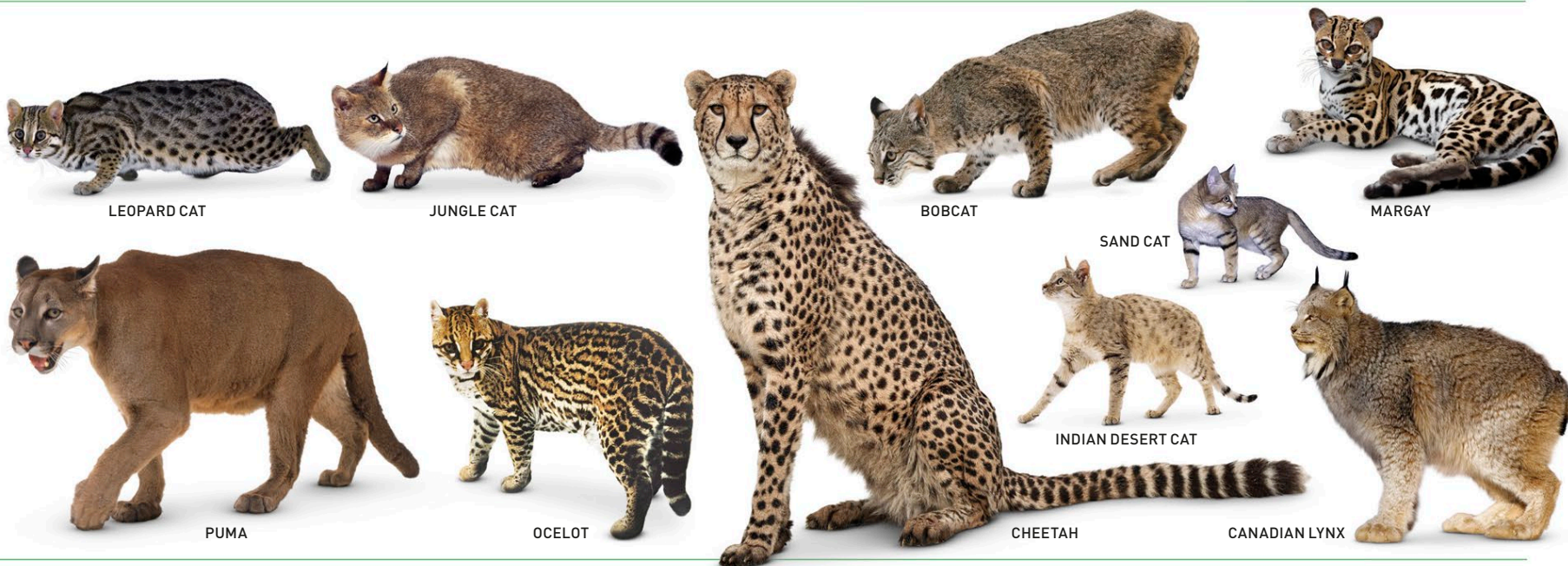
### 3 FLEXED TO LAND

The powerful back legs propel the cheetah forward so well that the back feet overtake the forefeet, ready to spring again.



## LION HUNTS

Lionesses do most of the hunting. Once killed, the prey is feasted upon by all that can get near enough. Youngsters usually give way to older members, and all are subordinate to the males.



A tiger's stripes are unique—no two tigers will ever have the same pattern.



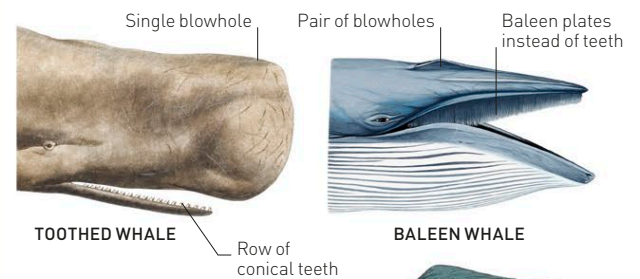


# Whales and dolphins

Although they live in water, whales, dolphins, and porpoises are all mammals. At intervals, they rise to the surface to breathe in fresh air and exhale stale air through blowholes, similar to nostrils, on the top of their head.

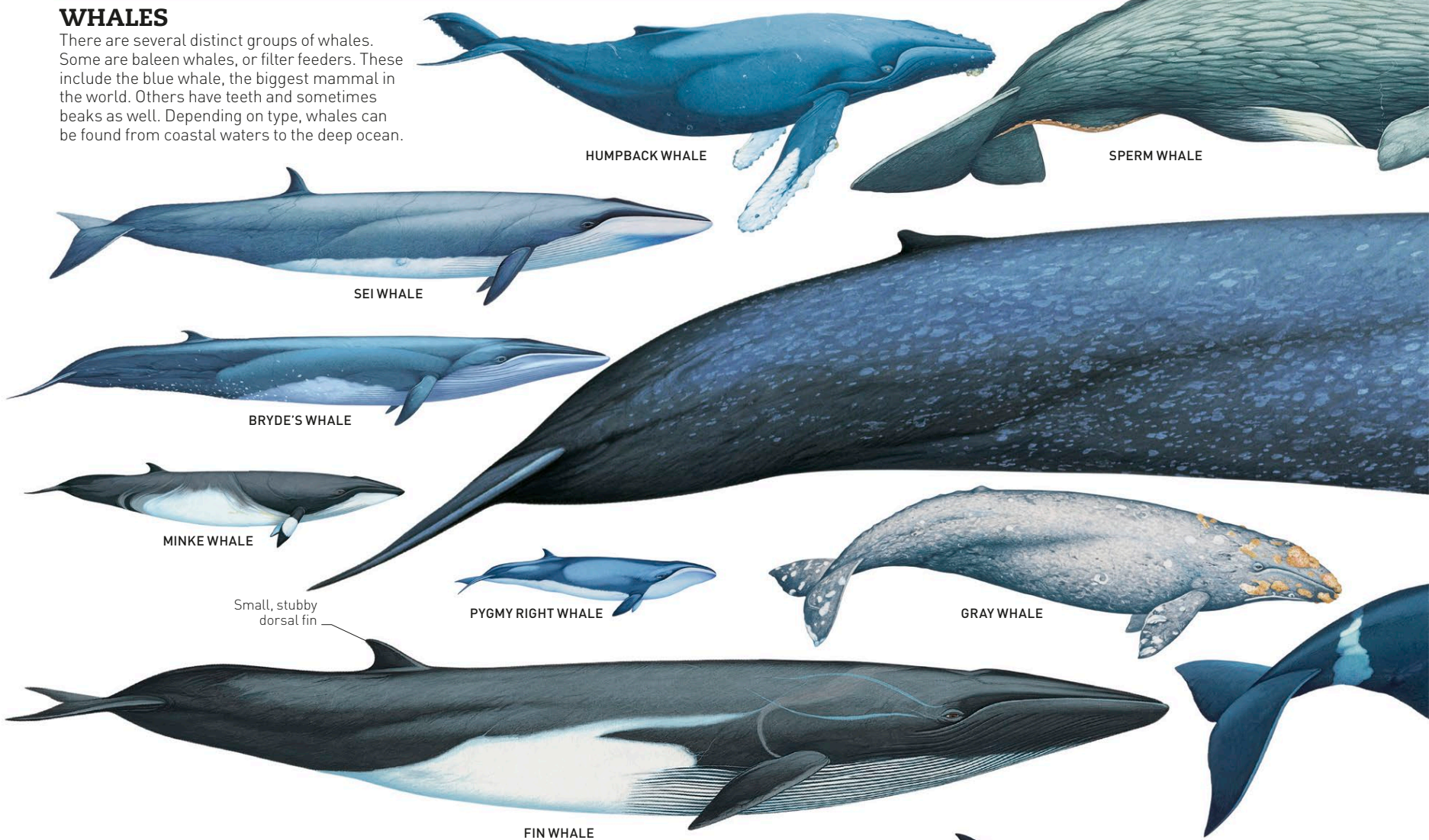
## TEETH AND FILTERS

Some whales have teeth for catching prey such as fish or squid. Filter-feeding whales have comblike plates called baleen hanging from their upper jaw. As they swim, baleen whales gulp water and the plates trap tiny prey.



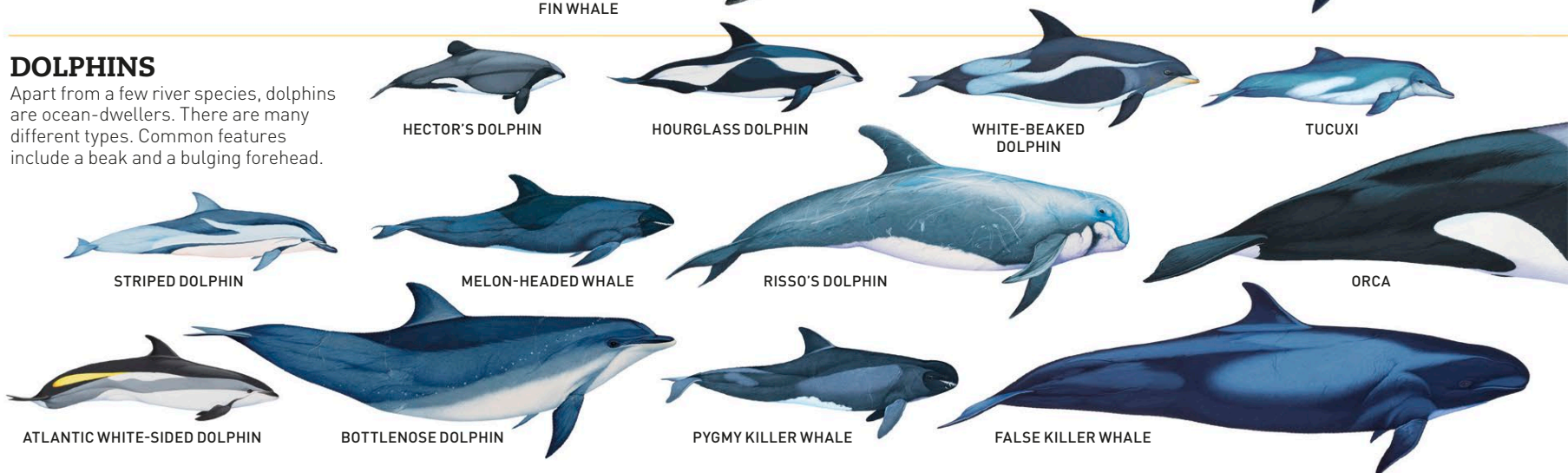
## WHALES

There are several distinct groups of whales. Some are baleen whales, or filter feeders. These include the blue whale, the biggest mammal in the world. Others have teeth and sometimes beaks as well. Depending on type, whales can be found from coastal waters to the deep ocean.



## DOLPHINS

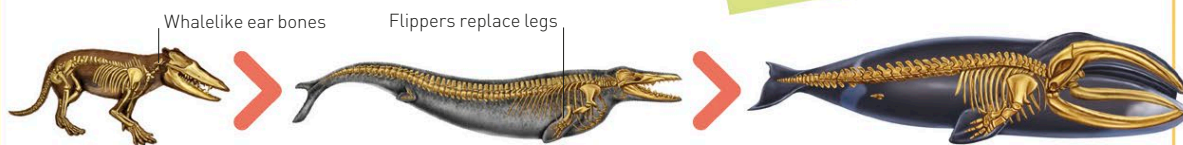
Apart from a few river species, dolphins are ocean-dwellers. There are many different types. Common features include a beak and a bulging forehead.





## FROM LAND TO SEA

Fifty million years ago (MYA), the ancestors of whales were not swimming in seas but living on land and walking on four legs. These animals gradually started spending more time feeding in water. Slowly, their bodies changed and whales eventually left dry land forever.



### 1 PAKICETUS (50 MYA)

About the size of a large dog, this animal sometimes swam after fish. Its fossilized ear bones match those of modern whales.

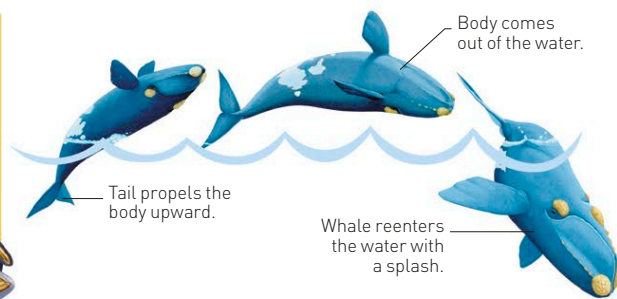
### 2 DORUDON (38 MYA)

Able to swim well, this early whale had front flippers, tiny hindlimbs, and a flexible tail. The nostrils had shifted to the top of the head as blowholes.

**THE BLUE WHALE CAN MEASURE UP TO 100 FT (30.5 M) LONG.**

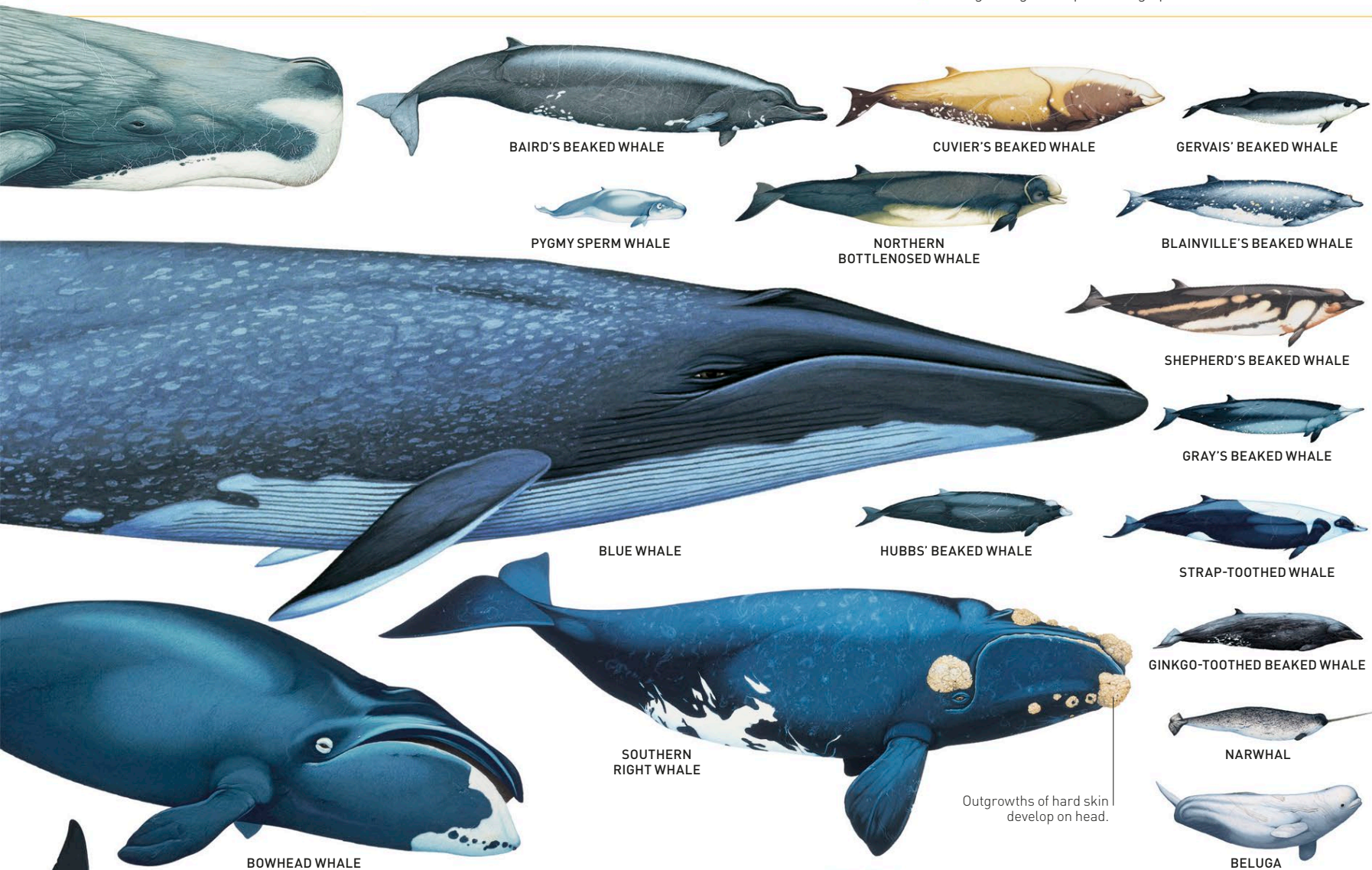
### 3 MODERN WHALE

Perfectly adapted for ocean life, the whale has a streamlined body, powerful flippers, and a flat tail to aid propulsion. The hindlegs have vanished.



## BREACHING

Whales often leap high out of the water and plunge back with a large splash. This is called breaching, and scientists are not sure why whales do it. Possibly it is a form of signaling or helps dislodge parasites.



BAIRD'S BEAKED WHALE

CUVIER'S BEAKED WHALE

GERVAIS' BEAKED WHALE

PYGMY SPERM WHALE

NORTHERN BOTTLENOSED WHALE

BLAINVILLE'S BEAKED WHALE

SHEPHERD'S BEAKED WHALE

GRAY'S BEAKED WHALE

BLUE WHALE

HUBBS' BEAKED WHALE

STRAP-TOOTHED WHALE

SOUTHERN RIGHT WHALE

GINKGO-TOOTHED BEAKED WHALE

NARWHAL

BOWHEAD WHALE

Outgrowths of hard skin develop on head.

BELUGA

SOUTHERN RIGHT WHALE DOLPHIN

ROUGH-TOOTHED DOLPHIN

INDUS RIVER DOLPHIN

LONG-FINNED PILOT WHALE

ATLANTIC SPOTTED DOLPHIN

FRANCISCANA

DALL'S PORPOISE

SPECTACLED PORPOISE

PEALE'S DOLPHIN

COMMON DOLPHIN

AMAZON RIVER DOLPHIN

HARBOR PORPOISE

VAQUITA

Large, broad flippers

COMMERSON'S DOLPHIN

FRASER'S DOLPHIN

DUSKY DOLPHIN

FINLESS PORPOISE

BURMEISTER'S PORPOISE

## PORPOISES

Most of this group are smaller and rounder-bodied than their relatives. Porpoises are usually found in shallow seas near the coast.



# Animal skeletons

Without a skeleton, most animals would be a shapeless blob. Vertebrates, such as mammals and birds, have a strong internal skeleton. Many invertebrates, such as insects, have a protective external skeleton, called an exoskeleton.

## WHAT DOES THE SKELETON DO?

A skeleton provides an animal's body with strength, shape, and protection. Muscles are attached to the bones, and joints between bones enable movement. Bones also store vital minerals and produce red blood cells.



**SUPPORT**  
The skeletal framework gives shape and strength to an animal's body.



**PROTECTION**  
Bones such as the ribcage and skull protect vital organs from injury.



**MOVEMENT**  
Bones act as levers and are points of attachment for the muscles.

## INNER SKELETONS

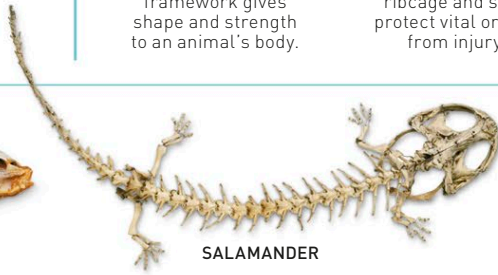
All vertebrates have an inner skeleton that supports the body and protects the organs. The skeleton is usually made of bone, although some animals—such as sharks—have a skeleton made of flexible cartilage.



FLATFISH



FISH



SALAMANDER



SNAKE



FROG



TURTLE



TORTOISE



CHAMELEON



GECKO



LIZARD



CAIMAN



PENGUIN



STARLING



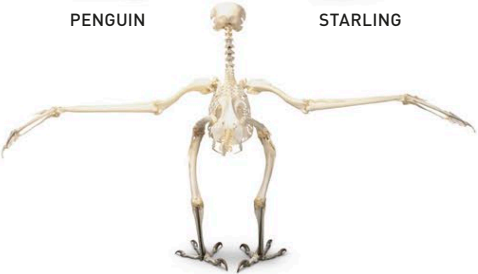
CROW



DUCK



PIGEON



BUZZARD



KESTREL



OWL



EAGLE





## OUTER SKELETONS

Several groups of invertebrates have an armorlike external skeleton. The rigid casing protects the animal from damage and attack by predators. When insects or creatures such as crabs grow, they shed their exoskeleton and make a new one.



LOBSTER



TARANTULA



CRAB



MILLIPEDE



RHINOCEROS BEETLE



DRAGONFLY



MEALWORM LARVA

## ECHINODERM SKELETON

These marine invertebrates include sea urchins, starfish, and their relatives. They have an exoskeleton made of plates, covered by a thin layer of skin. When these animals grow, their skeleton grows with them.



SEA URCHIN SKELETON

## HYDROSTATIC SKELETON

The shape of many soft-bodied invertebrates is supported by a water-based "skeleton" consisting of a fluid-filled cavity surrounded by a muscular wall.



JELLYFISH



AFRICAN ELEPHANT

AN ELEPHANT'S SKELETON IS THE HEAVIEST OF ALL THE LAND MAMMALS.



BAT



SQUIRREL



HARE



BADGER



GORILLA



CHIMPANZEE



HUMAN



CAT



MONKEY



WOLF



HORSE



TIGER

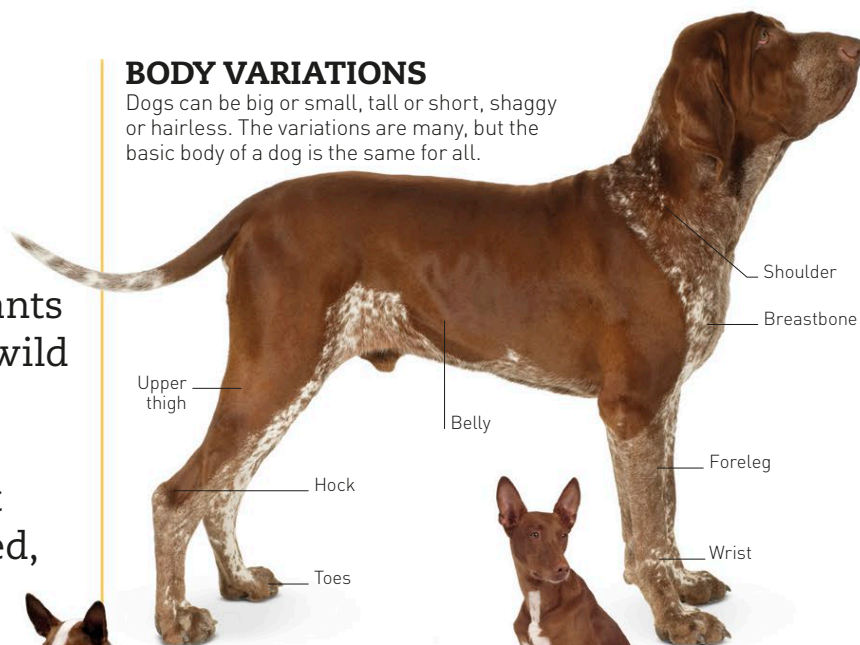


# Dogs

People and dogs have been together for at least 12,000 years. All dogs are descendants of gray wolves that left the wild for the camps of prehistoric hunters. Since those distant times, hundreds of different dog breeds have been created, in all sizes and types.

## BODY VARIATIONS

Dogs can be big or small, tall or short, shaggy or hairless. The variations are many, but the basic body of a dog is the same for all.



## EVOLUTION

There are more than 500 million dogs worldwide. All of them are related to each other through their ancestor, the gray wolf.

### WOLVES

Tribespeople all over the ancient world began to tame wolves as useful hunting companions.



### DOGS

People began to breed dogs for specific purposes and in doing so changed and standardized their form.



## CLOSE TO WOLVES

After centuries of change, most dogs are no longer at all like their wolf ancestors. Just a few are still close to the original wolf form. Some are popular pets and others are semiwild.



CANAAN



PERUVIAN INCA ORCHID



IBIZAN HOUND



NEW GUINEA SINGING DOG



CAROLINA



PHARAOH HOUND



PORTUGUESE PODENGO



BASENJI



MEXICAN HAIRLESS



PERUVIAN HAIRLESS

## SPITZ DOGS

The most famous spitz dogs are breeds such as the husky, which was once used for sled-pulling on polar expeditions. Spitz dogs have immensely thick, double coats and furry feet.



SIBERIAN HUSKY



GREENLAND DOG



SAMOYED



CHOW CHOW



LAIKA

## TERRIERS

Bold and lively, terriers come in many different sizes and types. They are strong-willed and must be trained properly to prevent bad habits, such as chasing other pets. The favorite game of many terriers is digging holes.



SCOTTISH TERRIER



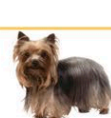
WEST HIGHLAND WHITE TERRIER



FOX TERRIER



JACK RUSSELL TERRIER



YORKSHIRE TERRIER



CAIRN TERRIER



NORFOLK TERRIER



BOSTON TERRIER



MANCHESTER TERRIER



WHEATEN TERRIER



BEDLINGTON TERRIER



BULL TERRIER



RUSSIAN BLACK TERRIER

## GUNDOGS

These dogs were developed to work with hunters. Some are used for locating prey. Other gundogs drive game birds out of cover and pick up those that are shot.



SPANISH WATER DOG



LAGOTTO ROMAGNOLO



BRITTANY

COCKER SPANIEL



GOLDEN RETRIEVER



IRISH SETTER



CHESAPEAKE BAY RETRIEVER

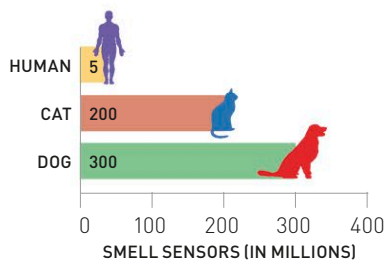


HUNGARIAN VIZSLA



## KEEN NOSES

The nose of a dog is packed with hundreds of millions of smell sensors. These pick up detailed messages about the world.



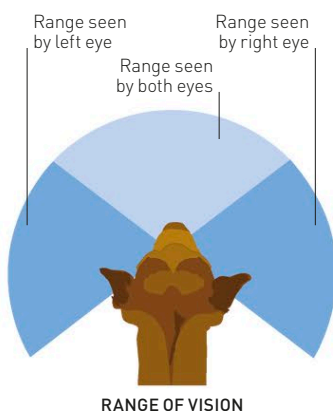
## EARS

There are a large variety of dog ear shapes. Most dogs have good hearing, and pointy-eared dogs hear better than droopy-eared breeds.



## A DOG'S-EYE VIEW

Dogs have a wider field of vision than humans and so can see more without moving their heads. They see detail clearly, have good 3-D vision, and can see movement at long range.



## BEHAVIOR

When pet dogs do things such as stopping to mark a tree, they are behaving as a wolf would in the wild. Dogs and wolves also use the same body language.



### HOWLING

Dogs don't howl often. They howl if they are shut in alone, possibly because they want company.



### MARKING TERRITORY

Dogs leave scent markings to communicate with other dogs.



### NOSE LICKING

A lick of the nose is usually a sign that a dog is calming itself down.



### YAWNING

Yawning is a calming signal. Dogs yawn to deflect threats and avoid conflict.



### DIGGING

Dogs dig to bury things and to reach animals that live underground.

## WORKING DOGS

Herding sheep and cattle, guarding property, and rescuing lost people are some of the jobs done by working dogs. Many of these breeds make very good pets.



## SCENT HOUNDS

With the best noses of all dog breeds, scent hounds have been used for centuries to track prey. They have strong hunting instincts, and some work well in a pack.



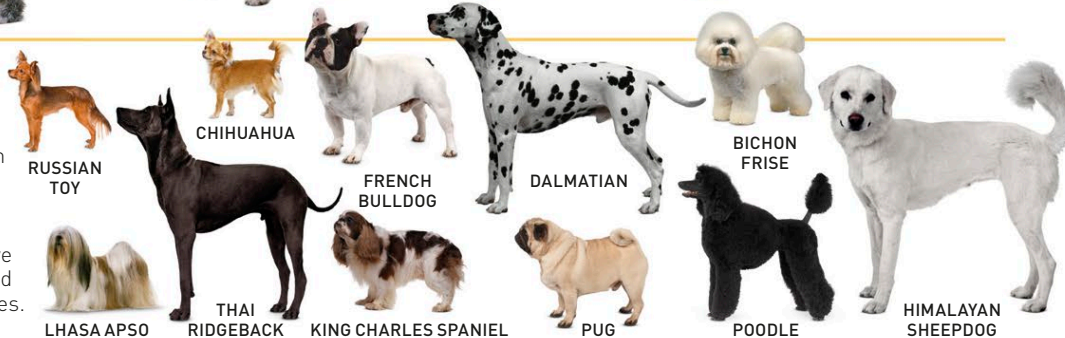
## SIGHT HOUNDS

Slender and long-legged, these hounds are swift hunters that follow prey by sight. They are mainly kept today for racing and as pets.



## COMPANION DOGS

Many breeds, most of them small, have been specially produced to make good companions. They are designed to have appealing looks and affectionate natures.



## CROSSBREDS

Some dogs are the result of a planned cross between two recognized breeds. Dogs with unknown parentage are called mixed breeds.





# Cats

Tens of millions of pet cats are kept worldwide. Some of these are pedigrees—breeds “designed” with a special look, such as a striking coat pattern or long hair. Most people love cats just for their appealing personalities and independent ways.



## EYES

A reflective layer in the eye helps a cat see well at night. This layer gleams green when light strikes it.



## WHISKERS

The touch-sensitive whiskers help a cat judge the width of gaps.



## TONGUE

Tiny barbs on a cat's tongue give it a rough texture. This is useful for grooming and for licking meat from bones.

## AGILE BODY

Cats are built for speed and agility. A bendy spine and loose-fitting skin allow them to twist and stretch in all directions. Powerful leg muscles enable them to run fast, leap high, and climb.

The tail provides balance when the cat jumps and climbs.

Strong hindlegs give cats a powerful spring.

Loose-fitting skin allows easy movement.

The sharp claws retract (pull back) into a pocket in the foot when not needed.

## SHORT-HAIRED CATS

The first cats to be kept as pets, probably about 4,000 years ago, were short-haired. This type is the favorite with cat owners today. Colors and markings show up clearly on short hair, and the coat is easy to groom. Some cat breeds have both short- and long-haired versions.



CHARTREUX

KHAO MANEE



MUNCHKIN



SIAMESE

## LONG-HAIRED CATS

These cats are shaggy, silky, or fluffy, depending on type. Some longhairs, such as the Persian, have an immensely thick underlayer to their coat that needs daily brushing and combing.



TURKISH VAN



SIBERIAN



NORWEGIAN FOREST CAT

## TAIL LANGUAGE

A cat uses its tail to give out messages about its feelings. Learning to read this “language” helps us understand cats.

**A MOTHER CAT HOLDS HER TAIL UPRIGHT AS A SIGN TO HER KITTENS TO FOLLOW HER.**



**PLEASED/EXCITED**  
Pointing straight up and quivering.



**WATCHFUL**  
Twitching slightly from side to side.



**READY TO ATTACK**  
Held bristling over the back.



**ANXIOUS**  
Upright and fluffed out.

## TRUE OR FALSE?

Cats are mysterious animals. It is not surprising that people wonder what to believe about them. These are some popular sayings.



**CATS HAVE NINE LIVES**  
False. Cats are good at landing on their feet after a fall or getting out of trouble, but they have only one life.



**CATS SPEND MOST OF THEIR TIME SLEEPING**  
True. Even an active cat sleeps on average for about two-thirds of its day.



**BLACK CATS BRING BAD LUCK**  
False. This is folklore that is repeated in many regions. Some people say black cats are lucky.



**CATS CAN BE RIGHT-PAWED OR LEFT-PAWED**  
True. Female cats are more likely to use the right paw, while male cats tend to use the left.



**CATS USE THEIR WHISKERS FOR BALANCE**  
False. Cats' whiskers are “feelers” for finding the way, not for balancing.

## KITTENS

Born blind and helpless, kittens turn into adult cats in a very short time. At about 10 weeks old, they no longer rely on their mother. They can wash themselves, climb, jump, and hunt pretend prey.



### 1 FOUR DAYS

Although its eyes are tight shut, the kitten can sense its surroundings.



### 2 TWO WEEKS

The eyes have opened, but the kitten cannot see very well.



### 3 FOUR WEEKS

Already toddling around, the kitten uses its tail for balance.



### 4 EIGHT WEEKS

Very active, the kitten is learning how to be a grown-up cat.



### 5 TEN WEEKS

The kitten is nearly independent and ready to leave its mother.





BOMBAY



EXOTIC SHORTHAIR



TONKINESE



ABYSSINIAN



EGYPTIAN MAU



EUROPEAN BURMESE



OCICAT



SAVANNAH



DEVON REX



SNOWSHOE



BRITISH SHORTHAIR



MANX



RUSSIAN BLUE



SCOTTISH FOLD



AUSTRALIAN MIST



ORIENTAL



JAPANESE BOBTAIL



BENGAL



KORAT



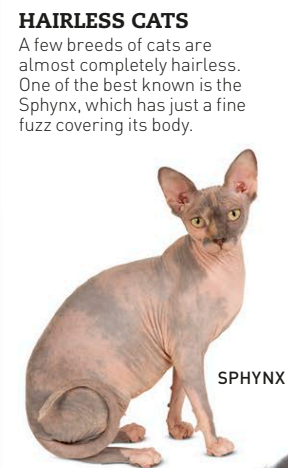
ASIAN



SINGAPURA



SELKIRK REX



SPHYNX

**HAIRLESS CATS**  
A few breeds of cats are almost completely hairless. One of the best known is the Sphynx, which has just a fine fuzz covering its body.



KINKALOW



AMERICAN CURL



KURILIAN BOBTAIL



PERSIAN



SOMALI



SCOTTISH FOLD



CYMRIC



RAGDOLL



CHANTILLY/ TIFFANY



TIFFANIE



PIXIEBOB



BIRMAN



TURKISH ANGORA



LAPERM



MUNCHKIN LONGHAIR



BALINESE-JAVANESE



MAINE COON

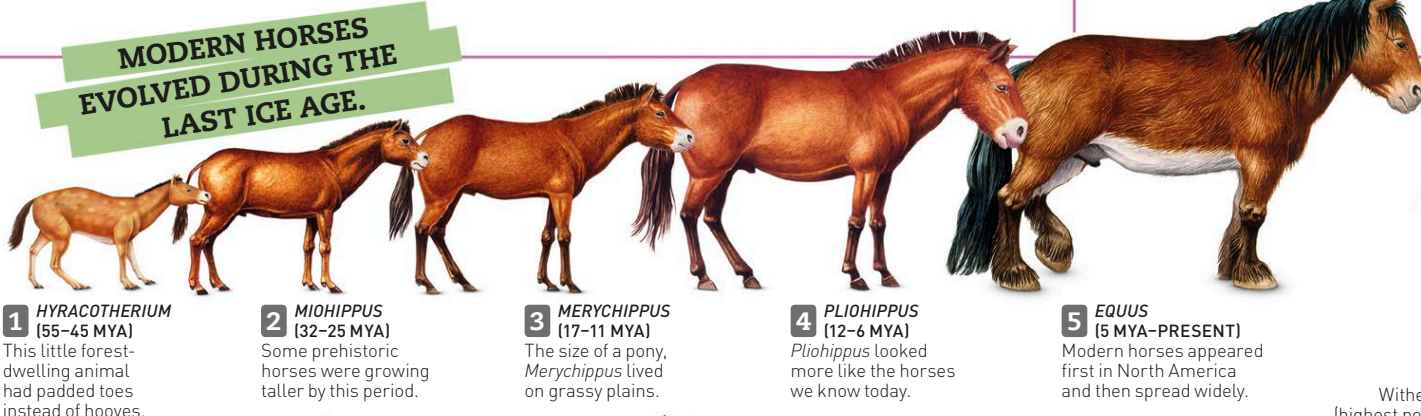


# Horses

People are thought to have first tamed wild horses for riding and pulling loads around 6,000 years ago. Until modern times, the horse was the fastest form of transportation available and an essential part of farming life. Today, horses are mostly used for leisure riding and other sports. There are hundreds of different breeds of all sizes.

## EVOLUTION OF THE HORSE

Forerunners of the horse first appeared 55 million years ago (MYA). These animals, about the size of a small dog, looked very different from modern horses. The pictures here show some of the stages of the horse's evolution.



**1 HYRACOTHERIUM**  
(55–45 MYA)

This little forest-dwelling animal had padded toes instead of hooves.

**2 MIOHIPPIUS**  
(32–25 MYA)

Some prehistoric horses were growing taller by this period.

**3 MERYCHIPPUS**  
(17–11 MYA)

The size of a pony, *Merychippus* lived on grassy plains.

**4 PLIOHIPPIUS**  
(12–6 MYA)

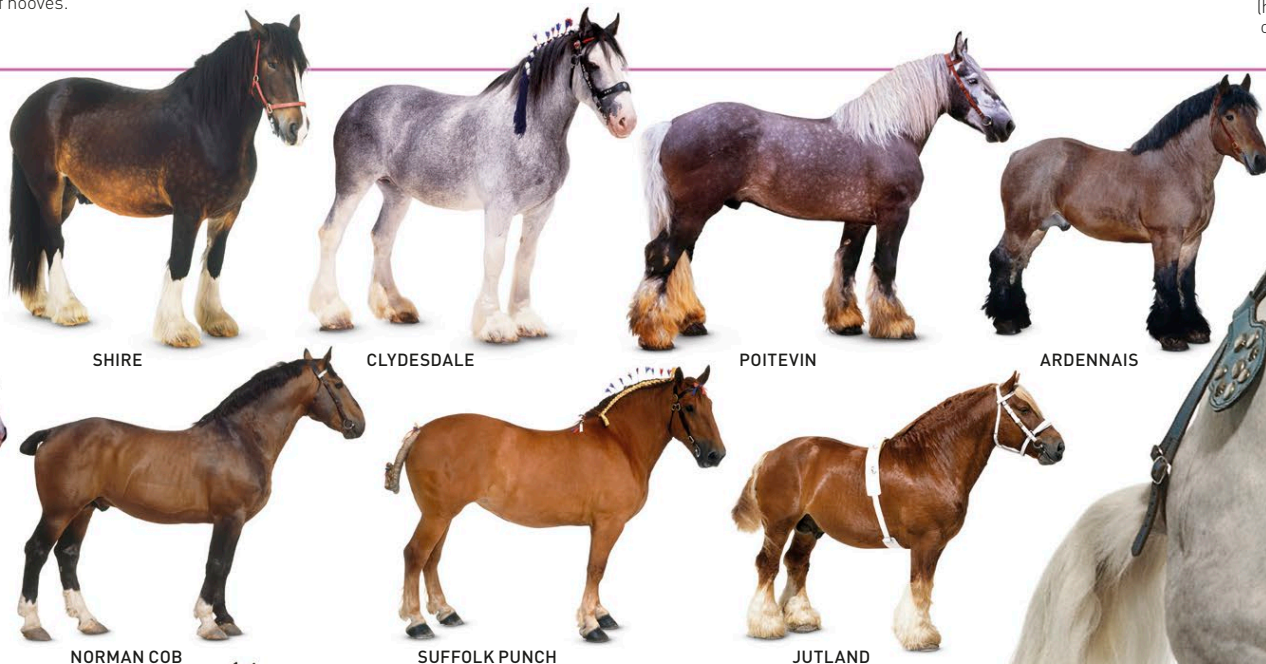
*Pliohippus* looked more like the horses we know today.

**5 EQUUS**  
(5 MYA–PRESENT)

Modern horses appeared first in North America and then spread widely.

## HEAVY HORSES

Also called draft or working horses, these large, strongly built animals are bred for hauling heavy loads. They were once widely used for farm work, but most of them are now kept for showing and other competitions.



SHIRE

CLYDESDALE

POITEVIN

ARDENNAIS

PERCHERON

NORMAN COB

SUFFOLK PUNCH

JUTLAND

## LIGHT HORSES

These horses are smaller and less powerful than draft horses. They are widely used for leisure riding and in sports such as racing, showjumping, and carriage driving.



THOROUGHBRED

ANDALUCIAN

ARABIAN

DANISH  
WARMBLOOD

KNABSTRUP

KARABAKH

APPALOOSA

## NAMING PARTS

The various parts of a horse's body have special names, which riders and other people who work with horses always use. These parts are often referred to as the "points" of a horse.

Forelock

Crest (topline of neck)

Withers  
(highest point of shoulders)

Flank

Hock (joint similar to human ankle)

Fetlock (a joint)

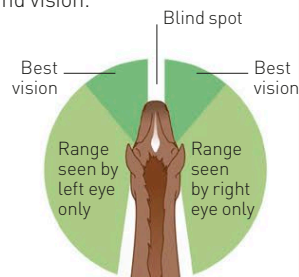
Hoof





## HOW HORSES SEE

As prey animals, horses need to spot danger. Eyes on the sides of their heads give them almost all-around vision.



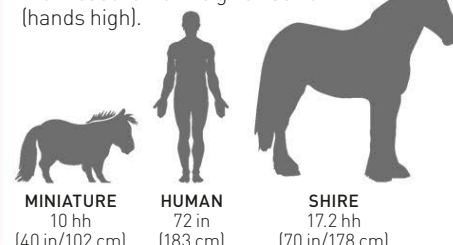
## LEG MARKINGS

Horses often have one or more white markings on their legs. The markings are given different names depending on how far up the leg they extend.



## HORSE HEIGHT

Traditionally, horses are measured in units called "hands." One hand is 4 in (10.2 cm)—about the width of a person's hand. If a horse is, say, 16 hands 2 in in height, the measurement is given as 16.2 hh (hands high).



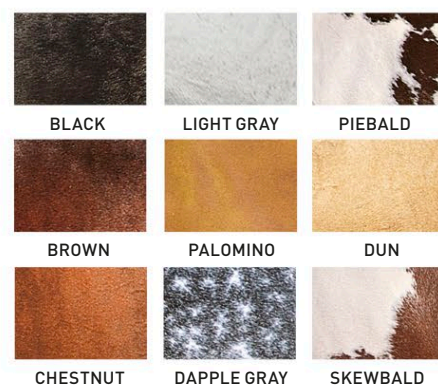
## HEAD MARKINGS

White markings on a horse's head are very common and occur with many coat colors. They are named according to their pattern.



## COAT COLORS

Horses have many coat colors and patterns. Manes and tails are often a different color from the body.



## PONIES

A pony is a small horse standing no taller than 58 in (147 cm)—14.2 hh—at the highest part of its back. There are many breeds native to different countries and regions.



SKYRIAN



SHETLAND



GOTLAND PONY



SORRAIA



HAFLINGER



CONNEMARA



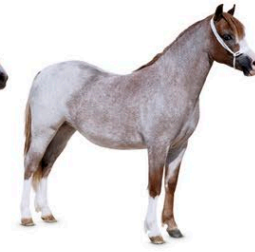
BASHKIR



PONY OF THE AMERICAS



EXMOOR



WELSH MOUNTAIN PONY

## RELATIVES

Domestic horses have several relatives. These are various types of asses and zebras. Only one breed of wild horse still exists—Przewalski's horse from Central Asia.



AFRICAN WILD ASS



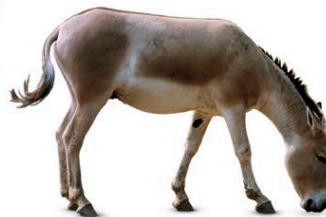
ZEBRA



PRZEWALSKI'S HORSE



DONKEY



ONAGER



## DUCKS AND GEESE

These birds are kept for meat and eggs, and sometimes their soft downy feathers are used for quilted bedding and clothing. Large and noisy, geese are wary of anything suspicious and make very good "watchdogs."



WHITE PEKIN DUCK



INDIAN RUNNER DUCK



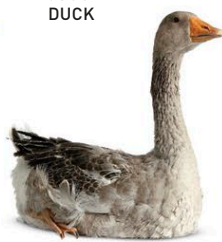
KHAKI CAMPBELL DUCK



MUSCOVY DUCK



EMBDEN GOOSE



TOULOUSE GOOSE

## CHICKENS

Farmers around the world raise billions of chickens a year. Some birds are reared for their meat and others as egg-layers.



PEKIN BANTAM



BRAHMA



BUFF ORPINGTON



CUCKOO MARANS



LIGHT SUSSEX



GOLDEN-LACED WYANDOTTE

# Farm animals

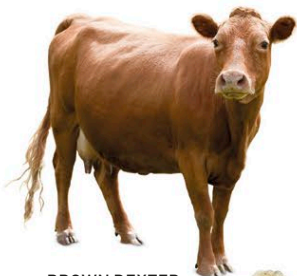
Many animals that were once wild are now reared on farms to provide us with food or materials. Some farms specialize in one type of animal—for example, cows, pigs, or chickens—while others rear a variety of livestock.

## CATTLE

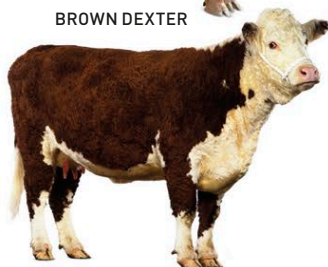
There are many types of cattle, some kept for milking and others for providing beef. After thousands of years of careful breeding, domestic cattle look very little like their wild ancestors.



FRIESIAN



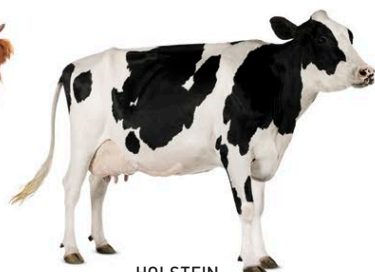
BROWN DEXTER



HEREFORD



HIGHLAND



HOLSTEIN



LONGHORN



JERSEY



GREYFACE DARTMOOR

## SHEEP

Usually given more freedom to roam than most farm animals, sheep are kept, sometimes in huge numbers, for meat and wool. Some breeds are shorn of their thick coats, known as fleeces, every year.



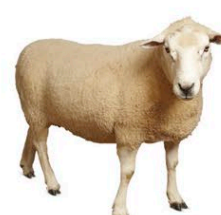
COTSWOLD



LINCOLN LONGWOOL



WENSLEYDALE



TEXEL CROSS



HEBRIDEAN



JACOB



## THE FIRST FARM ANIMALS

Farming developed over thousands of years, as people gradually learned which animals could be useful to them. They also found out how to handle the larger, more dangerous ones such as horses and camels. The dates when most animals were first farmed are not known exactly.



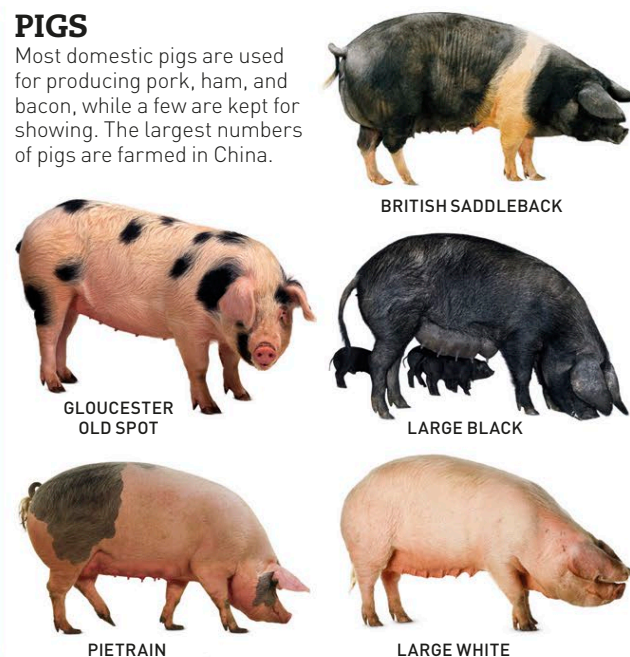
## GOATS

Worldwide, goats are popular for their milk, meat, and hair. Easier to keep and feed than cattle, they are particularly important to many small farmers in Asia and Africa.



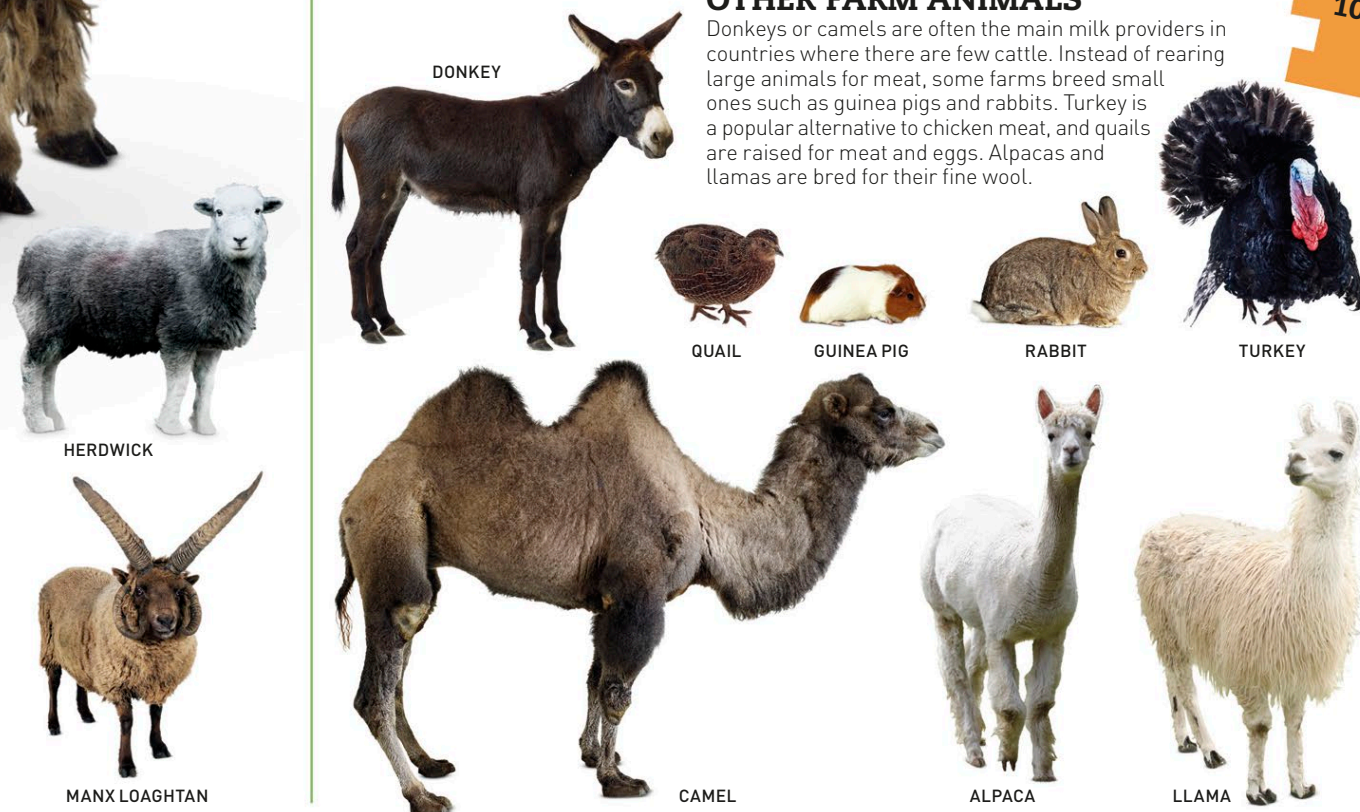
## PIGS

Most domestic pigs are used for producing pork, ham, and bacon, while a few are kept for showing. The largest numbers of pigs are farmed in China.



## OTHER FARM ANIMALS

Donkeys or camels are often the main milk providers in countries where there are few cattle. Instead of rearing large animals for meat, some farms breed small ones such as guinea pigs and rabbits. Turkey is a popular alternative to chicken meat, and quails are raised for meat and eggs. Alpacas and llamas are bred for their fine wool.



**A HONEYBEE MAY VISIT 100 FLOWERS IN ONE TRIP TO COLLECT POLLEN OR NECTAR.**



## BEEKEEPING

Many people keep bees for fun, but beekeeping is also run as a farming business. Some beekeepers look after hundreds of hives and sell their honey and beeswax to big customers such as supermarkets.



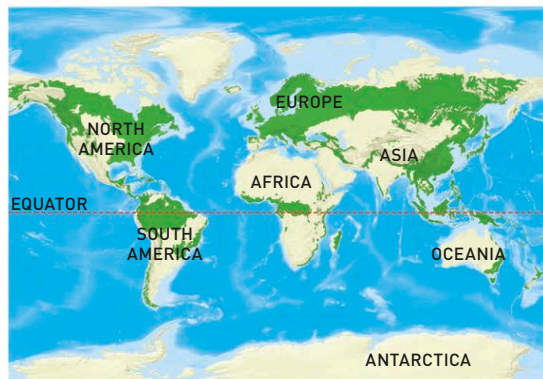


# Forest

About 30 percent of the world's land area is forest. These large areas of trees form dense canopies, which restrict the amount of light that reaches the ground. The types of trees in the forest vary with the climate, but all are home to a range of plants and animals.

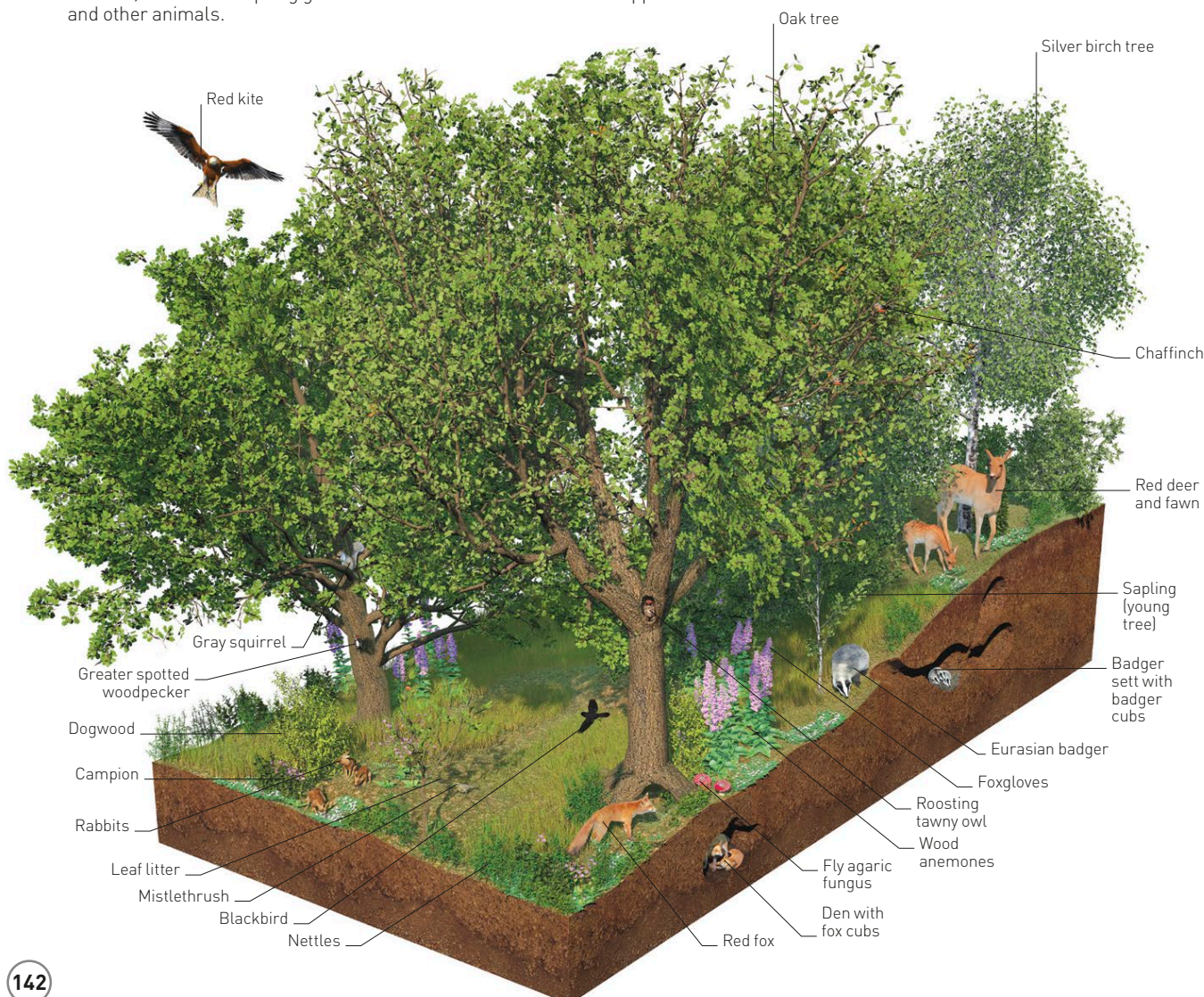
## WHERE ON EARTH?

Forests grow wherever the climate is warm and rainy enough to support large numbers of trees. This allows forests of different types to grow on every continent, except Antarctica—from the hot, tropical rainforests near the equator to the cool, snowy forests of the far north.



## BIODIVERSITY

Every natural forest has a variety of trees and other plants and provides homes for many animals. In regions with cold winters and warm summers, many trees lose their leaves in winter. Animals survive by lying low or moving somewhere warmer, but the new spring growth feeds masses of insects that support birds and other animals.



## TYPES OF FORESTS

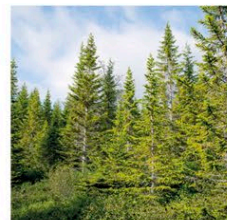
Some forests contain many different species of trees, while others contain large groups of the same type. In some parts of the world, trees need special adaptations to survive cold, hot, dry, or wet seasons.



**TEMPERATE DRY**  
These forests have hot, dry summers and mild, wet winters. Trees can be evergreen or deciduous.



**TEMPERATE DECIDUOUS**  
A deciduous tree has large, thin leaves that make food in summer. In winter, when the weather is cold and there is little sun, deciduous trees shed their leaves.



**BOREAL EVERGREEN**  
In cold regions, the summer is too short for deciduous trees to grow well. Here, most of the trees are conifers, with tough, needle-shaped leaves that are resistant to the cold.

## MAMMALS

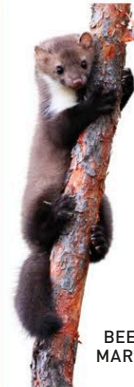
Many forest mammals feed on leaves, fruit, nuts, and seeds. Others, including many bats, prey on insects. Small mammals are targeted by bigger hunters such as foxes, and some forests support packs of wolves.



POLECAT



EURASIAN BADGER



BEECH MARTEN



RACCOON



HEDGEHOG



STRIPED SKUNK

## BIRDS

In forests with cold winters, many of the birds are summer visitors from warmer regions. They nest, raise their young, then leave. Other birds stay in the forest all year round.



GREAT HORNED OWL



COAL TIT



ROBIN

## PLANT LIFE

Many different types of trees grow in forests. They shelter a variety of smaller plants that can grow in shady conditions. In deciduous forests, some small plants flower in spring before they are shaded by the new leaves growing on the trees.



MOSS

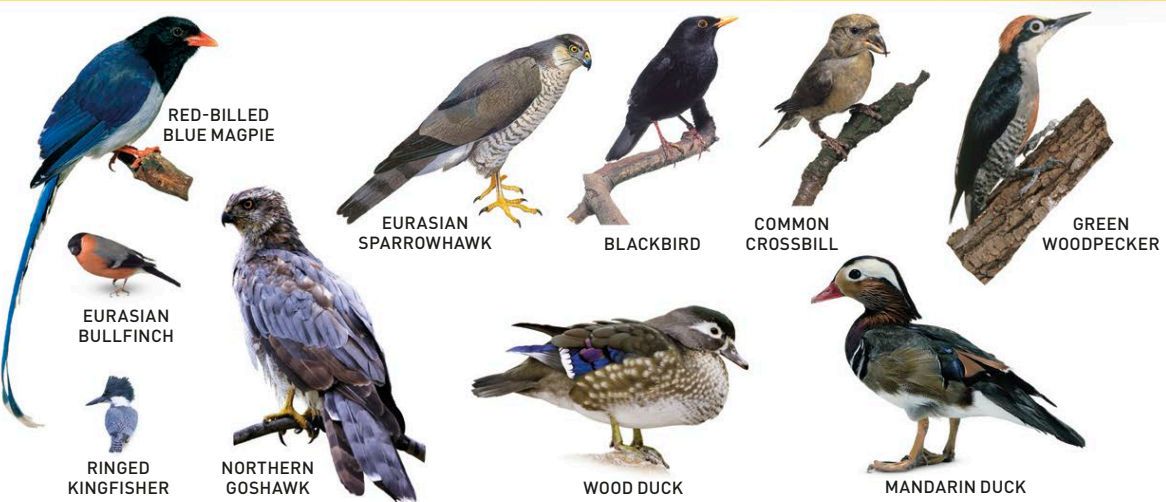


ENGLISH OAK



MONTPELLIER MAPLE





### INVERTEBRATES

Most forest animals are insects, spiders, snails, worms, and other invertebrates. They flourish in summer, but most of them hide away or die off in winter.

PURPLE EMPEROR

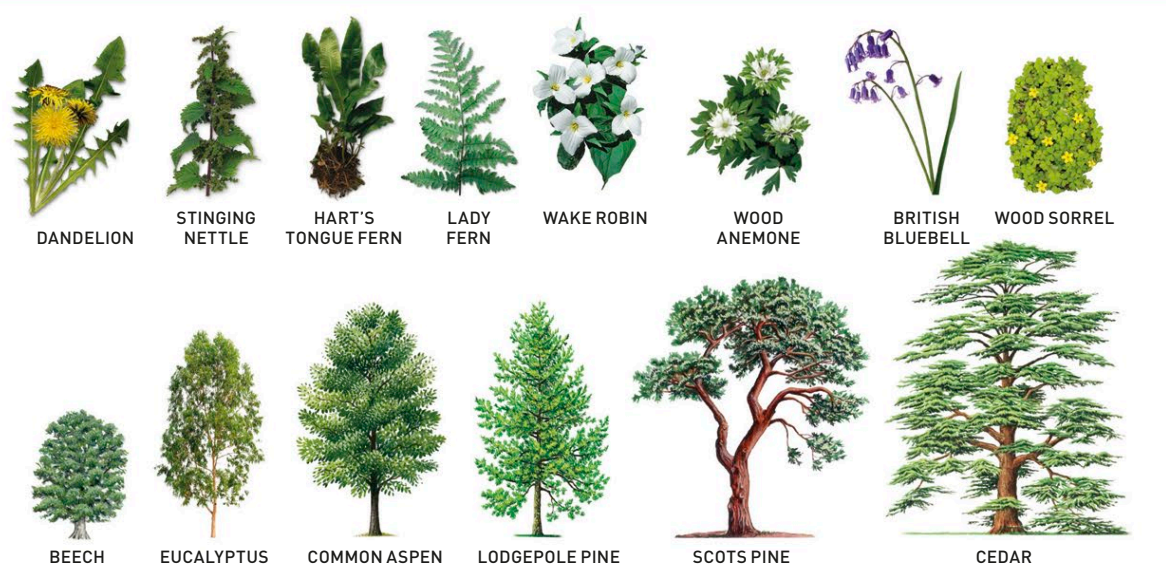
LADYBIRD

STAG BEETLE

WOOD ANT

HORNET MOTH

COMMON WASP



### FUNGI AND LICHENS

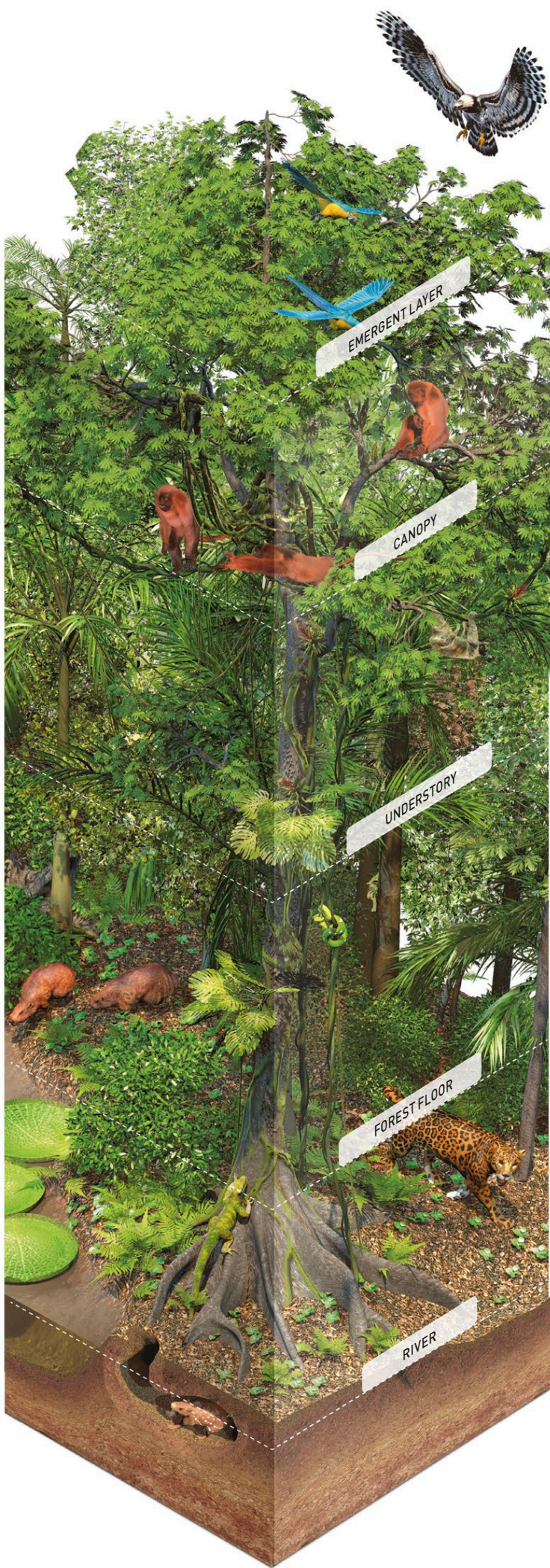
Dead leaves and other plant remains are recycled by mushrooms and other fungi. They break down the tough plant tissue and turn it into food for other plants. Lichens are relatives of fungi that can make their own food.

lichen

MUSHROOMS

ORANGE LICHEN





## EMERGENT LAYER

The rainforest has many layers, which give animals different places to live. Soaring above the rest of the forest, a few extra-tall trees form the highest layer. These giants make good perches for birds.



SUNLIGHT



**HARPY EAGLE**  
Mexico to South America



**BLUE MORPHO BUTTERFLY**  
Central and South America



**SCARLET MACAW**  
Mexico to South America



**HANGING PARROT**  
Southeast Asia



**DENDROBIUM ORCHID**  
Southeast Asia

## CANOPY

Most of the forest trees have broad crowns that form a continuous layer of branches called the canopy. This is where many of the animals live and feed, high above the forest floor.



SUNLIGHT



**BLUE POISON-DART FROG**  
South America



**RED-EYED TREE FROG**  
Central America



**GREEN TREE PYTHON**  
New Guinea; Australia



**MISTLETOE CACTUS**  
Central America



**SHINING-GREEN HUMMINGBIRD**  
South America



**WHITE-THROATED TOUCAN**  
South America



**AFRICAN GRAY PARROT**  
West and Central Africa

## UNDERSTORY

Beneath the canopy is a layer of smaller trees and shrubs that can grow in the shade of the tall trees. It is alive with insects, lizards, and tree-living snakes.



SUNLIGHT



**MAGNIFICENT BIRD OF PARADISE**  
Papua New Guinea



**EMERALD TREE BOA**  
South America



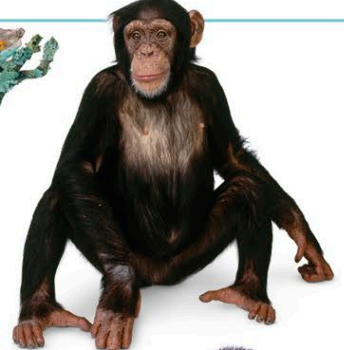
**FRANQUET'S FRUIT BAT**  
West and Central Africa



**KUHL'S FLYING GECKO**  
Southeast Asia



**PARSON'S CHAMELEON**  
Madagascar



**CHIMPANZEE**  
West to Central Africa

## FOREST FLOOR

The dim light at ground level means that few plants can grow except in clearings. Fallen fruit and seeds provide food for small animals, which are hunted by predators such as jaguars.



SUNLIGHT



**RAFFLESIA**  
Southeast Asia



**TIGER CENTIPEDE**  
Southeast Asia



**GOLDEN SCARAB**  
South America



**KING COBRA**  
South and Southeast Asia



**EMPEROR SCORPION**  
Africa



**MANDRILL**  
Central Africa



**WESTERN GORILLA**  
Central Africa

## RIVER

Thick vegetation grows along the sunlit banks of rivers. In the rainy season, some rivers swell so high that they overflow and flood vast areas of the surrounding forest.



SUNLIGHT



**MADAGASCAN TOMATO FROGS**  
Madagascar



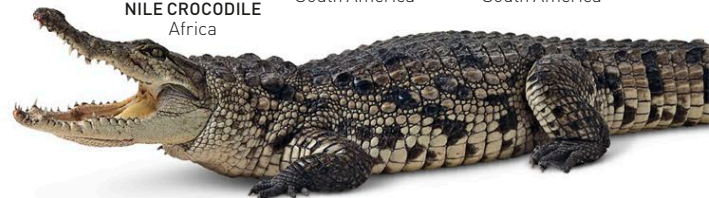
**MATAMATA TURTLE**  
South America



**PIRANHA**  
South America



**CAPYBARA**  
South America



**NILE CROCODILE**  
Africa





**VAMPIRE BAT**  
Mexico to South America

**BRAZIL NUT TREE**  
South America

**KAPOK TREE**  
Mexico; Central and South America; West Africa

**BLACK SPIDER MONKEY**  
South America

**MALAYAN FLYING FOX**  
Southeast Asia

**GUEREZA**  
West and Central Africa

**KINKAJOU**  
Mexico to South America

**MALACHITE**  
North to South America

**TAWNY RAJAH**  
South Asia

**PILEATED GIBBON**  
Southeast Asia

**ANT PLANT**  
Southeast Asia; Australia

**POSTMAN BUTTERFLY**  
Central and South America

**JUNGLE NYMPH**  
Southeast Asia

**BROMELIAD PLANT**  
Mexico to South America

**COCOA TREE**  
Central and South America

**SOUTH AMERICAN COATI**  
South America

**GIANT ANTEATER**  
Central and South America

**JAGUAR**  
Central and South America

**SCARLET IBIS**  
South America; Caribbean

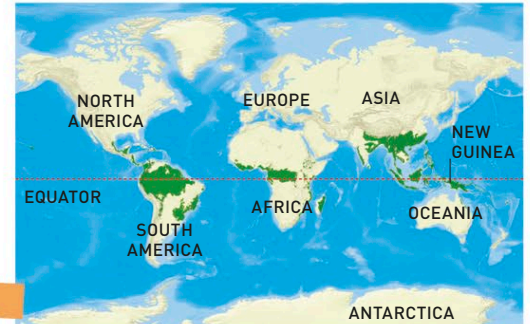
**ANACONDA**  
South America and Trinidad

# Rainforest

Tropical rainforests grow in regions that are always warm and wet, so trees and other plants can grow, flower, and produce seeds and fruit all year round. The trees provide homes and food for an amazing variety of animals, with more different species than anywhere else on Earth.

## WHERE IN THE WORLD?

Tropical rainforests grow near the equator. The climate here is hot and wet all year round and has no cold winters or dry summers. The biggest areas of rainforest are in Central and South America, Central Africa, Southeast Asia, and New Guinea. There are smaller patches in Madagascar, India, and northern Australia.



**THE AMAZON TROPICAL RAINFOREST IS THE LARGEST IN THE WORLD.**

## DEADLY LIFE IN THE RAINFOREST

The rainforests provide homes for many dangerous animals and plants. This list includes some of the most deadly.

### POISON-DART FROG

These tiny but vividly colored frogs from tropical America release toxins through their skin.



**STRAWBERRY POISON-DART FROG**

### GABOON VIPER

This heavy-bodied venomous snake lurks in ambush on the African forest floor.



**GABOON VIPER**

### VARIOUS PLANTS

Extracted from various South American plants, the chemical compound called curare was used to poison the tips of blow darts for hunting.

### BRAZILIAN WANDERING SPIDER

With its venomous bite, this big, long-legged hunter is the world's most deadly spider.

### BULLET ANT

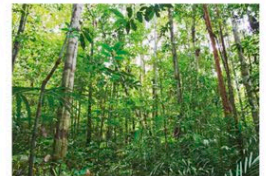
Native to Central and South America, this giant ant has such a painful sting that people say it feels like being hit by a bullet from a gun.

## TYPES OF RAINFORESTS

The nature of rainforests depends on where they grow. The tallest trees grow in the warm lowlands, while smaller trees and different types of plants grow higher up in the mountains where the climate is cooler.

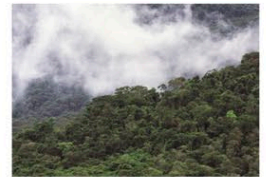
### LOWLAND RAINFOREST

The warm, wet lowland rainforest has the most plant and animal life and the richest variety of species.



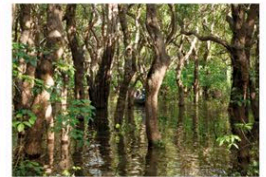
### CLOUD FOREST

Mountain forests are often hidden in the clouds. The trees are always wet and covered with mosses.



### FLOODED RAINFOREST

Every year, forests near rivers become flooded. The trees are surrounded by water inhabited by fish and turtles.



## LOSING THE RAINFORESTS

At least half the world's rainforests have been cut down for timber or to make way for farms. An area the size of a soccer field is cut down every second. If people carry on doing this, the forests will disappear.



**AGRICULTURE**  
Trees are felled so crops can be grown on the land. Some crops are used to make fuel for cars.



**CATTLE RANCHES**  
Meat for burgers is produced on ranches—fields of grass created on land that was once rainforest.



**LOGGING**  
Many rainforest trees are cut down for valuable timber called hardwood, which is sold worldwide.



**MINING**  
Minerals such as copper are mined from huge pits dug in the forest. These can cause river pollution.



# Savanna

Tropical regions of the world that are too dry for dense rainforest support open grasslands with scattered trees, known as savannas. In the tropical wet season, they are lush and green, but for half the year, they are hot, dry, and scorched by wildfires.

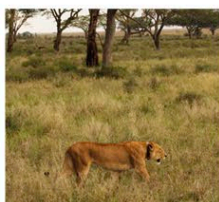
## WHERE IN THE WORLD?

Tropical grasslands form in warm regions near the equator that have long dry seasons. They include the African savannas and similar grasslands in South America, India, and northern Australia.



## AROUND THE WORLD

Many tropical grasslands are dry, with just a few trees. Others are more thickly wooded or become flooded by seasonal rains. Some have plants adapted for life on high mountains.



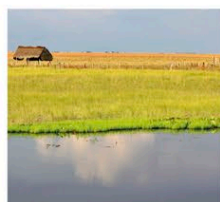
**SHORTGRASS SAVANNA**

The Serengeti in East Africa is a sea of grass dotted with trees.



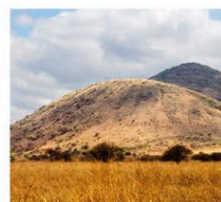
**WOODED SAVANNA**

This savanna in Australia is more like open woodland.



**FLOODED SAVANNA**

Much of the Llanos in South America floods in the rainy season.



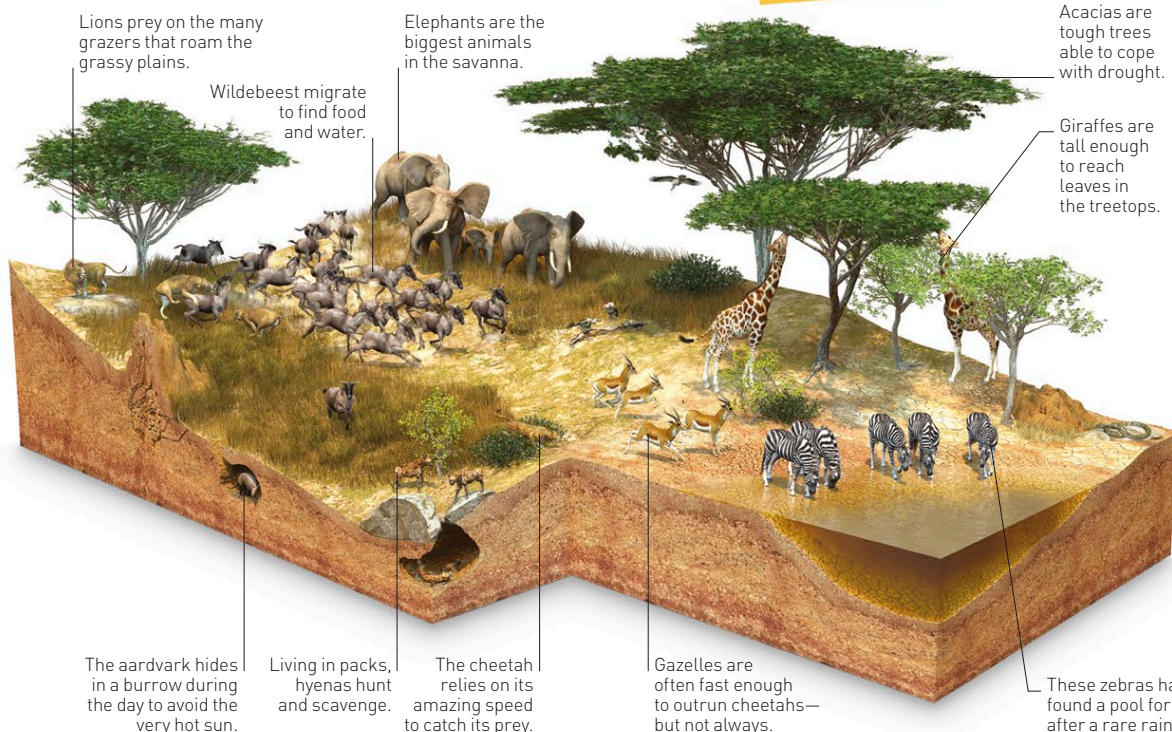
**MONTANE SAVANNA**

Above the tree line, it is cooler than in shortgrass savanna.

## LIFE IN THE AFRICAN SAVANNA

The plants and animals of typical savannas are adapted to survive months without rain. Many of the plants are able to avoid losing too much moisture, and the animals learn where to find supplies of vital drinking water.

**IN THE DRY SEASON, THE AFRICAN SAVANNA ONLY RECEIVES AROUND 4 IN (10 CM) OF RAIN.**



## BROWSERS AND GRAZERS

The plant life of the savannas provides food for a wide variety of animals. Some are browsers, which gather the leaves of trees and bushes. Others are grazers, which mainly eat grass and often live in big herds.



## HUNTERS AND SCAVENGERS

Powerful hunters such as lions prey on the big plant-eating animals. Others, including the giant anteater, hunt insects. Scavengers eat the remains of dead animals.



**BLACK VULTURE**



## REPTILES, AMPHIBIANS, AND INSECTS

The savanna grasslands swarm with insects such as flies, beetles, and termites. There are also many species of frogs, lizards, and snakes.

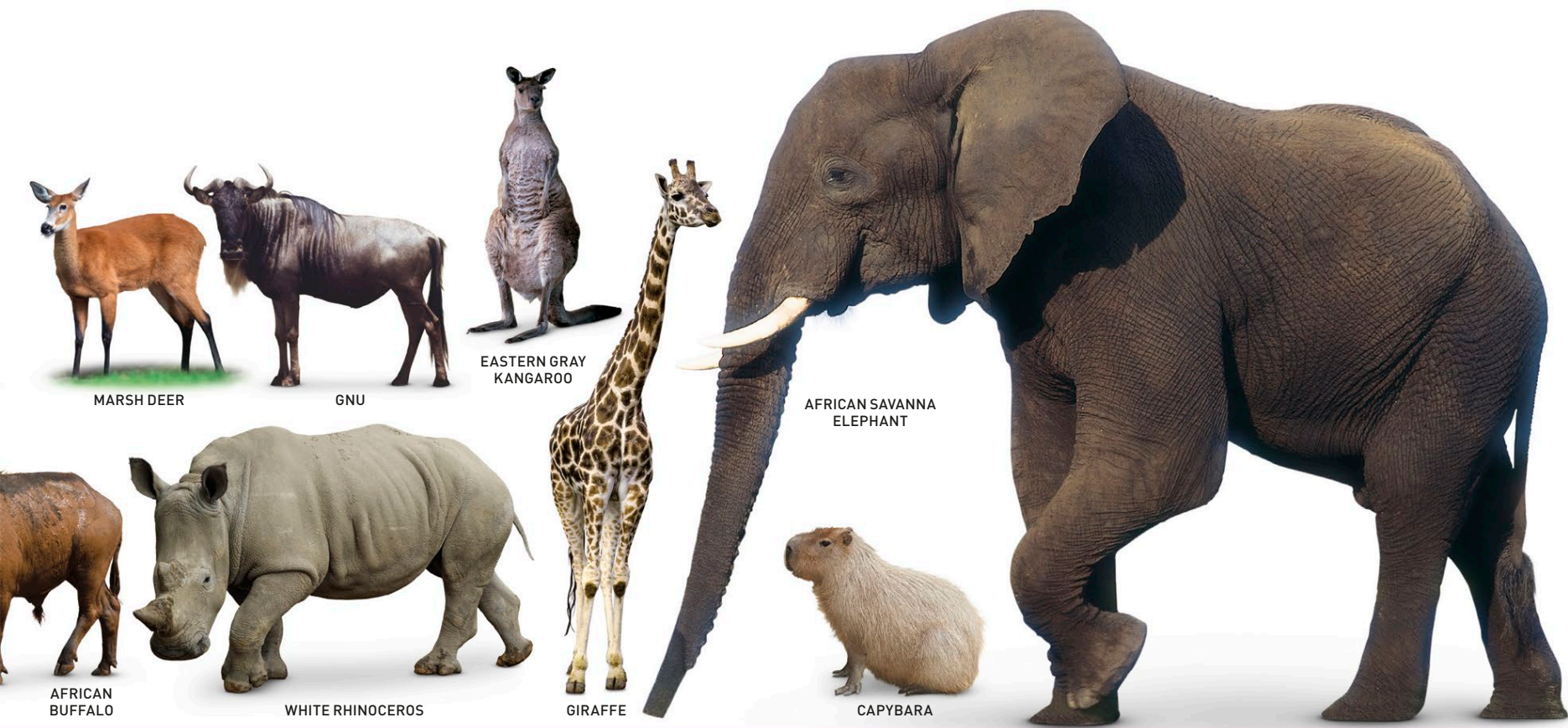


**AFRICAN ROCK PYTHON**



**NILE MONITOR**





MARSH DEER

GNU

EASTERN GRAY KANGAROO

AFRICAN SAVANNA ELEPHANT

AFRICAN BUFFALO

WHITE RHINOCEROS

GIRAFFE

CAPYBARA



AFRICAN WHITE-BACKED VULTURE

GIANT ANTEATER

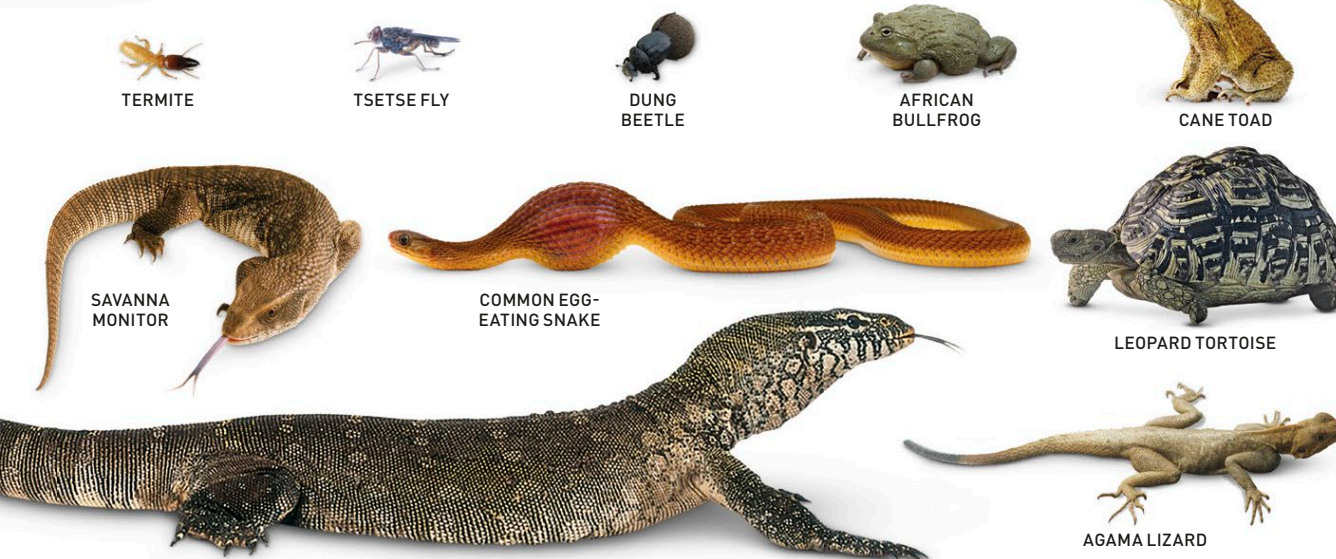
MANED WOLF

AFRICAN WILD DOG

JAGUAR

SPOTTED HYENA

**SPOTTED HYENAS LIVE IN LARGE GROUPS CALLED CLANS, WHICH ARE LED BY FEMALES.**



TERMITE

TSETSE FLY

DUNG BEETLE

AFRICAN BULLFROG

CANE TOAD

SAVANNA MONITOR

COMMON EGG-EATING SNAKE

LEOPARD TORTOISE

AGAMA LIZARD

## PLANTS

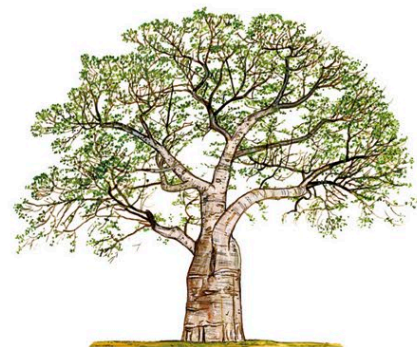
Grasses and other small plants survive the dry season by allowing the parts above ground to die back. When rain comes, they sprout from roots or seeds. Acacia trees are tough enough to avoid drying up, while baobab trees store water in their trunks.



ACACIA



TASMANIAN BLUE GUM



BAOBAB



# Deserts

Deserts are the driest habitats on Earth, with less than 10 in (25 cm) of rainfall a year. They may be hot, cold, or coastal, depending on their geographic position, but all are dry. Desert animals and plants must be able to survive with little or no water and endure significant daily ranges in temperature.

## WHERE IN THE WORLD?

The biggest deserts are in the hot, dry parts of north Africa, Arabia, and Australia. Other deserts have formed in Asia and the Americas in places that are far from oceans or cut off by mountain ranges.



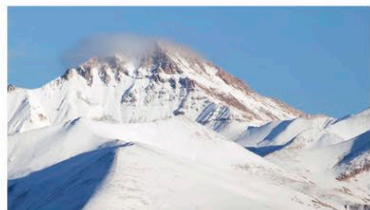
## TYPES OF DESERTS

All deserts share one feature—they are very dry. But they form in many ways, and each desert is different. Many are sandy, others are rocky, and a few are snowy. Some are not as dry as others and have a lot of plant life.



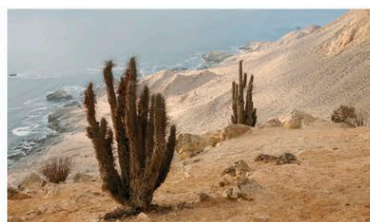
### HOT DESERT

In deserts such as the Sahara, heat makes any moisture dry up. These deserts are hot by day and cold by night. They can be sandy or stony.



### COLD DESERT

Most cold deserts are in mountain ranges or in the middle of continents, far from oceans. Any winter rain falls as snow.

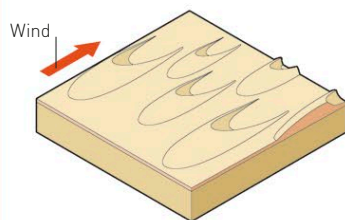


### COASTAL DESERT

Where deserts occur by the sea, they may be covered in fog but still go for years without rainfall, remaining very dry.

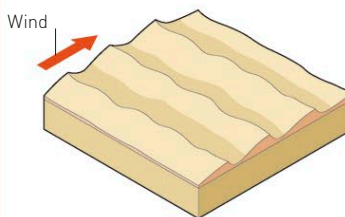
## SAND DUNES

The desert wind can blow dry sand into heaps called dunes. When the wind loses strength, it drops the sand suspended in it. The shape the resulting dunes form depends on wind direction and sand texture.



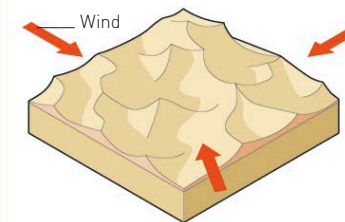
### CRESCENT DUNES

These dunes have less sand at their edges, meaning those parts of the dune move faster, giving a distinctive crescent shape.



### TRANSVERSE DUNES

Constant winds form long ridges of sand that look like waves on the sea. The crests lie across the direction of the wind.

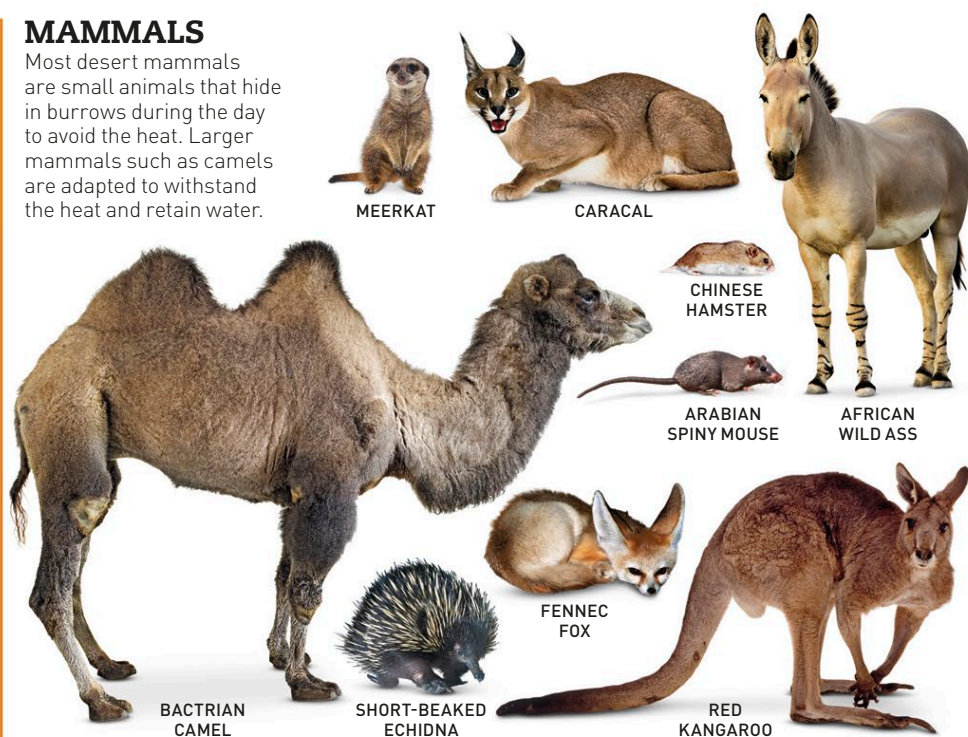


### STAR DUNES

Where the wind blows from different directions, it heaps up sand in irregular shapes. These dunes can grow very big.

## MAMMALS

Most desert mammals are small animals that hide in burrows during the day to avoid the heat. Larger mammals such as camels are adapted to withstand the heat and retain water.



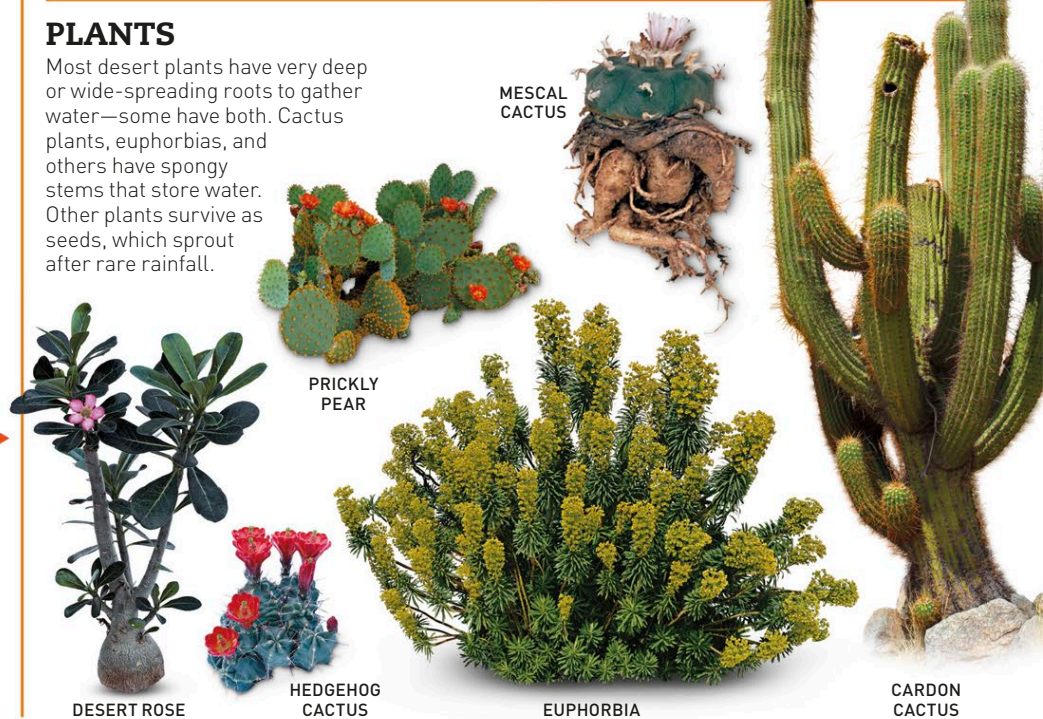
## REPTILES

The scaly, waterproof bodies of lizards and other reptiles stop them from drying out under the desert sun. Many snakes have a venomous bite so that they can kill prey quickly without using too much energy.



## PLANTS

Most desert plants have very deep or wide-spreading roots to gather water—some have both. Cactus plants, euphorbias, and others have spongy stems that store water. Other plants survive as seeds, which sprout after rare rainfall.





## BIRDS

Birds are well equipped for life in deserts, because most can fly to find water, prey, or plants that have seeded after local rainstorms. The ostrich cannot fly but is able to walk long distances.



OSTRICH



ROADRUNNER



GALAH



GILA WOODPECKER



LANNER FALCON



TURKEY VULTURE



BURROWING OWL

## INVERTEBRATES

Insects, spiders, and scorpions have hard-shelled bodies that do not dry out easily. Many can go for days without eating at all, which helps them survive where food is scarce.



HARVESTER ANT



JEWEL WASP



DESERT LOCUST



DESERT CRICKET



DARKLING BEETLE



DOMINO BEETLE



MEXICAN RED-KNEED TARANTULA



CRAB SPIDER



FALSE WHIP SCORPION



SCORPION

## LIFE IN THE MEXICAN DESERT

Only a few types of plants and animals can survive in deserts with extremely dry climates. In some deserts, such as the Sonoran Desert in Mexico, a little rain falls each year—these deserts provide a habitat for a wide variety of plants and animals, from tiny insects to big hunters like the coyote. In parts of other deserts, such as the Atacama Desert, rain has almost never been recorded.

**AFTER IT RAINS, THE DESERT SPRINGS TO LIFE, WITH MANY PLANTS FLOWERING AT ONCE.**

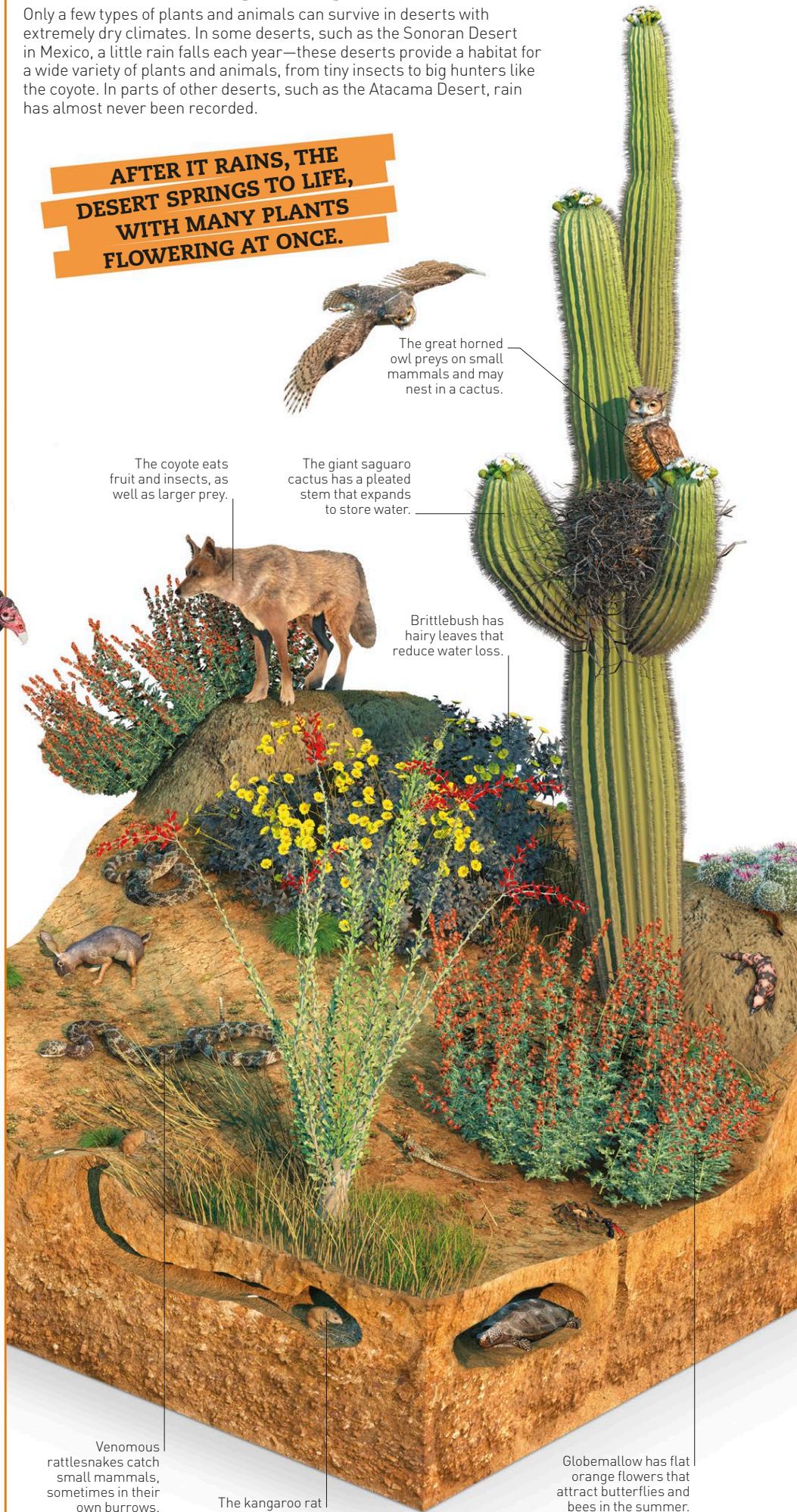


The great horned owl preys on small mammals and may nest in a cactus.

The coyote eats fruit and insects, as well as larger prey.

The giant saguaro cactus has a pleated stem that expands to store water.

Brittlebush has hairy leaves that reduce water loss.



Venomous rattlesnakes catch small mammals, sometimes in their own burrows.

The kangaroo rat can use its long back legs to roam widely in search of food.

Globemallow has flat orange flowers that attract butterflies and bees in the summer.



# Polar habitats

In winter, there is little sunlight near the cold North and South Poles. In summer, the seas teem with life, which supports large numbers of fish and other animals. Many land animals live in the Arctic, but but not many species live on land in Antarctica.

## WHERE ON EARTH?

The polar regions consist of the Arctic Ocean and nearby land and the continent of Antarctica and the surrounding ocean. Large areas of the seas in these regions are frozen in winter.



## POLAR REGIONS

There are two different polar regions on Earth. The Arctic is at Earth's North Pole, and Antarctica at the South Pole.



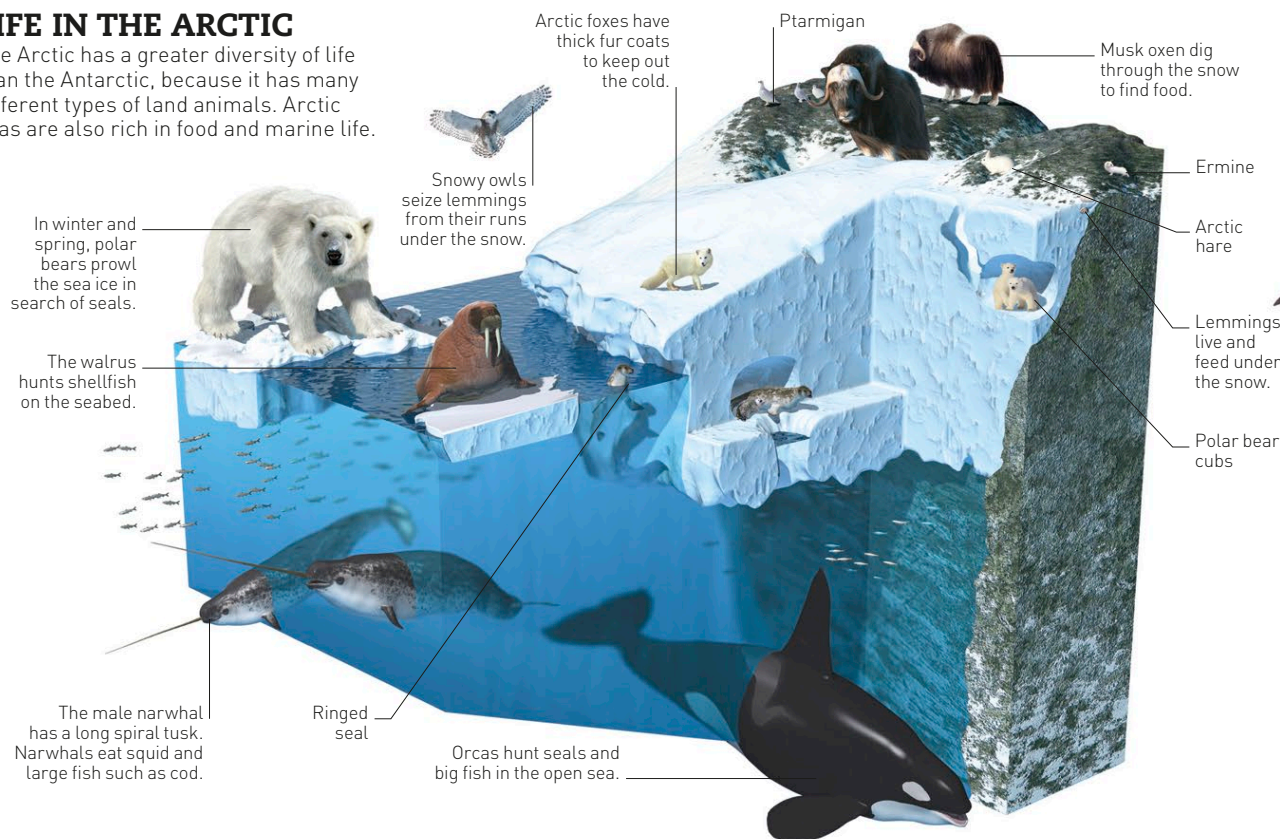
**THE ARCTIC**  
The Arctic is an icy ocean with land all around it, where animals can live.



**ANTARCTICA**  
Antarctica is an icy continent, and most of its animals live in the ocean.

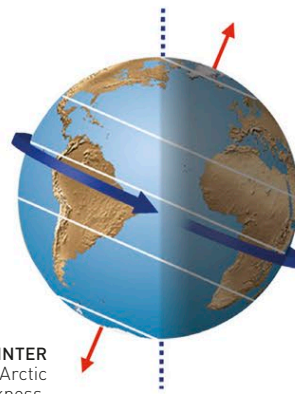
## LIFE IN THE ARCTIC

The Arctic has a greater diversity of life than the Antarctic, because it has many different types of land animals. Arctic seas are also rich in food and marine life.



## POLAR SEASONS

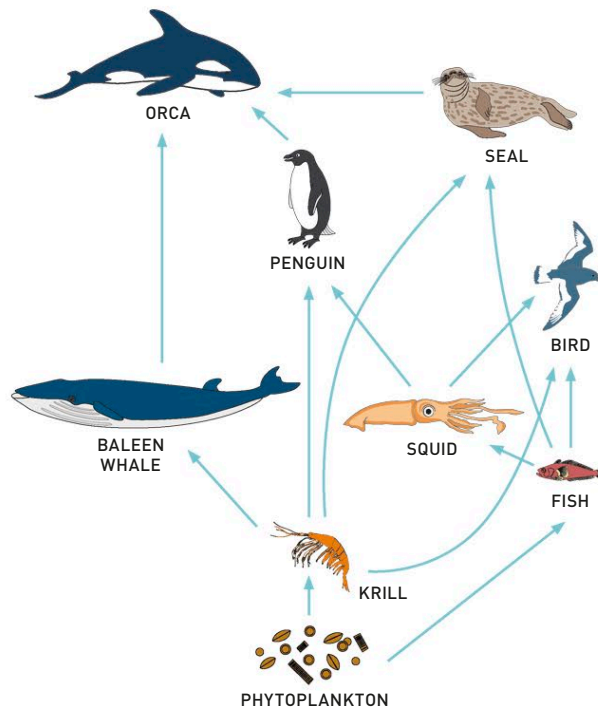
As Earth spins, most places experience day and night. But because of the tilt of Earth's axis, the polar regions are always dark in midwinter and stay light in midsummer. This is one reason why polar winters are so bitterly cold.



**NORTHERN WINTER**  
In December, the Arctic is in almost constant darkness.

## FOOD WEB

In the Antarctic, all the animals get their food from the sea. Tiny drifting algae [phytoplankton] feed swarms of krill, which are in turn eaten by baleen whales, seals, penguins, and birds. Fish are eaten by seals and birds, while orcas eat anything they can catch.



## LAND MAMMALS

The Arctic is the only polar region with land mammals. Some are summer visitors, but others such as the musk ox live in the Arctic all year round. Polar bears live mainly on the sea ice.

**ARCTIC HARE**



**COLLARED PIKA**

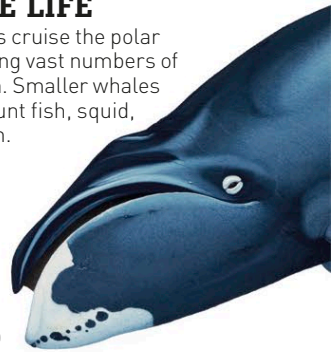


**ERMINE**



## MARINE LIFE

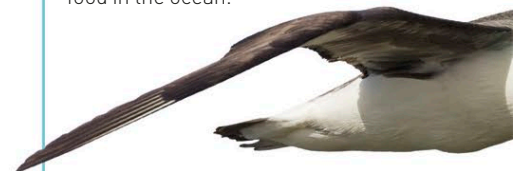
Giant whales cruise the polar oceans, eating vast numbers of krill and fish. Smaller whales and seals hunt fish, squid, and shellfish.



**BOWHEAD WHALE**

## BIRDS

Many land birds range over the Arctic, but some Antarctic birds, such as penguins, find their food in the ocean.



**ALBATROSS**



**SNOWY OWL**



**PEREGRINE FALCON**



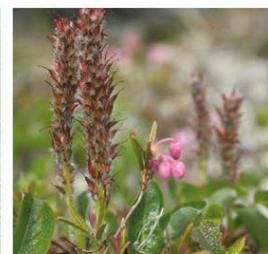


## PLANTS

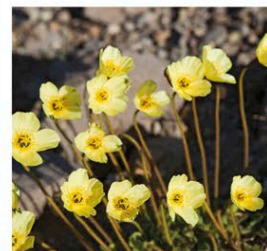
Only the toughest plants can survive the extreme cold of a polar winter. Most are low-growing, so they are sheltered from the wind, and there are no tall trees. In the Arctic, all the plants flower at once when spring arrives to make the most of the short summer.



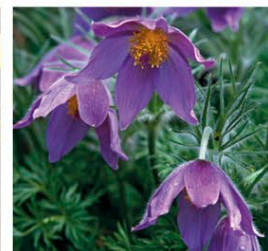
COTTONGRASS



ARCTIC WILLOW

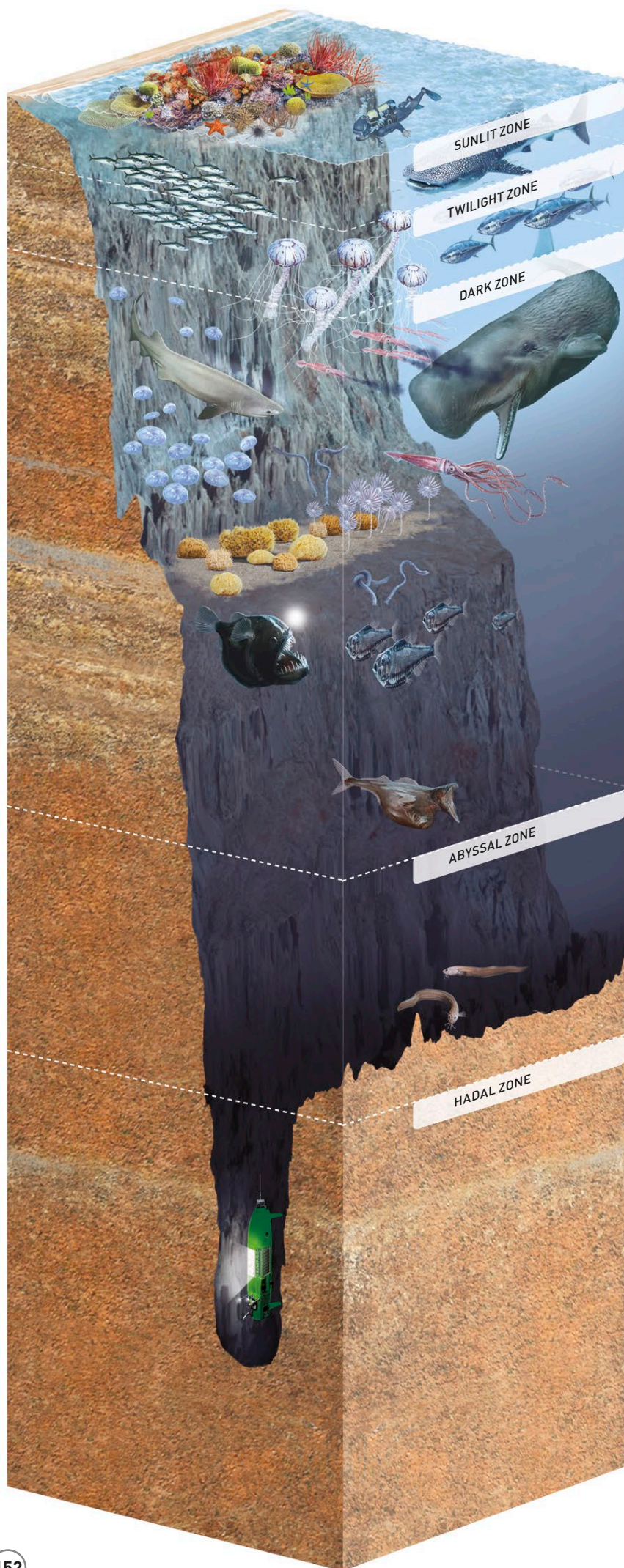


ARCTIC POPPY



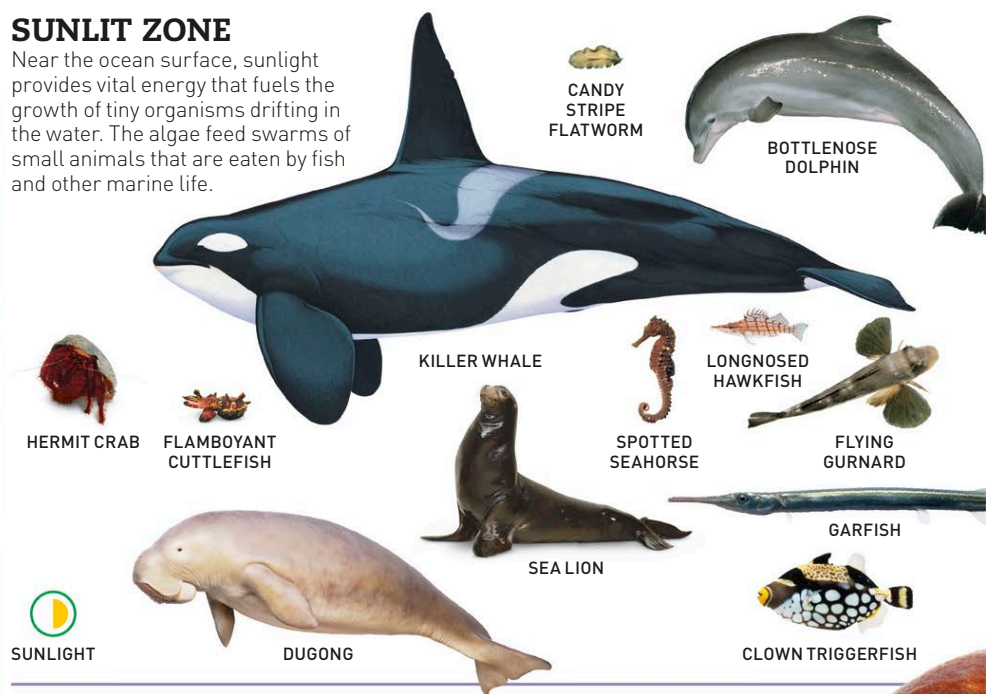
PASQUE FLOWER





## SUNLIT ZONE

Near the ocean surface, sunlight provides vital energy that fuels the growth of tiny organisms drifting in the water. The algae feed swarms of small animals that are eaten by fish and other marine life.



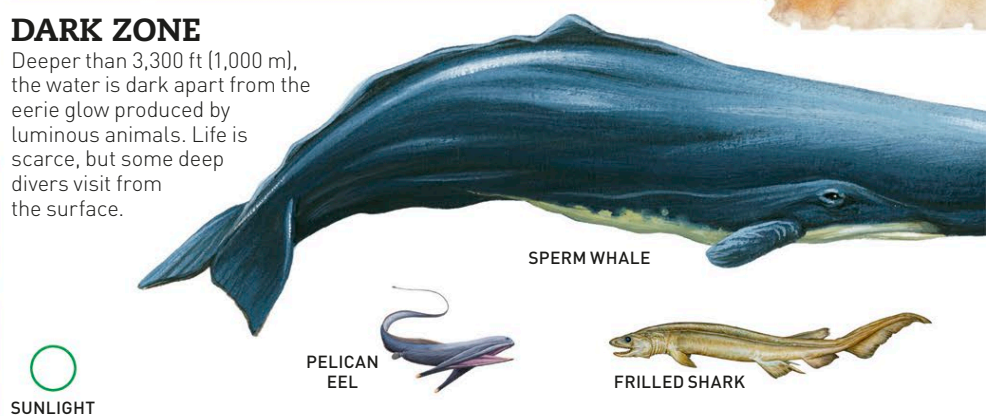
## TWILIGHT ZONE

Below 660 ft (200 m), there is only faint blue light. Algae that need light cannot survive, so there is not much food for small animals. Bigger animals hunt each other.



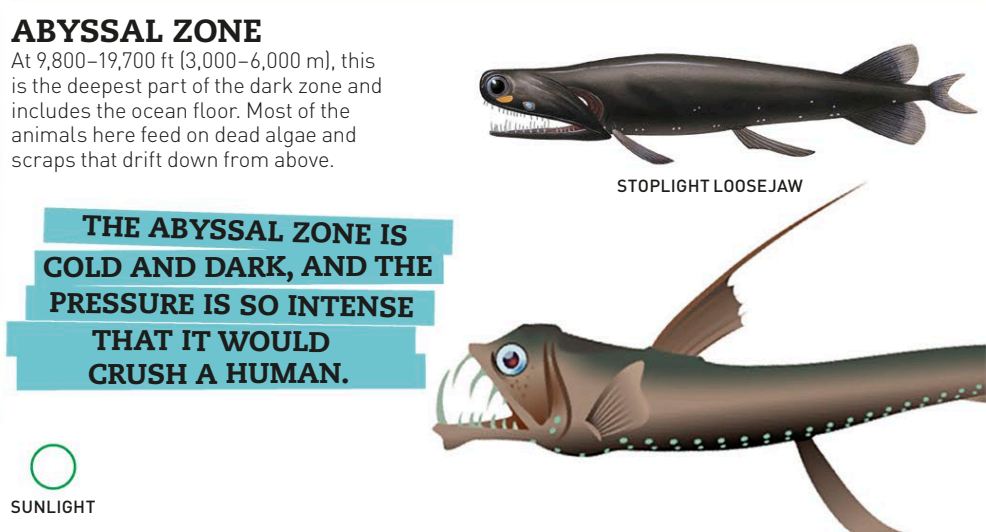
## DARK ZONE

Deeper than 3,300 ft (1,000 m), the water is dark apart from the eerie glow produced by luminous animals. Life is scarce, but some deep divers visit from the surface.

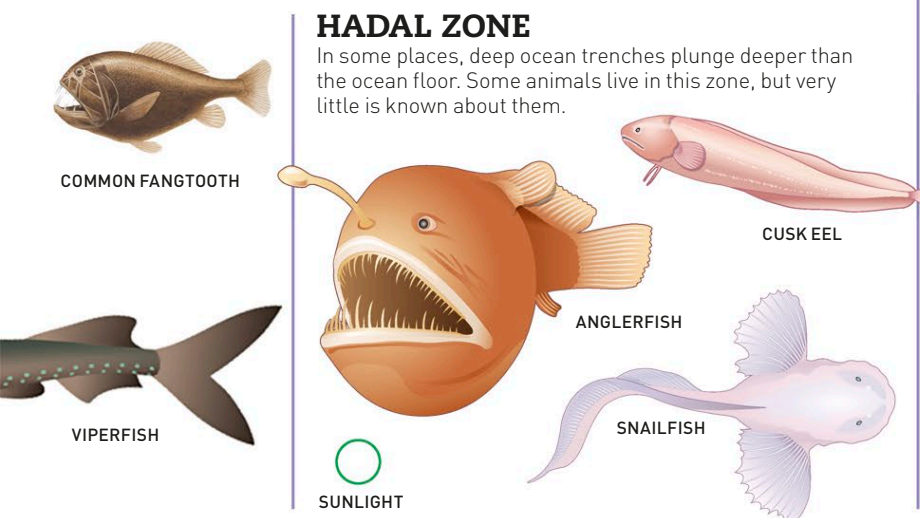
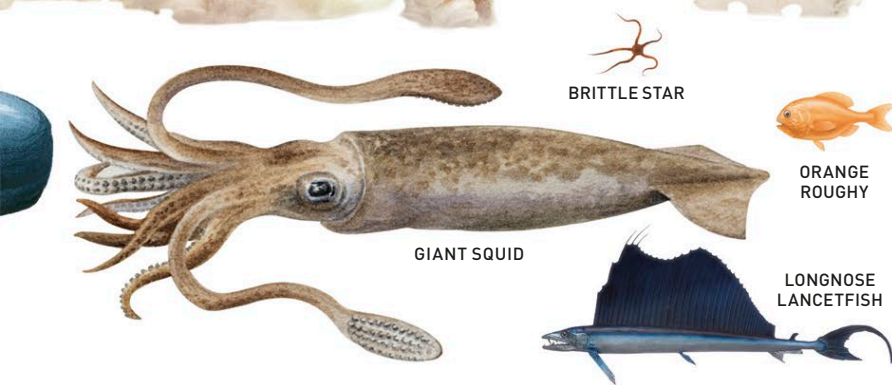
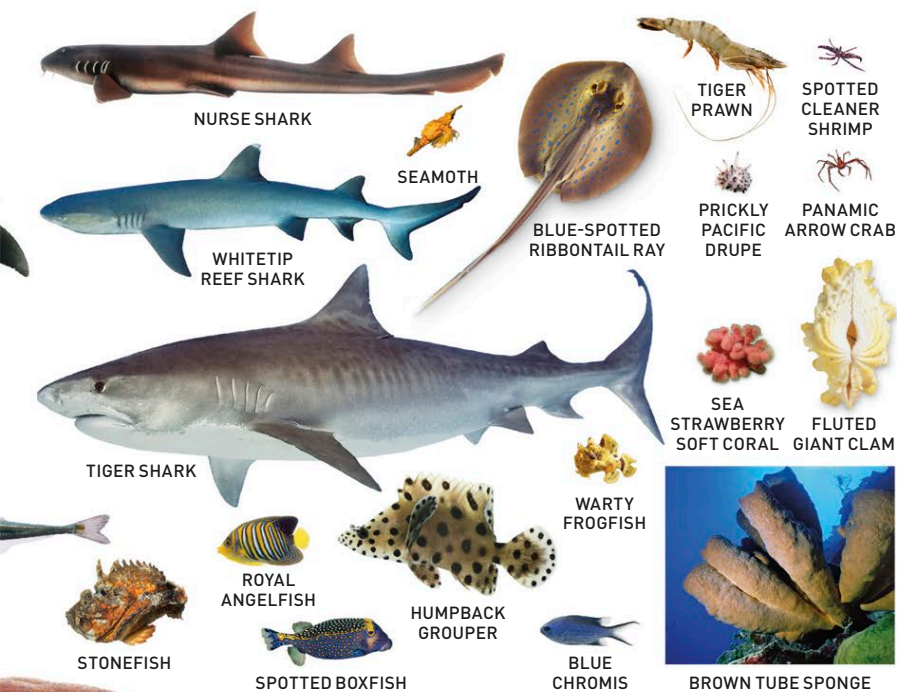


## ABYSSAL ZONE

At 9,800–19,700 ft (3,000–6,000 m), this is the deepest part of the dark zone and includes the ocean floor. Most of the animals here feed on dead algae and scraps that drift down from above.







## HADAL ZONE

In some places, deep ocean trenches plunge deeper than the ocean floor. Some animals live in this zone, but very little is known about them.

# Ocean

The oceans form the biggest environment for wildlife on the planet. Most organisms live near the sunlit surface, especially in shallow water near land, where the water is rich in food. But some animals are able to live in the ocean depths, where there is no light and very little to eat.

## WHERE ON EARTH?

The five interconnected oceans cover more than two-thirds of the planet. The biggest ocean is the Pacific, while the smallest is the Arctic Ocean at the North Pole. The Atlantic extends all the way from the Arctic to the Southern Ocean around Antarctica. All the oceans, whether cold or warm, are teeming with life.



## ANIMAL RELATIONSHIPS

The oceans are full of dangers, so some animals join forces to improve their chances of survival. Others tag along with larger animals to feast on scraps of food that their big partners ignore.



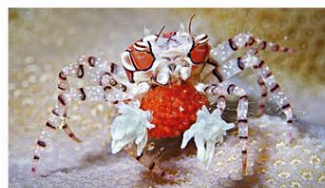
### CLOWNFISH AND ANEMONE

The stinging tentacles of a big sea anemone do not affect the clownfish, but they protect it from predators.



### MANTA RAY AND REMORA FISH

A sucker on its head allows the remora to cling to big fish, like this manta ray, as they cruise the oceans.



### BOXER CRAB AND ANEMONES

This tiny tropical crab holds a stinging sea anemone in each claw. It uses them for defense and to stun prey.

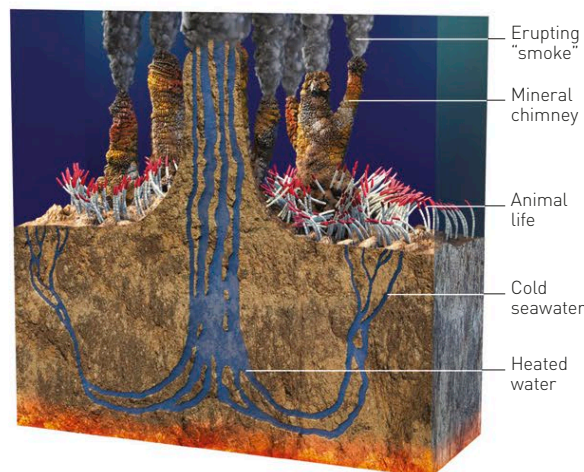
## GROUPS OF FISH

Many open-water fish travel in big groups called shoals or schools. Some contain thousands of fish. Living together like this makes it difficult for big hunters such as sharks to pick out individual fish.



## BLACK SMOKERS

In parts of the deep oceans, water seeps into the ocean floor, gets heated by hot volcanic rock, dissolves minerals from the rock, and erupts from the ocean floor. As it hits the cold ocean, the minerals turn to solid particles that look like smoke and build up to form "chimneys" up to 180 ft (55 m) high. Some of the chemicals in the water are turned into energy by bacteria, which are eaten by specialized animals.



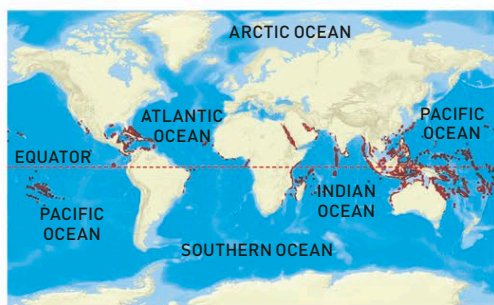


# Coral reef

Tropical coral reefs are the most complex of all underwater habitats. They are created by simple animals called corals that live in big colonies and have hard, stony skeletons. The coral colonies shelter an amazing variety of marine life, including many kinds of fish and invertebrates.

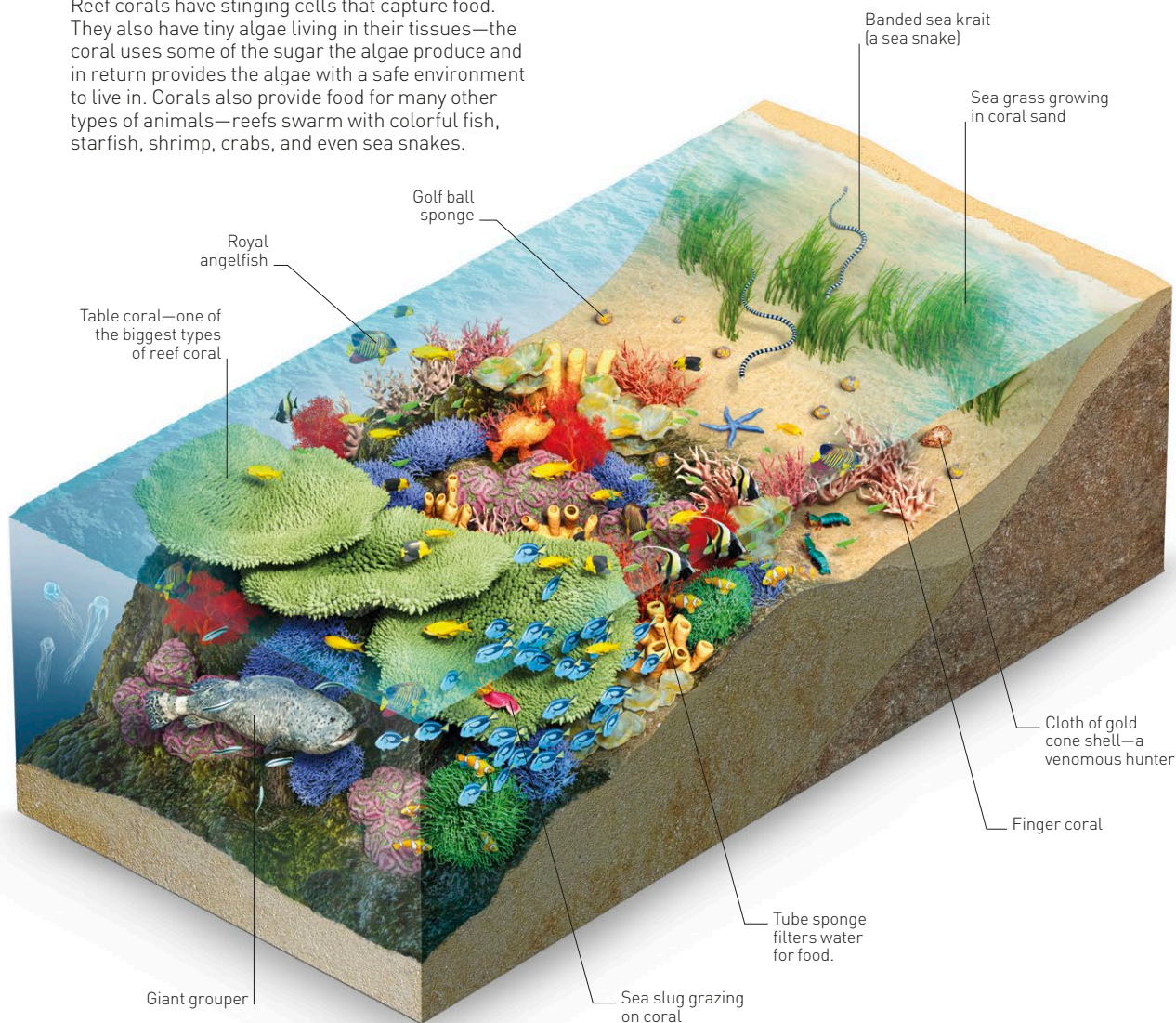
## WHERE IN THE WORLD?

Coral reefs grow in clear, shallow, warm water near tropical shores. Most of them lie in the western Pacific and Indian Oceans.



## LIFE IN A CORAL REEF

Reef corals have stinging cells that capture food. They also have tiny algae living in their tissues—the coral uses some of the sugar the algae produce and in return provides the algae with a safe environment to live in. Corals also provide food for many other types of animals—reefs swarm with colorful fish, starfish, shrimp, crabs, and even sea snakes.



## TYPES OF REEFS

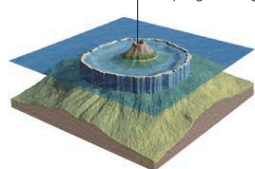
Many reefs grow around islands, forming fringes of coral in the shallow water. If an island is an extinct volcano, it gradually sinks, while the reef keeps growing upward. This creates a barrier reef. Eventually, the island sinks from sight, leaving a coral atoll.



### FRINGING REEF

This tropical volcanic island is surrounded by a fringing reef. The extinct volcano slowly starts to sink.

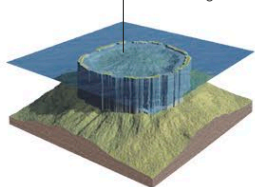
The island sinks, but the coral keeps growing.



### BARRIER REEF

As the island continues to sink, the reef grows upward, forming a barrier reef around a ring-shaped lagoon.

Reef encloses a shallow central lagoon.

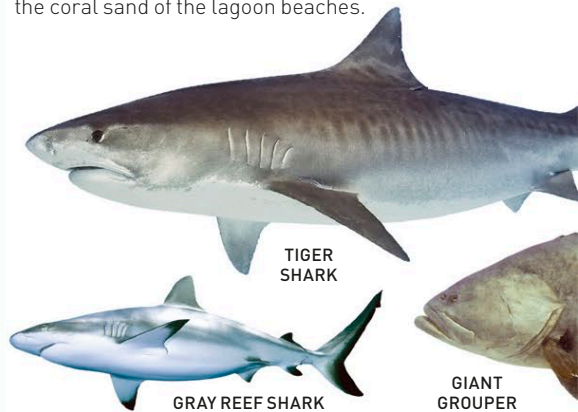


### ATOLL

The original island sinks below the waves, leaving behind a ring of coral—an atoll.

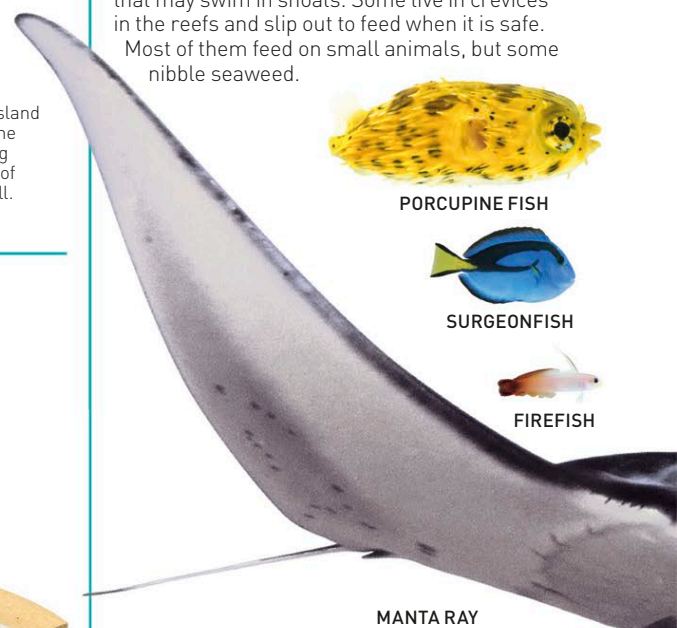
## BIG VISITORS

The animals living on the reefs attract big hunters such as giant groupers, sharks, and dolphins. These usually hunt in the deeper channels between the corals. Sea turtles may visit to lay their eggs in the coral sand of the lagoon beaches.



## REEF FISH

The water around the coral is alive with small fish that may swim in shoals. Some live in crevices in the reefs and slip out to feed when it is safe. Most of them feed on small animals, but some nibble seaweed.



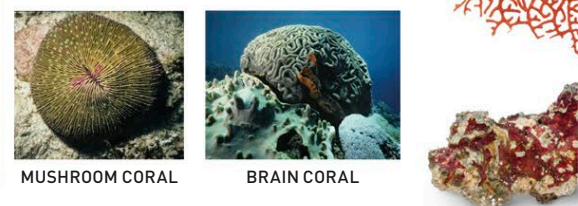
## REEF INVERTEBRATES

As well as corals, many other invertebrates live on the reefs. Sponges, sea squirts, and clams filter the water for food, while sea slugs, shrimp, and crabs search for scraps and living prey.



## CORALS

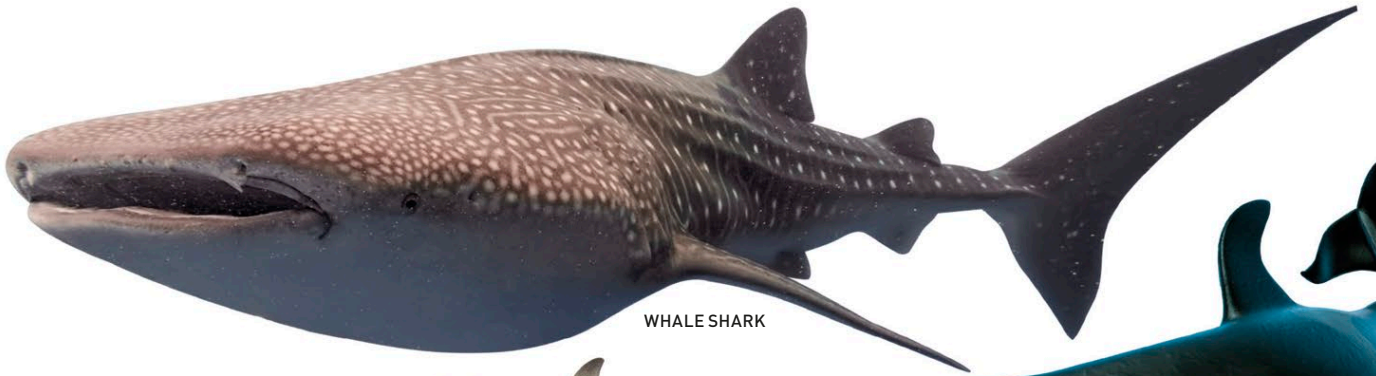
A coral reef is made up of many types of coral. They include brain corals, staghorn corals, and sea fans. Each coral is a colony of small animals called polyps, all connected together.







BLACKTIP REEF SHARK



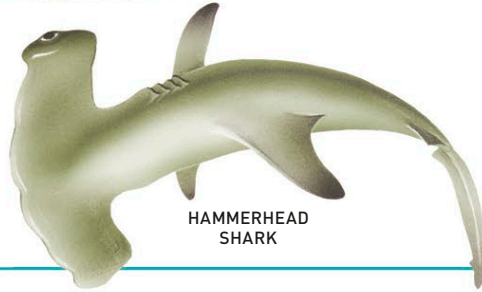
WHALE SHARK



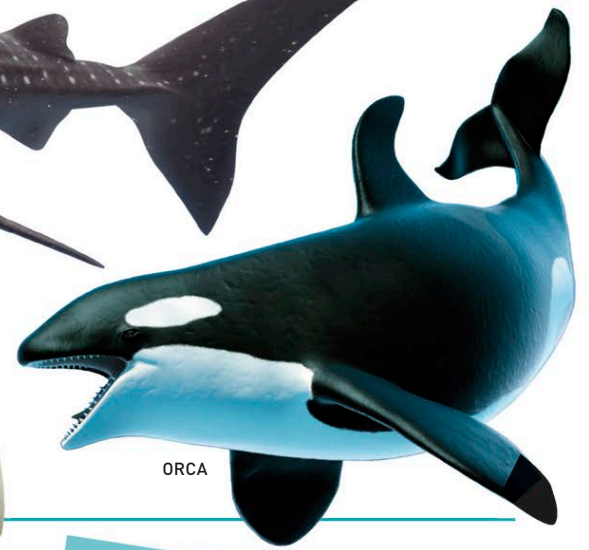
HAWKSBILL TURTLE



BOTTLENOSE DOLPHIN



HAMMERHEAD SHARK



ORCA



PARROTFISH



GREAT BARRACUDA



MANDARINFISH

THE DWARF SEAHORSE IS THE SLOWEST FISH IN THE WORLD, WITH A TOP SPEED OF 5.25 FT (1.5 M) PER HOUR.



ELECTRIC RAY



BLUE-SPOTTED RIBBONTAIL RAY



CLOWN TRIGGERFISH



QUEEN ANGELFISH



YELLOW SHRIMP GOBY



SEAHORSE



DAMSELFISH



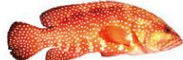
JEWELFISH



LIONFISH



COMMON CLOWNFISH



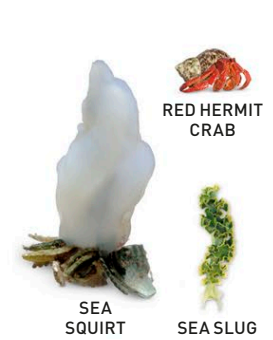
CORAL TROUT



THREADFIN BUTTERFLYFISH



LONGNOSED HAWKFISH



SEA SQUIRT

RED HERMIT CRAB



SEA SPONGE



SEA FAN



SOFT CORAL



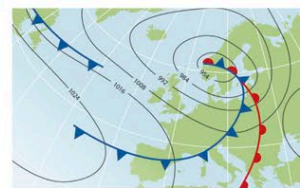
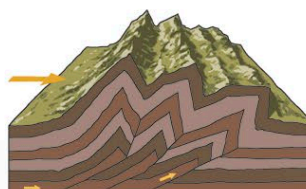
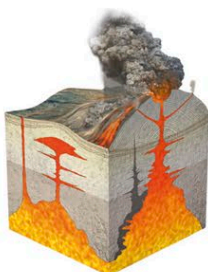
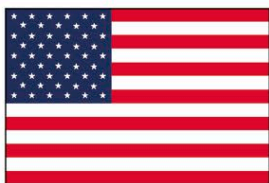
STAGHORN CORAL



CORAL REEF

Live coral grows on top of the stony remains of dead coral to build the reef.

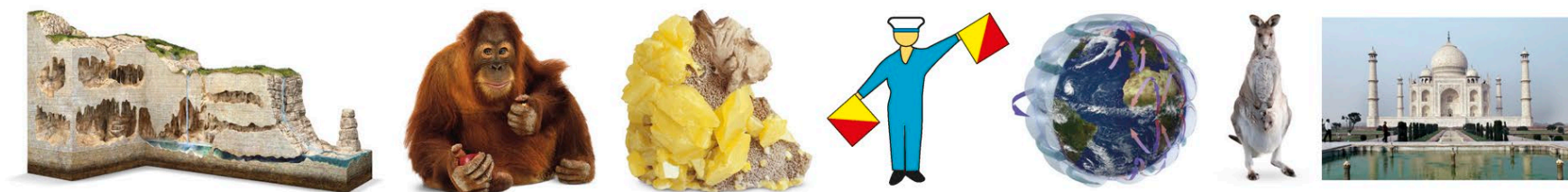








# Geography



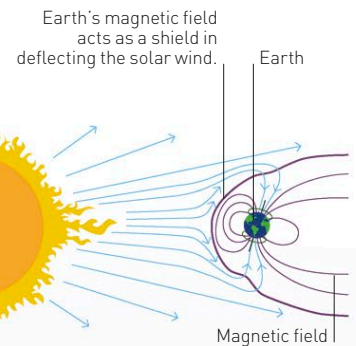


# Earth

Formed more than 4.5 billion years ago, Earth is the only place in the Universe known to support life. Its breathable atmosphere, liquid-water oceans, and varied landscapes support a rich diversity of living things.

## MAGNETIC FIELD

With its iron core, Earth acts like an enormous bar magnet with north and south poles. As Earth spins, swirling currents occur in the molten metal within its outer core. This movement generates a powerful magnetic field.



## EARTH'S STRUCTURE

Earth has a layered structure. At its center is a hot, metallic core surrounded by a thick layer of solid but slowly moving rock, called the mantle. Earth's thin crust sits on top.

**INNER CORE**  
This solid iron-nickel alloy core is boiling hot but stays solid due to the extreme pressure at Earth's center.

**OUTER CORE**  
A layer of liquid iron and nickel surrounds the inner core. It is in constant motion.

**MANTLE**  
The mantle is solid but slowly moves around.

**CRUST**  
Earth's outer layer is the cool, solid, and brittle crust.

**SEAS AND OCEANS**  
Saltwater seas and oceans cover almost three-quarters of Earth's surface.

**ATMOSPHERE**  
Earth is surrounded by a layer of gases known as the atmosphere, which gradually merges into space.

Over a quarter of Earth's surface is land made up of continental crust. This is thicker than the oceanic crust that occurs under the oceans.

## HABITATS

Plants and animals live in natural environments on Earth, called habitats. These habitats vary depending on rainfall, temperature, and location.



**OCEAN**

The largest habitat on Earth, the ocean is home to well over a million types of organism, including plants and animals.



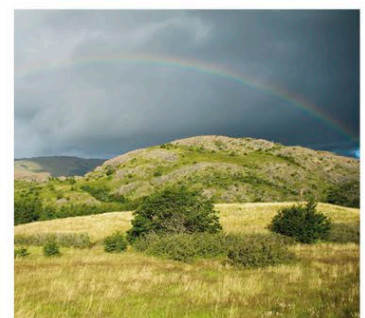
**CORAL REEF**

Formed in clear, warm, shallow tropical waters, coral reefs are like beautiful underwater gardens, teeming with marine life.



**POLAR REGIONS**

With freezing temperatures, the Arctic and Antarctic are among the most inhospitable places on Earth.



**GRASSLAND**

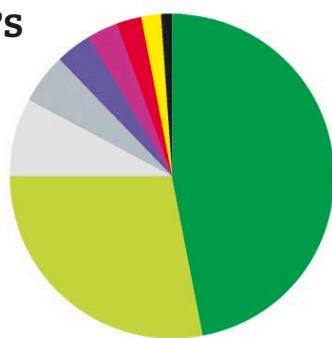
Found on every continent except Antarctica, grassland covers about one-third of Earth's land surface.





## INSIDE EARTH'S CRUST

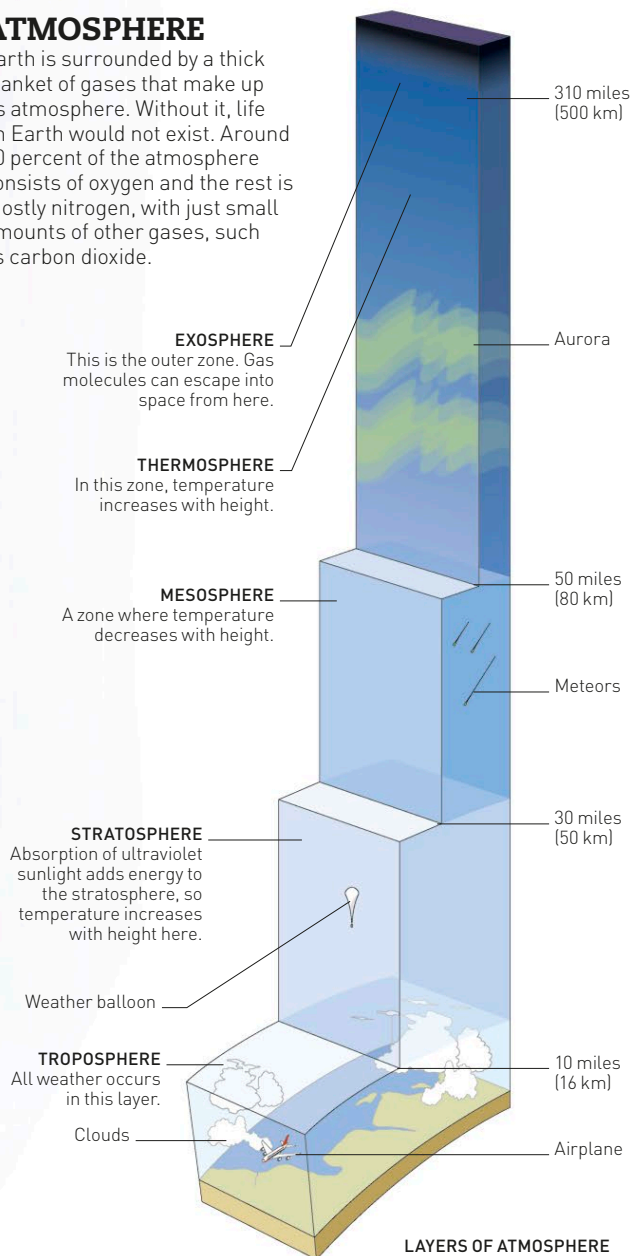
The crust is Earth's outer rocky layer. It forms the continents and ocean floor and contains many different chemical elements. Most of the crust is formed of silicon dioxide, which consists of joined-together silicon and oxygen atoms.



ELEMENTS IN EARTH'S CRUST

## ATMOSPHERE

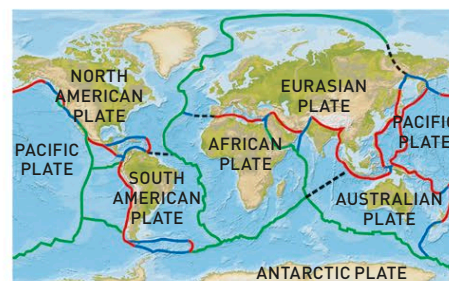
Earth is surrounded by a thick blanket of gases that make up its atmosphere. Without it, life on Earth would not exist. Around 20 percent of the atmosphere consists of oxygen and the rest is mostly nitrogen, with just small amounts of other gases, such as carbon dioxide.



LAYERS OF ATMOSPHERE

## TECTONIC PLATES

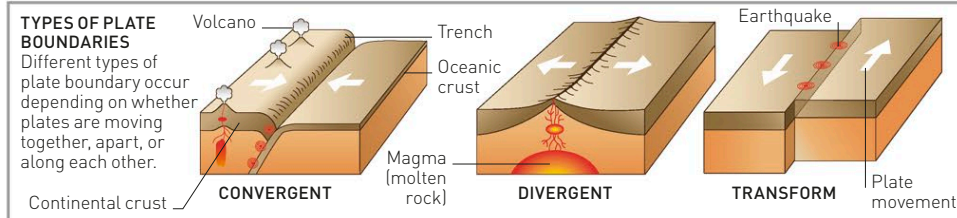
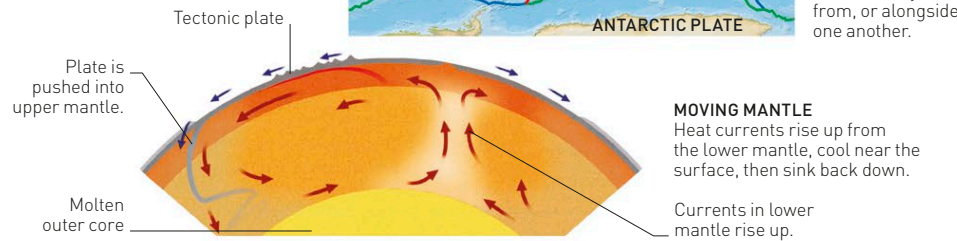
Earth's crust is broken into pieces, or tectonic plates, that fit together like a jigsaw puzzle. These plates float on the mantle—solid but slowly moving rock with pockets of liquid magma. When the mantle moves, so do the plates.



**KEY**

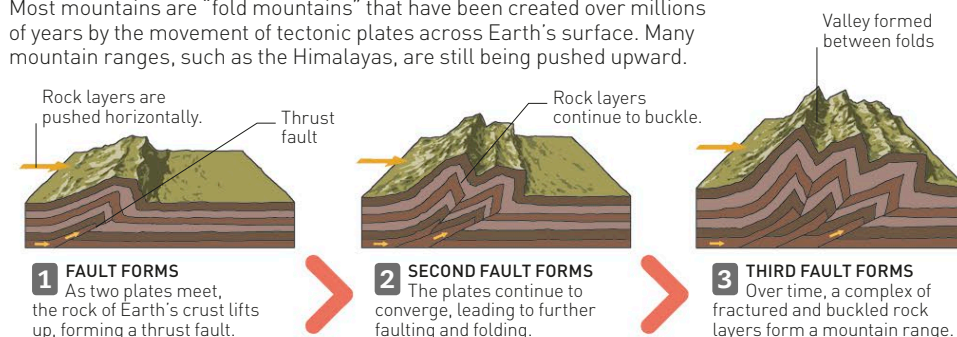
- Convergent
- Divergent
- Uncertain
- Transform

**ON THE MOVE**  
Earth's plates are constantly moving toward, away from, or alongside one another.



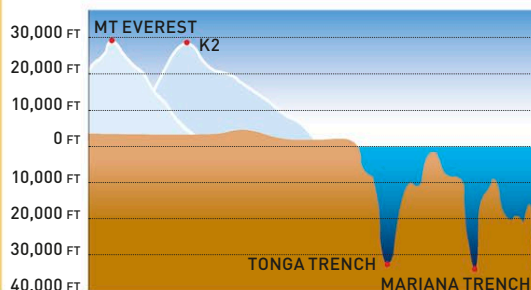
## MOUNTAIN BUILDING

Most mountains are "fold mountains" that have been created over millions of years by the movement of tectonic plates across Earth's surface. Many mountain ranges, such as the Himalayas, are still being pushed upward.



## HIGHEST AND DEEPEST

At 29,029 ft (8,848 m), the top of Mount Everest—part of the Himalayas, a mountain range in Asia—is Earth's highest point. By contrast, the Mariana Trench, in the Pacific Ocean, is the deepest, reaching 35,840 ft (10,924 m) below sea level.

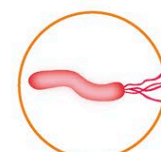


## LIFE ON EARTH

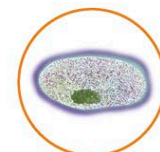
More than 3.5 billion years ago, life on Earth began. Over time, it has evolved and diversified to suit its natural environment.



**ARCHAEA**  
A very early form of life, consisting of single cells.



**BACTERIA**  
Microscopic bacteria live in most habitats. Some cause diseases.



**PROTISTS**  
Made of single cells with nuclei, some protists can make their own food.



**FUNGI**  
Fungi get their nutrients from dead organic matter.



**PLANTS**  
Plants use sunlight to make food and release oxygen into the air.



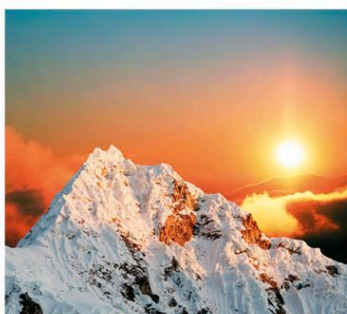
**ANIMALS**  
Animals get their food from eating other organisms.



**DESERT**  
With sparse rain and extreme temperatures, little life survives here.



**RIVER AND WETLAND**  
Despite covering less than 1 percent of Earth's surface, freshwater rivers and wetlands support a lot of plants and animals.



**MOUNTAIN**  
Wildlife is plentiful on warm, lower mountain slopes, but at higher altitudes, temperatures drop, and little can survive.



**FOREST**  
Forests are made up of the biggest plants on Earth—trees. They provide shelter and food to a vast array of life.

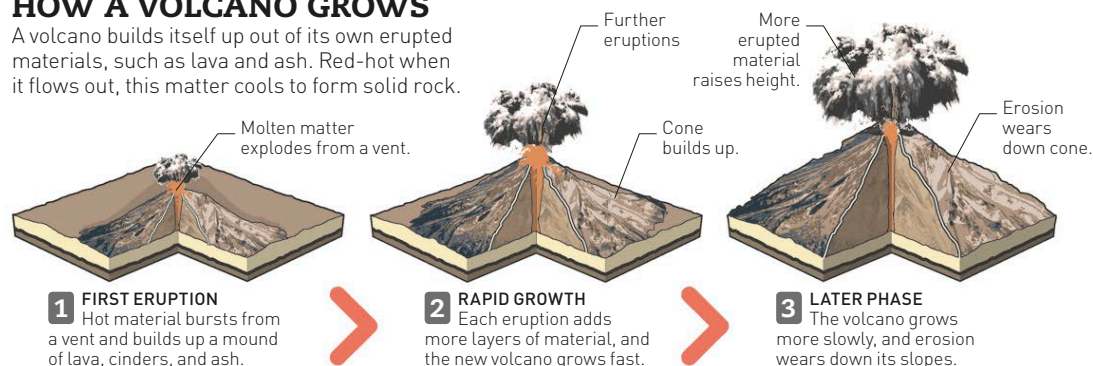


# Volcanoes

Deep inside Earth are pockets of hot, molten rock. Now and then, this gassy fluid rises and can erupt at the surface as molten lava, gas, ash, and rock fragments. Some volcanoes stay active over millions of years, whereas others erupt only for a few years.

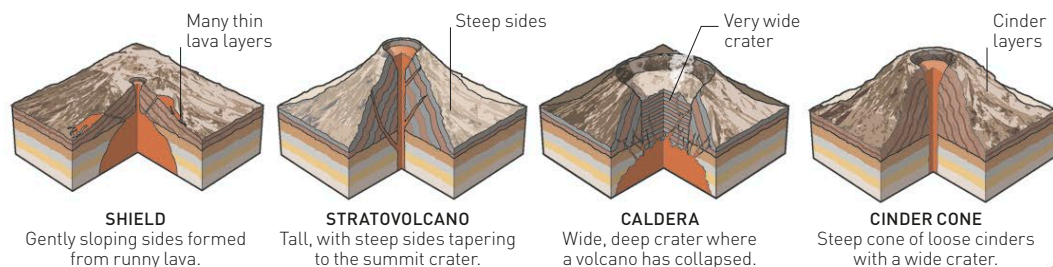
## HOW A VOLCANO GROWS

A volcano builds itself up out of its own erupted materials, such as lava and ash. Red-hot when it flows out, this matter cools to form solid rock.



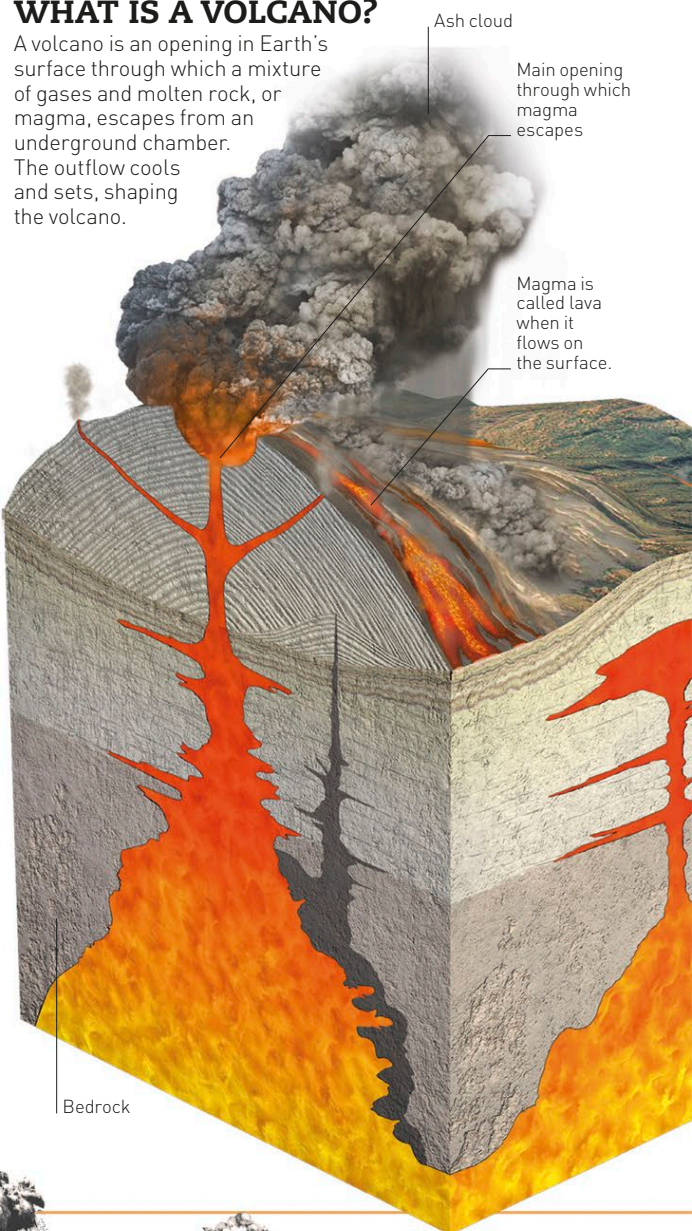
## VOLCANO TYPES

Not all volcanoes have a steep “smoking mountain” shape. Other forms include shield volcanoes—which look like huge, upturned dinner plates—and small cinder cones. Calderas are craters that appear when a volcano collapses.



## WHAT IS A VOLCANO?

A volcano is an opening in Earth's surface through which a mixture of gases and molten rock, or magma, escapes from an underground chamber. The outflow cools and sets, shaping the volcano.

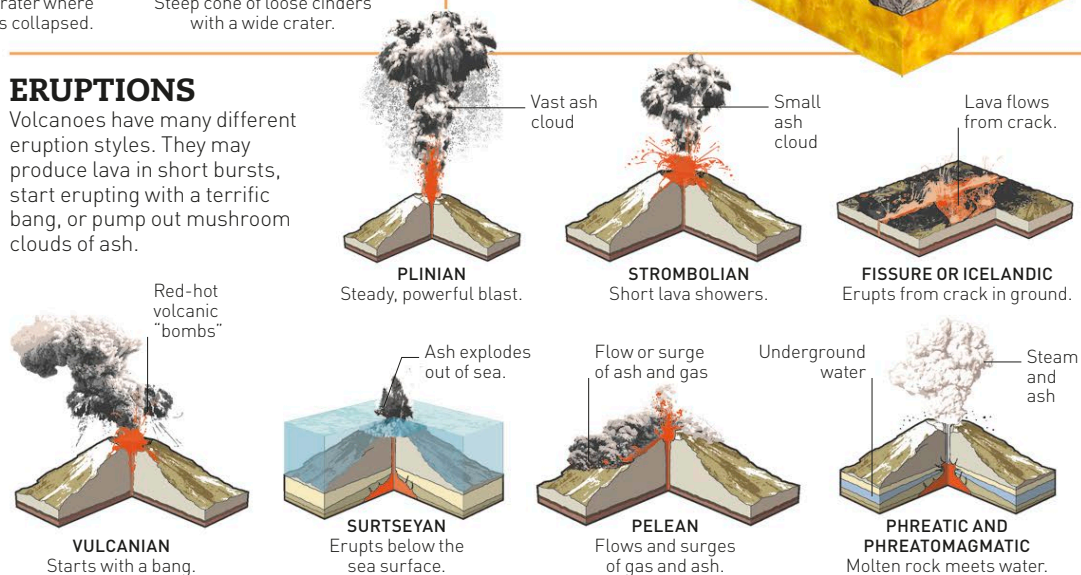


## LARGEST ACTIVE SHIELD VOLCANOES

LOCATION	SHAPE	SUMMIT HEIGHT	MAXIMUM WIDTH OF BASE
Mauna Loa, Hawaii		13,677 ft (4,169 m)	59 miles (95 km)
Erta Ale, Ethiopia		2,011 ft (613 m)	50 miles (80 km)
Sierra Negra, Galápagos		4,921 ft (1,500 m)	31 miles (50 km)
Nyamuragira, Democratic Republic of the Congo		10,033 ft (3,058 m)	28 miles (45 km)
Kilauea, Hawaii		4,091 ft (1,247 m)	31 miles (50 km)

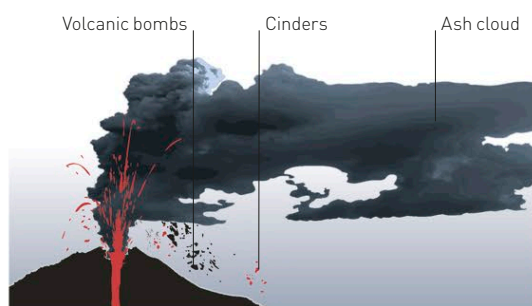
## ERUPTIONS

Volcanoes have many different eruption styles. They may produce lava in short bursts, start erupting with a terrific bang, or pump out mushroom clouds of ash.



## VOLCANIC FALLOUT

An eruption blasts a lot of dangerous material into the air. Molten lava “bombs,” hot cinders, rocks, and ash fly upward, then fall to the ground. Poisonous, suffocating gases are also given off.



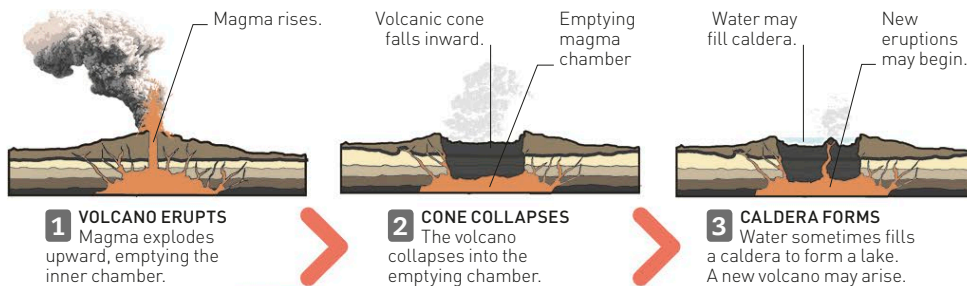
## LAVA

The red-hot flow that pours from a volcano is lava—the name given to molten rock, or magma, once it reaches the surface. The hottest lavas are thin and runny and flow a long way before cooling and solidifying. Others are sticky and silica-rich and do not flow as far.



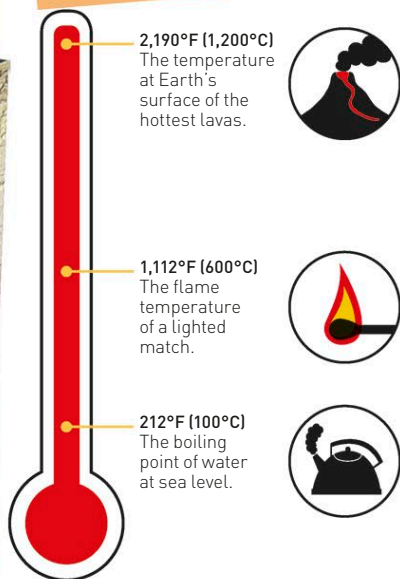
## CALDERAS

A caldera is a vast crater in the ground formed when a volcano comes apart during an explosive eruption and the surface collapses into the emptying magma chamber.



**A THICK LAVA FLOW CAN TAKE YEARS TO COOL DOWN COMPLETELY.**

Magma erupts from surface crack.

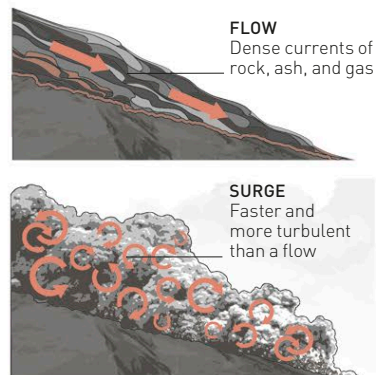


## RED-HOT

Scientists are exploring ways of tapping into the huge energy produced by hot magma. One day, this could provide the world with a big new source of power.

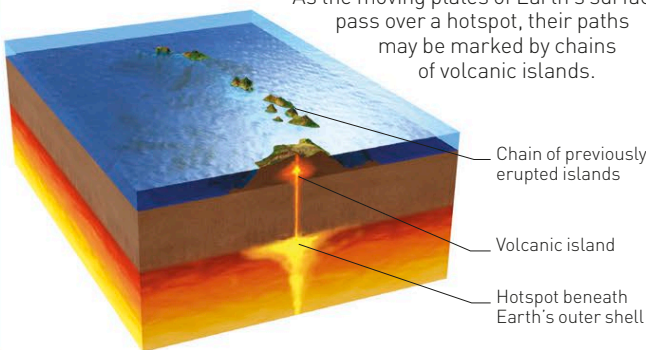
## FLOWS AND SURGES

Pyroclastic flows are lethal currents of hot gas, ash, and rocks. These currents race down a volcano, destroying everything in their path. Just as deadly are billowing, choking clouds called pyroclastic surges. They contain more gas than pyroclastic flows and can move faster.



## VOLCANIC ISLAND CHAINS

Beneath some ocean floors are volcanic areas, or "hotspots." If these erupt, lava builds up until it rises out of the sea as an island. As the moving plates of Earth's surface pass over a hotspot, their paths may be marked by chains of volcanic islands.



## LIVING NEAR A VOLCANO

Many people spend their lives next door to a volcano. They are prepared to put up with the risk of danger because there are a few advantages, too.

### POSITIVES



**TOURISM**  
Sightseers bring in money.



**AGRICULTURE**  
Volcanic soil is good for growing crops.



**ENERGY**  
Hot underground water is used by industry.

### NEGATIVES



**DEATH**  
Eruptions can kill people and ruin land.



**MUDFLOWS**  
Violent floods wash down volcanic debris.



**REFUGEES**  
People lose their homes and livelihoods.



## MOST DEADLY

These are 10 of the biggest volcanic disasters. The worst, Tambora, killed more than 70,000 people. The most famous is Vesuvius's eruption in 79 CE.

- 1 MOUNT TAMBORA, 1815**  
**Sumbawa island, Indonesia.** Ejected ash blocked the Sun and lowered global temperatures.
- 2 KRAKATOA, 1883**  
**Krakatoa island, Indonesia.** Made the loudest bang ever recorded and blew up most of the island.
- 3 MT. PELÉE, 1902**  
**Martinique, Caribbean Islands.** Ash and gas flowed at speeds of more than 370 mph (600 kph).
- 4 NEVADO DEL RUIZ, 1985**  
**Colombia.** Gigantic mudflows overwhelmed an entire town.
- 5 MOUNT UNZEN, 1792**  
**Japan.** Created a landslide and a tsunami.
- 6 LAKI, 1783**  
**Iceland.** Poisonous gas killed half of Iceland's farm livestock.
- 7 KELUT, 1919**  
**Java, Indonesia.** Mudslides destroyed more than 100 villages.
- 8 SANTA MARÍA, 1902**  
**Guatemala.** Ash detected 2,500 miles (4,000 km) away.
- 9 GALUNGGUNG, 1882**  
**Java, Indonesia.** Destroyed 114 villages.
- 10 VESUVIUS, 79 CE**  
**Italy.** The cities of Herculaneum and Pompeii were wiped out. An eruption in 1631 caused further deaths.



KRAKATOA ERUPTION



CAST OF A POMPEII DISASTER VICTIM

## SUPERVOLCANOES

These are the monsters capable of eruptions thousands of times larger than those of any other kind of volcano. Luckily, there aren't many of them. Here are some of the most important.

### YELLOWSTONE

This map shows the vast area of North America affected in one of Yellowstone's ancient eruptions.



Yellowstone Caldera

- YELLOWSTONE CALDERA**  
**Wyoming.** Makes up much of Yellowstone Park.
- LONG VALLEY CALDERA**  
**California.** Recent uplifting of ground observed.
- VALLES CALDERA**  
**New Mexico.** Hot springs are a sign of volcanic activity.
- LAKE TOBA**  
**Sumatra, Indonesia.** World's largest volcanic lake.
- LAKE TAUPU**  
**New Zealand.** Has erupted 28 times.
- AIRA CALDERA**  
**Japan.** Contains a currently active volcanic cone.

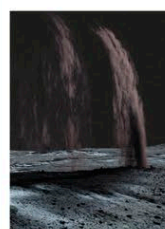
## WHERE IN THE WORLD?

Most volcanoes erupt along the boundaries of Earth's tectonic plates. Those around the Pacific Ocean are known as the "Ring of Fire." Many others erupt on the ocean floor, and some form above "hot spots" rising from the mantle.

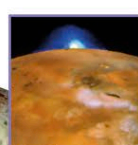
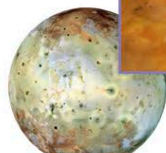


## IN SPACE

Earth is not the only body in the Solar System to have volcanoes. Some of our neighbors in space have many volcanic regions.



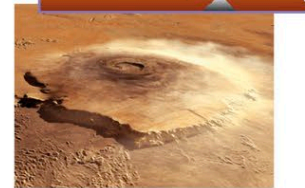
**TRITON**  
Volcanic eruptions on Neptune's biggest moon can last a whole year.



**IO**  
This moon of Jupiter has many active volcanoes.

### OLYMPUS MONS

### MT. EVEREST



**SLEEPING GIANT**  
Olympus Mons, a vast volcano on Mars, is three times as high as Mount Everest. It is not active at the moment.

**VENUS**  
The planet's surface is made almost entirely of volcanoes.





# Earthquakes

Earth's surface is broken up into different regions called tectonic plates. These are always on the move and sometimes shift in ways that cause violent vibrations. Such vibrations are called earthquakes.

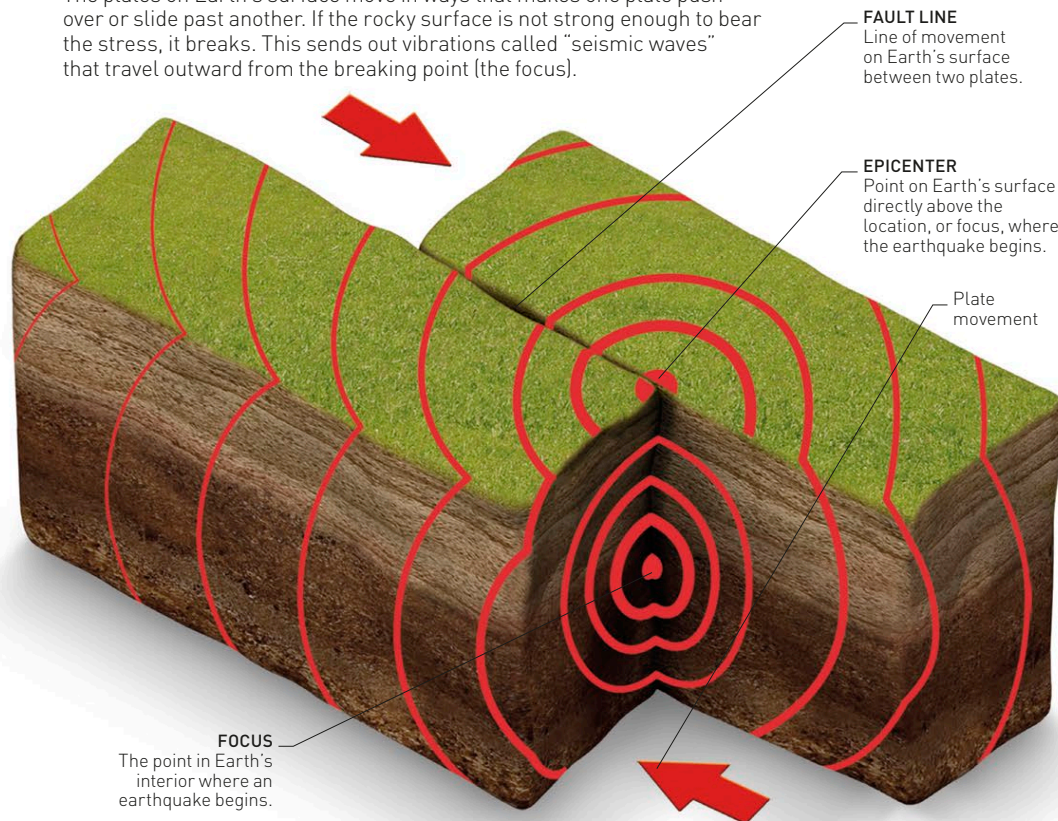
## EARTHQUAKE-PRONE ZONES

Some countries are more affected by earthquakes than others because they lie on the boundaries of tectonic plates. The 10 countries shown here have the highest death rates in the world due to violent earthquakes.



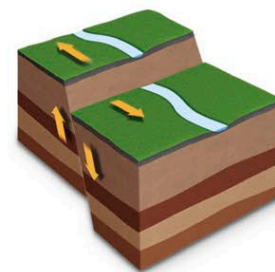
## WHAT CAUSES EARTHQUAKES?

The plates on Earth's surface move in ways that makes one plate push over or slide past another. If the rocky surface is not strong enough to bear the stress, it breaks. This sends out vibrations called "seismic waves" that travel outward from the breaking point (the focus).

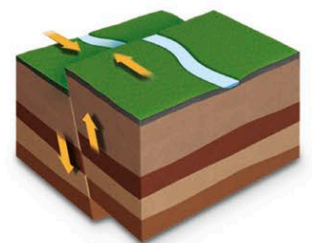


## FAULT TYPES

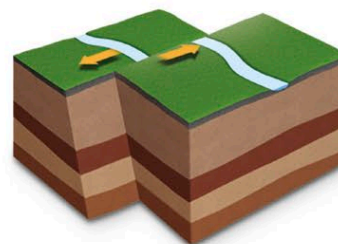
Faults that produce earthquakes can occur at plate boundaries or even in mountain ranges. When pressure in the crust exceeds the strength of rock, earthquakes occur or new faults are made. The blocks of rock on either side of a fault can shift and slide past each other in various ways.



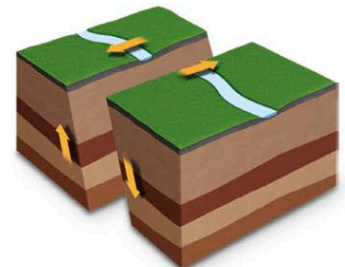
**NORMAL FAULT**  
Rock on one side of the fault moves down, so it is lower than the rock on the other side of the fault.



**REVERSE FAULT**  
One block is pushed up relative to the other, so it ends up at a higher level.



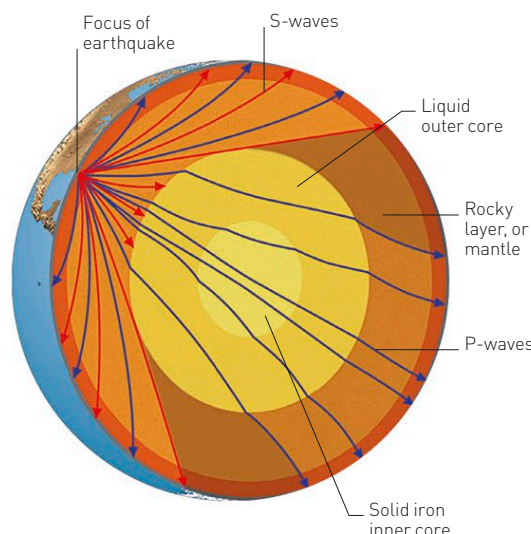
**STRIKE-SLIP FAULT**  
The rocks on either side of the fault move in different directions, scraping side by side.



**OBLIQUE-SLIP FAULT**  
The rocks on either side of the fault move sideways and up or down relative to each other.

## SEISMIC WAVES

Two types of seismic waves created by an earthquake can travel right through Earth's interior. P-waves pass through both solid and liquid layers. S-waves, slower but more dangerous waves, move only through solid rock.



## HOW SEVERE?

The Mercalli scale, below, is one way of measuring the intensity of an earthquake. For more precise estimates, scientists use the "moment magnitude" scale, which measures the amount of energy released during a quake.



**I-II**  
Hardly felt by people, but can be measured by instruments.



**III-IV**  
Felt indoors as a quick vibration that makes hanging objects shake.



**V-VI**  
Rocking motion felt by people; also makes buildings tremble.



**VII-VIII**  
Buildings shake badly, and tree branches break and fall.



**IX-XI**  
Buildings crack and some fall; underground pipes torn apart.



**XII**  
Most buildings are destroyed; rivers are forced to change course.

## MAJOR EARTHQUAKES

Earthquakes can cause terrible devastation. The following have some of the highest-ever measurements on the moment magnitude scale.

- 1 CHILE, MAY 22, 1960**  
Registering at magnitude 9.5, this is the largest recorded earthquake. It occurred in the Pacific Ocean and caused a series of tsunamis that left 2 million people homeless.
- 2 PRINCE WILLIAM SOUND, ALASKA, MARCH 28, 1964**  
This huge earthquake (magnitude 9.2) caused a tsunami that rose to 220 ft (67 m) and hit Hawaii, Canada, and the US. In the first day, there were 11 aftershocks with magnitudes greater than 6.0.
- 3 SUMATRA, INDONESIA, DECEMBER 26, 2004**  
With a magnitude of 9.1-9.3, this earthquake ruptured the longest fault of any recorded quake, spanning 900 miles (1,500 km) in ten minutes. It caused the 2004 Indian Ocean tsunami.
- 4 HONSHU, JAPAN, MARCH 11, 2011**  
This 9.0-magnitude earthquake occurred off the coast of Japan and reached depths of 15 miles (24.4 km). The resulting tsunami caused more than 15,800 deaths.
- 5 KAMCHATKA, RUSSIA, NOVEMBER 4, 1952**  
Registering a magnitude of 8.2, this earthquake set off a Pacific-wide tsunami that hit Peru, Chile, New Zealand, many Pacific islands, and California.



## MEASURING EARTHQUAKES

Scientists measure earthquake vibrations with an instrument called a seismometer. An early device for measuring earthquakes was in use in ancient China in c.2nd century CE.

**1855** Italian physicist Luigi Palmieri designs a seismometer that can record the direction, intensity, and duration of earthquakes too small for humans to notice.



**1902** Italian scientist Giuseppe Mercalli invents a scale for measuring earthquakes based on observation of effects.

**1925** The seismometer built by Americans Harry Wood and James Anderson is precise enough to be used 10 years later for the Richter scale.



**Seismograph, recorded 1920s**

**AROUND 500,000 EARTHQUAKES ARE RECORDED BY INSTRUMENTS EVERY YEAR.**

**1700**

**2015**

**1703** French inventor Jean de Hautefeuille builds a basic seismometer by filling a bowl with mercury and noting the amount and direction of spill during an earthquake.

**1751** Italian teacher Andrea Bina uses a pendulum with a pointer to trace movement in the sand below during an earthquake.



**Bina's pendulum**

**1880** While working in Japan, British geologist John Milne develops the first accurate seismometer.

**1907** German physicist Emil Wiechert builds a machine that records an earthquake using an oscillating pendulum.



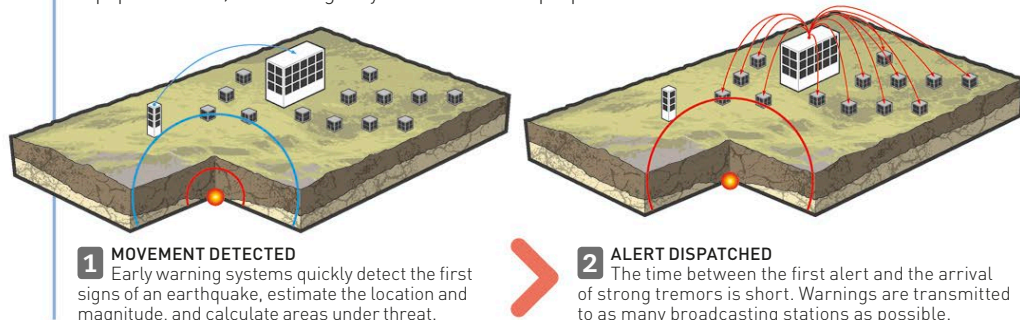
**Wiechert's pendulum**

**1934** American seismologist Charles Richter develops a widely used scale that measures the energy released by an earthquake.

**1979** The moment magnitude scale is introduced as a more accurate version of the Richter scale.

## EARLY WARNING SYSTEMS

Early warning systems act to protect people, animals, and property by alerting people to incoming seismic waves from an earthquake. This gives people time to take cover, businesses and power stations time to make equipment safe, and emergency services time to prepare for action.



## EARTHQUAKE DRILL

One simple emergency drill has been proven to reduce injuries from earthquakes: Drop, Cover, Hold On. This is because most injuries come from falling objects such as lamps and glass rather than from building collapse.



**1 DROP**  
Drop to the ground immediately to protect yourself as much as possible where you are.

**2 COVER**  
Take cover under a sturdy desk or table if possible; if not, move to the corner of the room.

**3 HOLD ON**  
Hold on to the desk or table while covering your head and neck with your arms.

## RESISTING EARTHQUAKES

While no structure can be guaranteed completely safe from earthquake damage, the buildings listed here have proven to be very resistant to massive ground shakes.

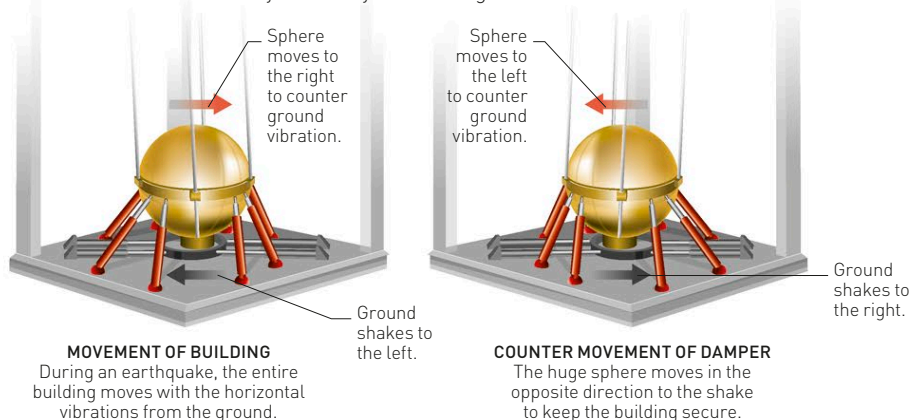
- CHICHÉN ITZÁ, MEXICO**  
The Mayan pyramid of El Castillo at Chichén Itzá is very strong, as it has a base much broader than its summit.
- TOMB OF CYRUS, IRAN**  
Built in 400 BCE, this uses "base-isolation" to survive shakes: its base moves independently of its foundations.
- YOKOHAMA LANDMARK TOWER, JAPAN**  
This skyscraper has a mass damper, sits on rollers, and is made from flexible materials.
- TRANSAMERICA PYRAMID, US**  
Rising to 853 ft (260 m), this skyscraper in San Francisco, CA, has foundations that reach 52 ft (16 m) into the ground.
- TAIPEI 101, TAIWAN**  
Stretching twice as high as the Transamerica Pyramid, this relies on a huge mass damper to resist movement.



**TAIPEI 101**

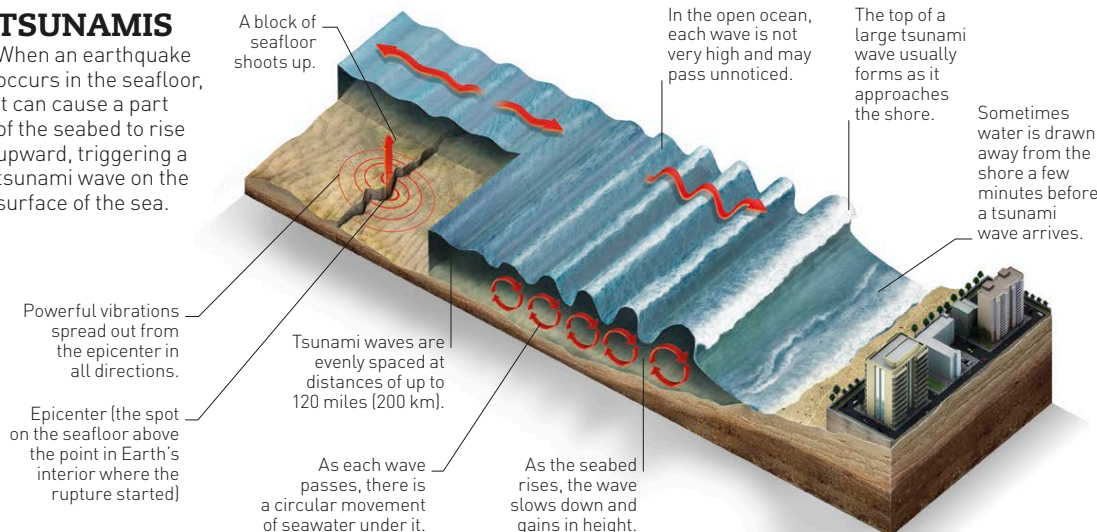
## MASS DAMPER

One way to help skyscrapers cope with an extreme ground shake is to install a mass damper—a huge steel sphere—at the center, suspended by cables. It moves back and forth to counter any motion by the building itself.



## TSUNAMIS

When an earthquake occurs in the seafloor, it can cause a part of the seabed to rise upward, triggering a tsunami wave on the surface of the sea.



## MAJOR TSUNAMIS

Tsunamis are assessed according to the size of their waves, how many occur in one event, how far they come on shore, and how much damage they cause.

- 1 INDIAN OCEAN, DECEMBER 26, 2004**  
This tsunami's waves reached 164 ft (50 m) and killed more than 227,000 people, affecting 14 countries.
- 2 NORTH PACIFIC COAST, JAPAN, MARCH 11, 2011**  
Traveling at 497 mph (800 kph), the 33-ft (10-m)-high waves of this tsunami forced 450,000 people from their homes.
- 3 PORTUGAL, NOVEMBER 1, 1755**  
Set off by an 8.5-magnitude earthquake, this tsunami hit Portugal, Morocco, and Spain with waves 98 ft (30 m) high.
- 4 KRAKATOA, INDONESIA, AUGUST 27, 1883**  
Caused by the eruption of the Krakatoa Caldera volcano, this tsunami created multiple waves reaching 121 ft (37 m) high.
- 5 ENSHUNADA SEA, JAPAN, SEPTEMBER 20, 1498**  
Waves from this tsunami were powerful enough to cross a section of land separating Lake Hamana from the sea.



# Shaping the land

Earth's surface is constantly changing. Earth's plates move, forming mountains and continents. At the same time, erosion by wind, waves, moving ice, and other forces wears away the surface, carrying away rock under the influence of gravity.

## EROSION

Water, wind, and ice wear down rocks and soil. They also move the resulting materials to new places, and in doing so change the shape of the land. The process is called erosion. Natural forces cause most erosion, but human activity, such as deforestation, also contributes.



**GLACIER**  
Huge ice masses called glaciers scrape away rocks and earth as they move down mountain valleys.



**WATER**  
Moving water erodes coasts, cliffs, and riverbanks, picking up and transporting rocks, pebbles, and soil.



**WIND**  
A powerful erosive force, wind blows away the top surface of soil and wears away rock.

## EROSION AND DEPOSITION

Rivers and streams mold the landscape. From glacier beginnings, a river travels fast, picking up rocky debris and carving deep into valleys. The river slows but continues to erode the landscape and also deposits some material along the way. When it reaches the sea, it drops silt to form deltas and beaches.

**KETTLE LAKE**  
Melting ice from retreating glacier forms shallow lake.

**TERMINAL MORaine**  
Ridge of rock, gravel, and soil at final point of glacier's advance.

**POOL**  
Cascading water forms pool at base of waterfall.

**U-SHAPED VALLEY**  
Moving glacier ice erodes rock to form U-shaped valley.

**GORGE**  
Fast-moving river or waterfall deepens valley or gorge.

**FLOODPLAIN**  
Sediment deposited by river creates flat floodplain.

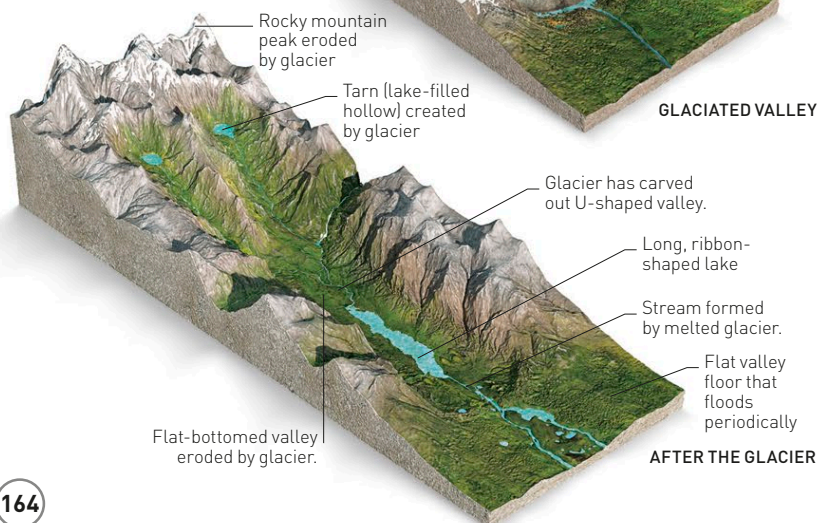
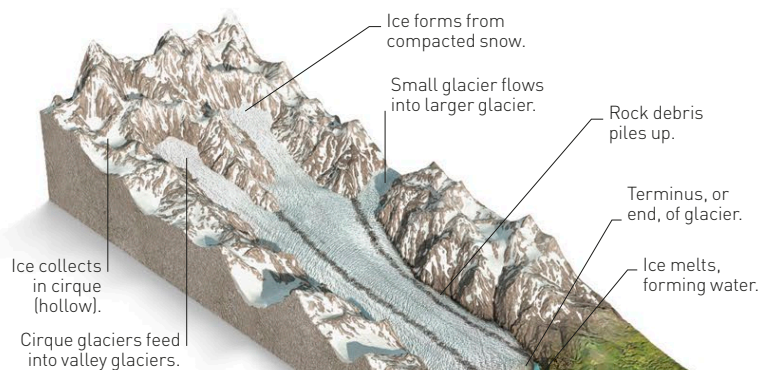
**MEANDER**  
River bend caused by erosion on one side and silt deposits on the other.

**ARCH**  
Pounding waves form arch in headland.

**RIVERS DUMP ABOUT 22 BILLION TONS OF SEDIMENT INTO THE SEA EVERY YEAR.**

## GLACIERS

Icy glaciers flow through mountain valleys, reshaping them. They move slowly, usually less than 3.3 ft (1 m) a day, but carry rock debris, which grinds hollows and U-shaped valleys in the landscape.



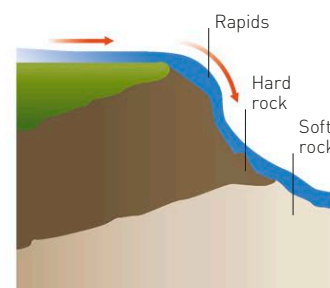
**DELTA**  
A delta forms where a slow-moving river deposits sediment where it meets the sea.

**BEACH**  
Beaches are created from eroded material carried by the sea.

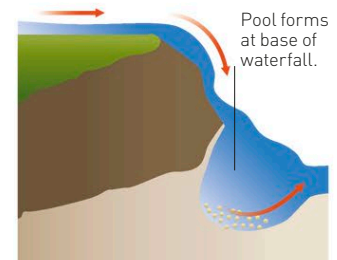
**SAND SPIT**  
On the coast, sandy deposits settle and project out into the sea.

## WATERFALL FORMATION

A waterfall forms when a river pours over a rocky edge. The water flow erodes the rock, creating a pool and undermining the ledge. Soft rock erodes more quickly than hard rock, so the amount of erosion varies, as does the height and flow of the water.



**RAPIDS**  
Rapids occur when the flow of a shallow river is broken up by hard rock projecting out of the water.



**WATERFALL**  
When a river erodes soft rock, beyond the rapids, it carves out a pool into which the water cascades.



## WATER EROSION

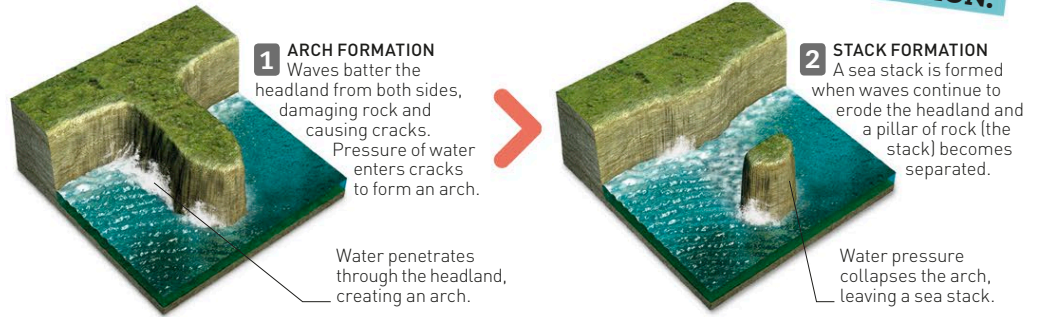
Helped by strong winds, ocean waves batter against coastal landforms. Dislodged rocks and pebbles are ground down and rub abrasively against headlands, cliffs, and standing rocks.



ERODED ROCK, LOCH ARD GORGE, AUSTRALIA

## ARCHES AND STACKS

As waves approach a headland, they curve around, attacking the sides. In a process called corrasion, stones flung up by the waves erode the sides, causing cracks. Compressed air brought in by waves expands, enlarging cracks and forming arches and stacks.



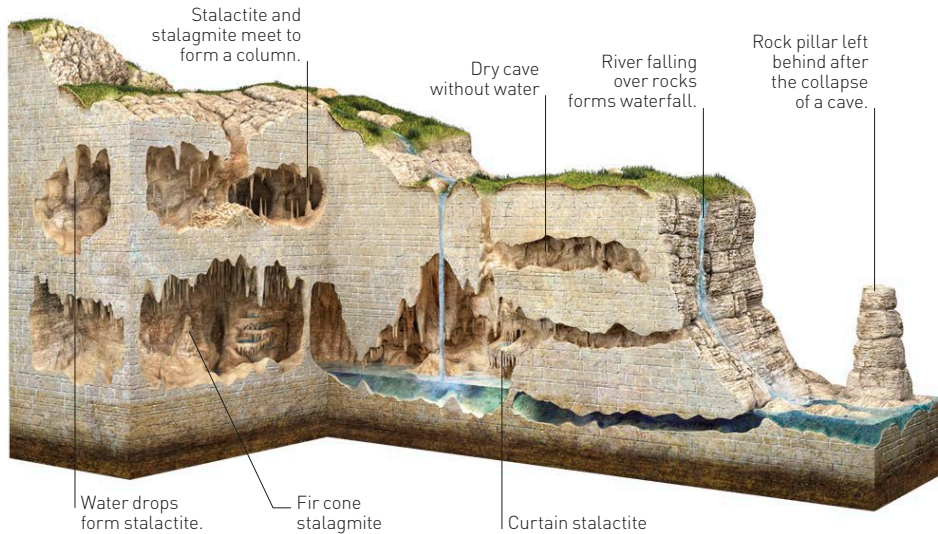
## LIMESTONE LANDSCAPES

Deep below Earth's surface are large cave systems. Rainwater, which is slightly acidic, gradually dissolves the limestone, creating cracks. Flowing water widens the cracks, forms channels, and eventually creates cave systems.



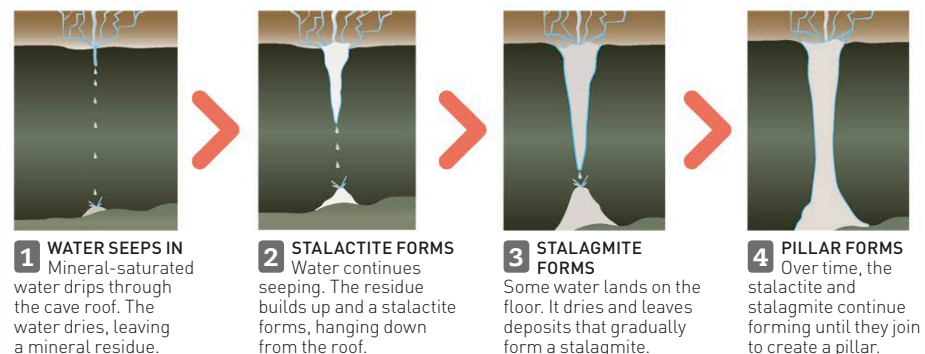
## INSIDE A CAVE

Limestone caves are wondrous places. Over centuries, the limestone rock dissolves to create huge chambers, often containing many incredibly shaped pillars, and river-filled tunnels. Caves vary in size. Some are shallow, but the deepest, in France, lies nearly 1 mile (1.5 km) below ground.



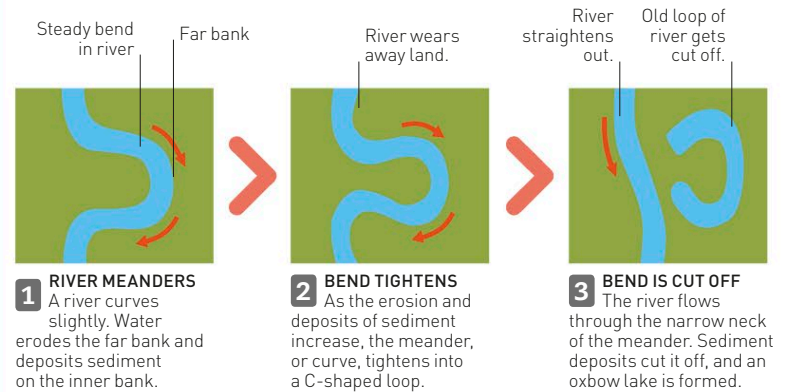
## STALACTITES AND STALAGMITES

Slim, beautifully shaped stalactites hang down from the roof of a cave. Stalagmites rise up from the floor of the cave. Both are made when calcium minerals dissolved in water form again when the water evaporates. Over time, they create fantastic shapes.



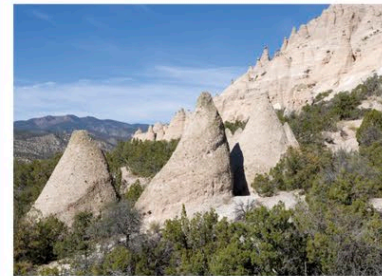
## OXBOW LAKES

On low-lying land, snakelike meanders may form when the course of a river bends, and may eventually become oxbow lakes. Meanders have two sets of curves: one side is formed by erosion as the river erodes the land, and the other side forms from deposits of silt and sediment.



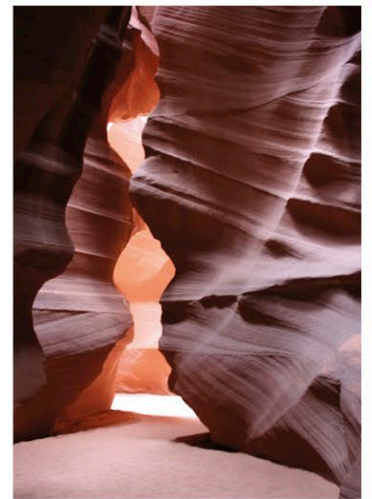
## WIND EROSION

Wind is a powerful erosive agent. It blows away soil, sand, and other light substances, depositing them at different locations, often sculpting new landforms. Wind erosion can be destructive, particularly for farmers. Trees and terraces help protect land.



CONICAL FORMATIONS, TURKEY

In some parts of the world, the impact of wind has changed landscapes, eroding rocks into new forms.

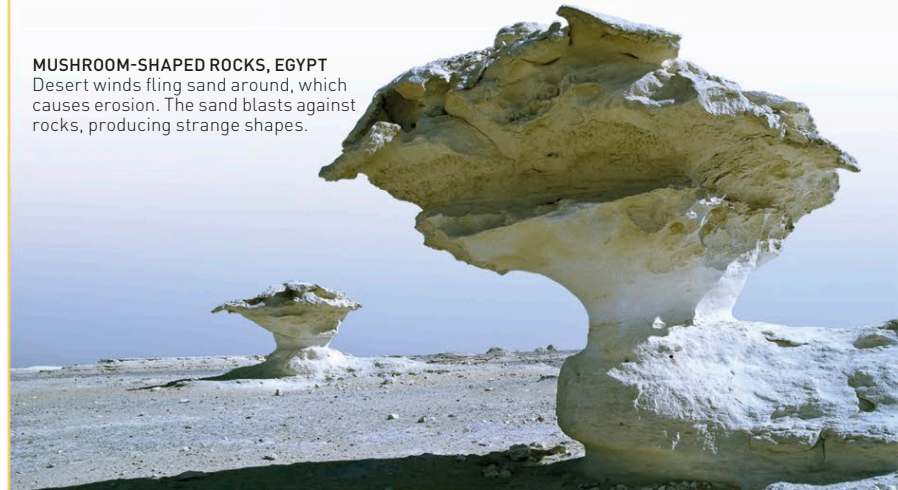


SANDSTONE SWIRLS, US

Wind, and the sand particles it carries, erode sedimentary rocks such as sandstone, creating fantastic swirls.

## MUSHROOM-SHAPED ROCKS, EGYPT

Desert winds fling sand around, which causes erosion. The sand blasts against rocks, producing strange shapes.





# Rocks and minerals

The outer layers of Earth are mostly solid rock. Mountains and canyons are visible examples, but much more rock is hidden under the soil and the sea. Rocks are made of minerals. They can be changed or destroyed by weather, water, heat, or pressure. About 4,000 different kinds of mineral are found in Earth's crust, each with unique crystals.

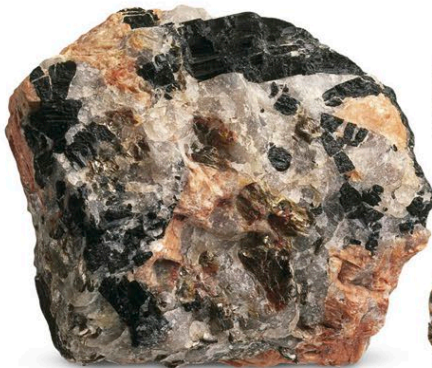
**WHAT'S THE DIFFERENCE?**  
Minerals are natural chemical substances that usually form as solid crystals. Each type can be recognized by its hardness, color, and atomic structure. Rocks are a mixture of minerals locked together. For example, granite is made of the minerals quartz, feldspar, and mica.



MINERAL: QUARTZ

## IGNEOUS ROCKS

These are formed when molten rock, or magma, cools. They vary from coarse-grained granite, formed deep within Earth's crust, to fine-grained basalt lavas erupted from volcanoes.



TOURMALINE PEGMATITE



PUMICE



ANDESITE



OBSIDIAN



PINK GRANODIORITE



RHYOLITE



PORPHYRY

## SEDIMENTARY ROCKS

These rocks form as deposits of sediment on Earth's surface, in rivers, lakes, deserts, and seas. They are made from grains of sand and clay worn away from older rocks by wind and water. Over a very long period of time, the grains settle into layers of mud, or sediment. These layers are buried and eventually harden into new rock.



GREYWACKE



LIMESTONE WITH FOSSILS



FLINT



OIL SHALE



SHALE



PUDDINGSTONE

## MINERALS

There are thousands of different minerals, though only about 30 make up most rocks. Minerals usually form from chemical solutions that vary in temperature and pressure depending upon the depth within Earth.



CHRYSTOPRASE



MAGNETITE



ENARGITE



TENNANTITE



COCKSCOMB BARITE



ARSENOPYRITE



HORNLENDE



BROOKITE



CHALCOCITE



HALITE



SULFUR



CHALCOPYRITE



NAILHEAD CALCITE



GALENA



CORUNDUM

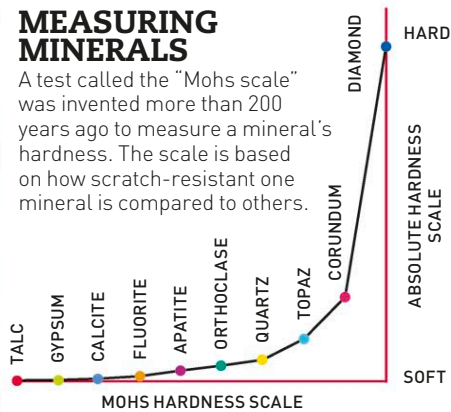


GOLD



## MEASURING MINERALS

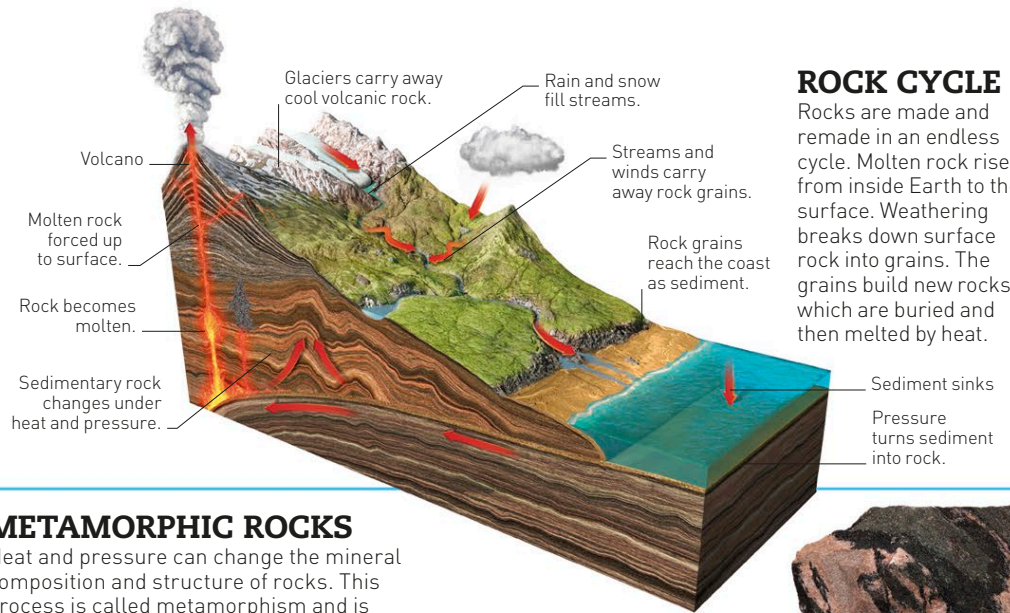
A test called the "Mohs scale" was invented more than 200 years ago to measure a mineral's hardness. The scale is based on how scratch-resistant one mineral is compared to others.



ROCK: PINK GRANITE

## ROCK CYCLE

Rocks are made and remade in an endless cycle. Molten rock rises from inside Earth to the surface. Weathering breaks down surface rock into grains. The grains build new rocks, which are buried and then melted by heat.



## METAMORPHIC ROCKS

Heat and pressure can change the mineral composition and structure of rocks. This process is called metamorphism and is more intense deep within Earth.



LIMESTONE BRECCIA

DOLOMITE

CLAYSTONE NODULE



RED MARL



CHALK



LOESS



IRONSTONE



SANDSTONE



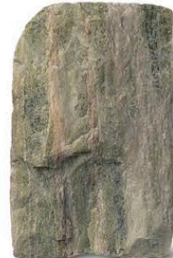
MYLONITE



ECLOGITE



MIGMATITE



GREEN MARBLE



SERPENTINITE



SLATE



GNEISS



SKARN



RHODOCHROSITE



DIAMOND



PURPLE FLUORITE



REALGAR



ROSE QUARTZ



SPHALERITE



AZURITE



HEMATITE



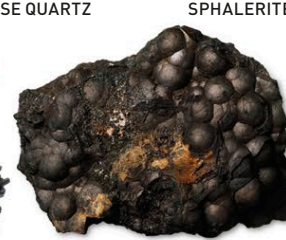
NICKELINE



PROUSTITE



STIBNITE



BOTRYOIDAL ARSENIC



COVELLITE



ORPIMENT



SMOKY QUARTZ



BLUE SAPPHIRE



RUTILE



CHRYSOBERYL



HEMIMORPHITE



MALACHITE



BERYL



BORNITE

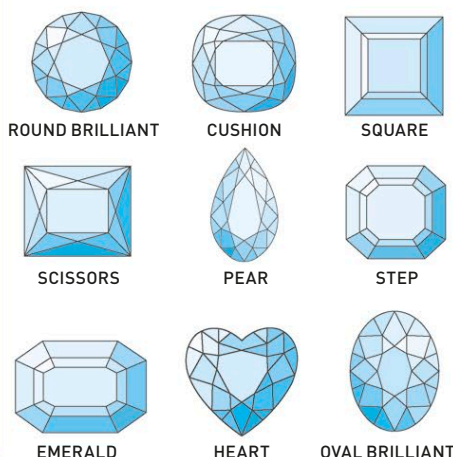


# Gems

A gemstone, or gem, is a mineral that has been polished and shaped by a skilled craftsman in order to enhance its beauty. The most highly prized gems are hard-wearing and rare. There are more than 5,000 known minerals on Earth, but fewer than 100 are used as gemstones.

## GEM SHAPES

Gemstones can be shaped in many ways. Some shapes, or "cuts," are very popular for rings, especially diamond rings. More than three-quarters of all diamonds today are cut into the "round brilliant" shape.



## BIRTHSTONES

Some gemstones are traditionally associated with certain months of the year. It is believed to be lucky to wear the gem for your birth month.

JANUARY  GARNET	FEBRUARY  AMETHYST	MARCH  AQUAMARINE	APRIL  DIAMOND
MAY  EMERALD	JUNE  PEARL	JULY  RUBY	AUGUST  PERIDOT
SEPTEMBER  SAPPHIRE	OCTOBER  TOURMALINE	NOVEMBER  TOPAZ	DECEMBER  TURQUOISE

## PRECIOUS STONES

Traditionally, gems such as opal, emerald, sapphire, ruby, and diamond were named "precious" stones. This was because their rarity made them the most valuable. Today, gems are valued in several different ways. The term "precious" is outdated, although jewelers still find it useful.



## SEMI-PRECIOUS STONES

Gems found in large quantities were once said to be "semiprecious" and had a lower value than rare stones. However, a gem's beauty and popularity are now also considered part of its value. Some "semiprecious" stones sell for more money than "precious" ones.



## QUARTZ GEMS

Quartz is one of the most common and varied minerals on Earth. It comes in an amazing number of colors and intricate patterns.





## FACETING A DIAMOND

When mined, gemstones often look dull; they must be cut and polished to shine. The best way to maximize the beauty of a transparent gem is to cut its surface into flat faces called facets. These reflect light both from within the crystal and from its surface to make the gem sparkle.



## MINING

Gemstones are found in different geological settings across the world, especially when associated with ore minerals. They are sometimes brought to Earth's surface by volcanic eruptions.



## BIGGEST GEMS

Gemstones can be huge. The Olympic Australis opal weighs 7.5 lb (3.45 kg); the American Golden topaz is 10 lb (4.57 kg); and the largest colorless diamond, the Cullinan, is 4 in (10 cm) long.



## ORGANIC GEMSTONES

Organic gemstones are made from animal or plant materials. For instance, coral is formed from sea creatures, pearls develop in certain shellfish such as oysters, and amber is made of fossilized tree resin.





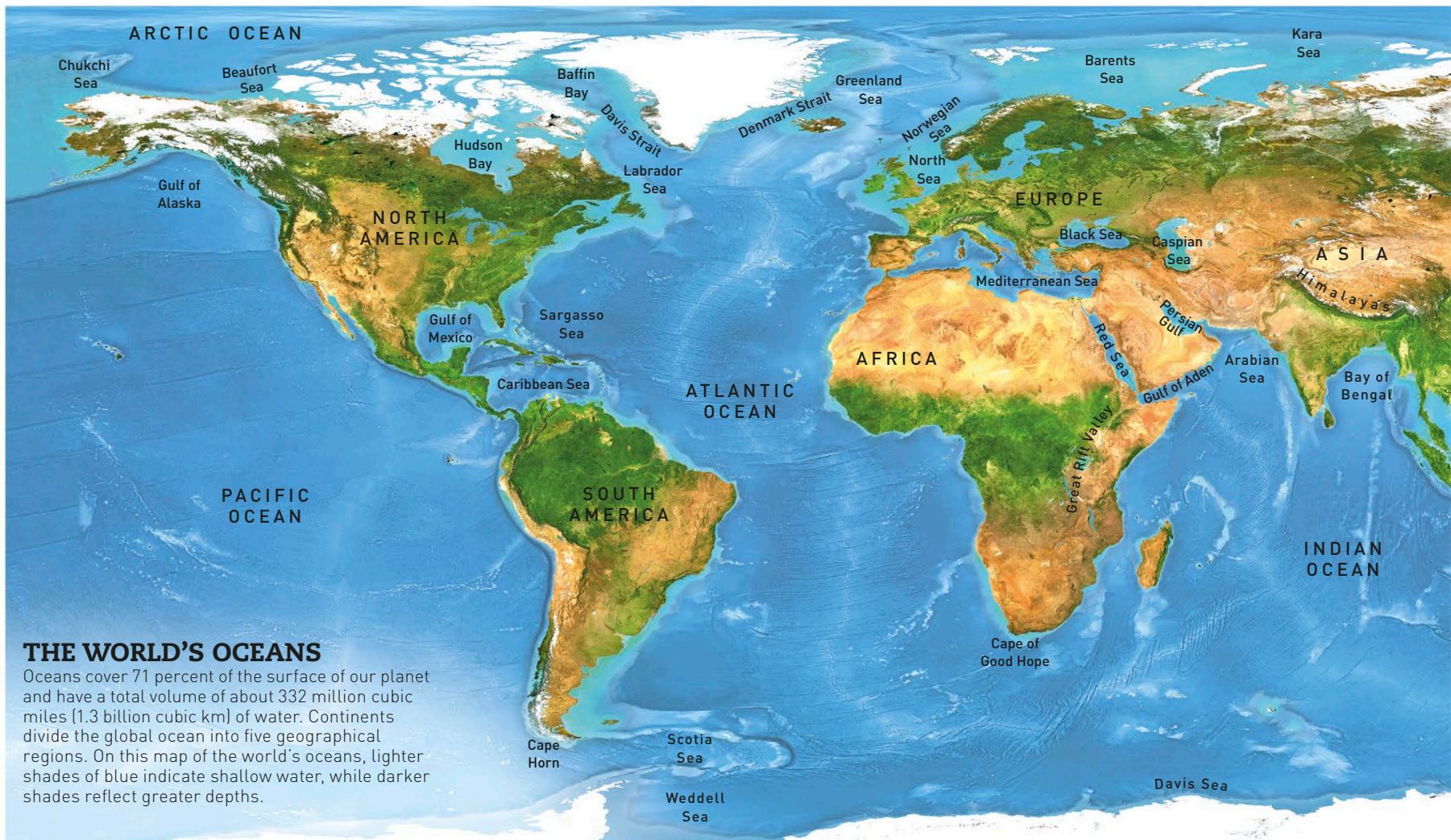
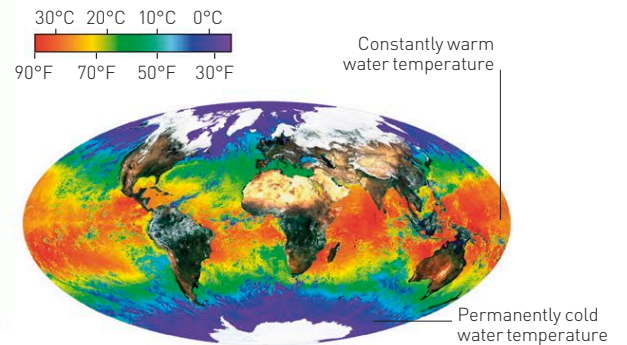
# Water on Earth

**ABOUT 97 PERCENT OF THE WORLD'S WATER LIES IN THE OCEANS.**

The presence of abundant water on Earth is vital for life. Water fills colossal salty oceans, swirls in clouds as water vapor, and falls as rain on land to fill freshwater rivers and lakes, freezing into ice at the poles and on mountain tops.

## WATER TEMPERATURE

Deep-ocean water is permanently cold, but the temperature of surface water varies. It is warmest around the equator, where the Sun's heat is more intense. At the poles, wind-blown warm water cools and sinks, driving ocean circulation.

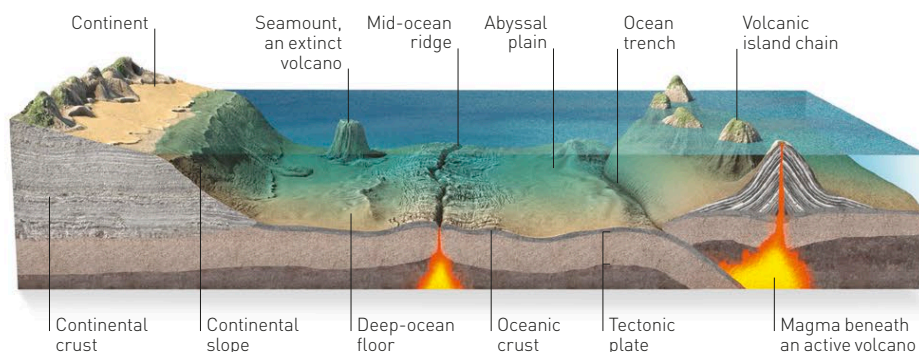


## THE WORLD'S OCEANS

Oceans cover 71 percent of the surface of our planet and have a total volume of about 332 million cubic miles (1.3 billion cubic km) of water. Continents divide the global ocean into five geographical regions. On this map of the world's oceans, lighter shades of blue indicate shallow water, while darker shades reflect greater depths.

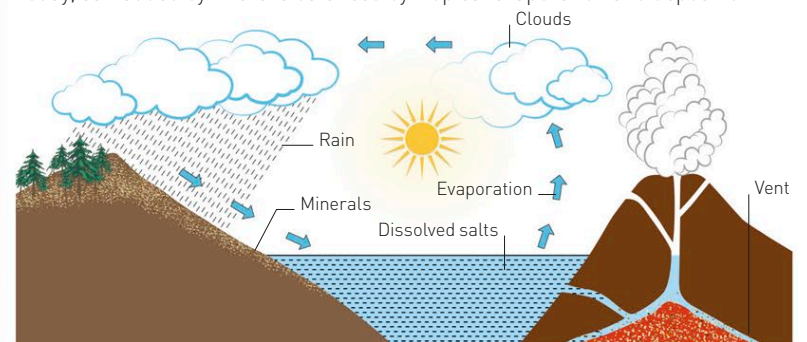
## OCEAN FLOOR

Ocean basins filled with seawater are home to some of Earth's tallest volcanoes; longest mountain ranges, called mid-ocean spreading ridges; and deepest valleys, known as trenches. New ocean crust forms at spreading ridges.



## SALT WATER

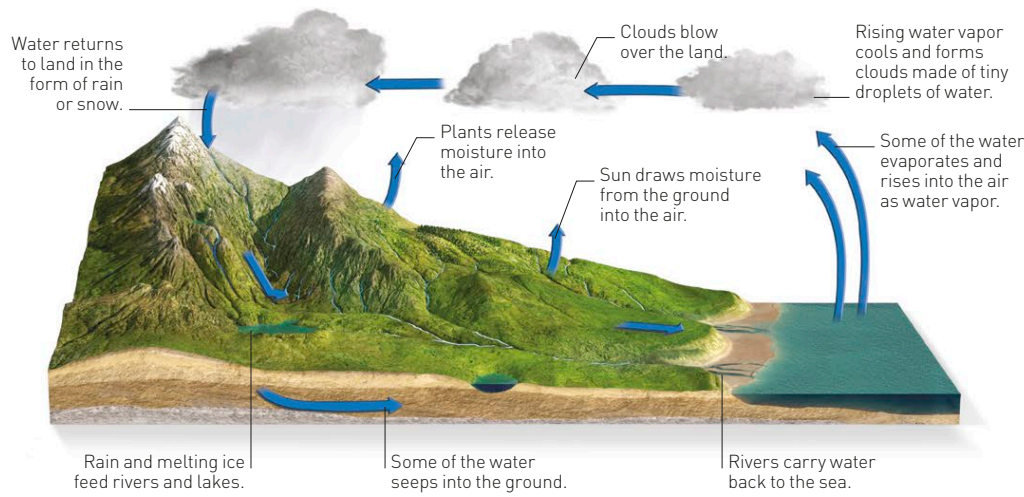
Earth's surface originally had only fresh water, but over millions of years, rain pouring down on the land weathered the rocks and carried dissolved minerals on its journey to the seas. The minerals included sodium chloride (common salt). Today, salt added by rivers is balanced by tropical evaporation and deposition.





## WATER CYCLE

Powered by the Sun's heat, water circulates between sea, air, and land. The Sun-warmed surface water is constantly evaporating (turning into water vapor). The rising vapor cools and condenses, forming clouds from which rain and snow fall. Nearly 70 percent of Earth's freshwater is held in glaciers and ice caps. The rest flows over the land before the water finds its way back to the sea.



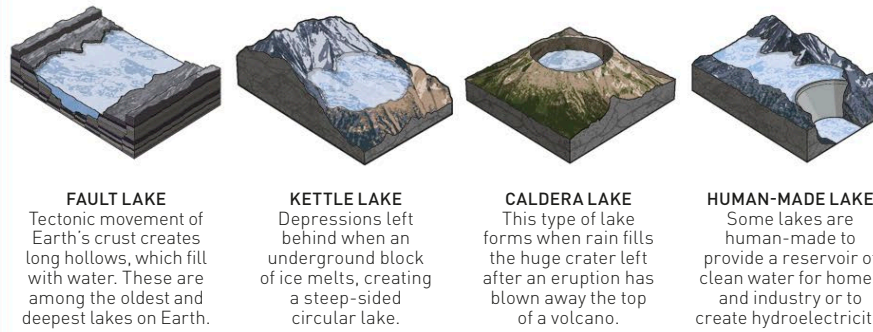
## LARGEST LAKES

Some lakes are just shallow pools that eventually dry out, while others are so vast that they form inland seas.

- CASPIAN SEA**  
Area: 143,000 sq miles (371,000 sq km) This lake was once part of the Mediterranean Sea; it was cut off when sea levels fell during the last ice age.
- SUPERIOR**  
Area: 31,700 sq miles (82,100 sq km) The biggest of the five glacial meltwater Great Lakes of North America and the largest freshwater lake in the world.
- VICTORIA**  
Area: 26,595 sq miles (68,880 sq km) The waters of Lake Victoria in Africa fill a shallow basin in the center of a plateau.
- HURON**  
Area: 23,000 sq miles (59,600 sq km) This is the second largest of the North American Great Lakes.
- MICHIGAN**  
Area: 22,000 sq miles (58,000 sq km) Also one of the five Great Lakes, but located entirely within the US.

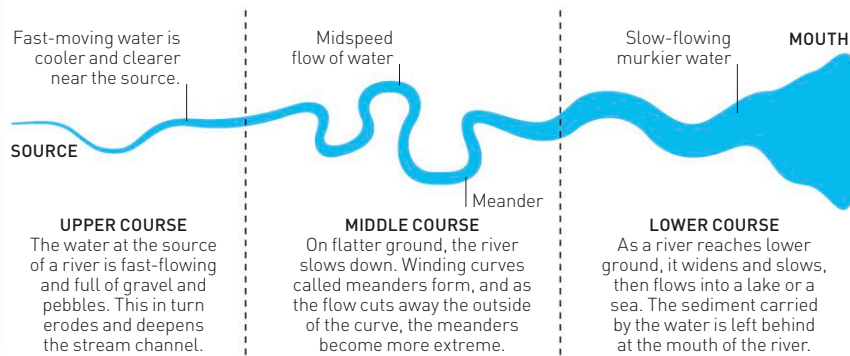
## LAKE TYPES

Lakes form in various ways, depending on how the hollow on Earth's surface was created, and most contain fresh water. They are found in a number of environments, including mountains, deserts, and plains. Some lakes are millions of years old, but most are much younger.



## RIVERS

Rivers drain water from the land down to the sea. Small, fast-flowing streams join up to form bigger, slower ones. They start life in higher ground, where rainwater or melting snow collects and trickles downhill. Some rivers also form when lakes overflow or from springs.



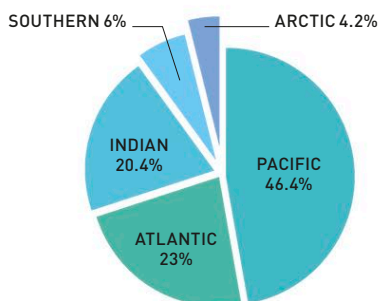
## LONGEST RIVERS

Earth's largest and longest rivers carry vast quantities of water and sediment to the sea.

- NILE**  
Length: 4,160 miles (6,695 km) Africa's River Nile has two major tributaries (branches): the Blue Nile and the White Nile.
- AMAZON**  
Length: 4,005 miles (6,450 km) More water flows through South America's mighty Amazon than any other river.
- YANGTZE**  
Length: 3,964 miles (6,378 km) China's Yangtze River is the world's deepest river, as well as the third-longest river.
- MISSISSIPPI-MISSOURI**  
Length: 3,710 miles (5,970 km) The Mississippi and Missouri Rivers combine to form North America's longest river system.
- YENISEI**  
Length: 3,445 miles (5,539 km) The Yenisei River starts in Mongolia and flows through Russia.

## OCEAN SIZES

This chart shows the total area covered by each ocean. The Pacific is the deepest and by far the largest ocean, covering almost half the Earth. The Arctic is the smallest, coldest, and shallowest ocean.



## WATER POWER

Earth's essential resource can move with considerable force, and modern techniques have been developed to harness this incredible power into energy.



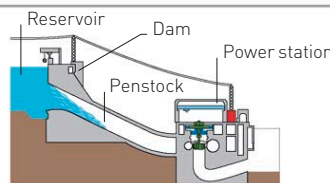
**HYDROELECTRIC**  
Hydroelectric dams are built to convert a river's kinetic energy (energy of movement) into electrical power.



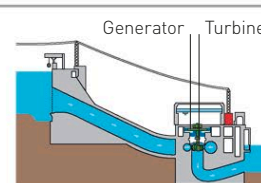
**TIDAL SURGE**  
Tidal barrages work in a similar way to hydroelectric dams, generating power from rising and falling tides.

### HYDROELECTRIC ENERGY

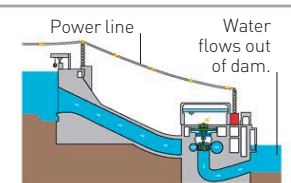
Hydroelectric power stations use the force of moving water to produce electrical energy. The amount of energy created is determined by the flow of water.



- 1 WATER IS RELEASED**  
Water is stored in a reservoir and released into giant tubes (penstocks) inside the dam.



- 2 WATER PRESSURE**  
The force of the water spins the blades of the turbines, which are connected to electricity generators.



- 3 ELECTRICITY IS PRODUCED**  
Power lines carry away electricity, while the water flows off downstream, away from the dam.

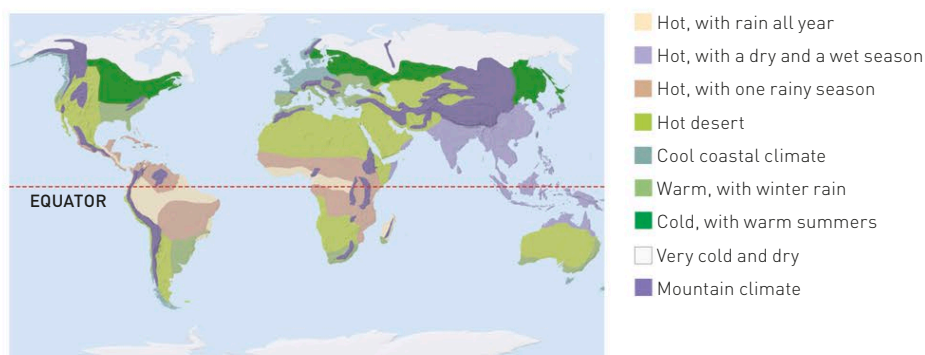


# Climate and weather

Sunshine, air, and water interact to create the constantly changing conditions we call weather. Weather can change fast within a day and slowly from season to season. The average weather pattern in one place makes up its climate.

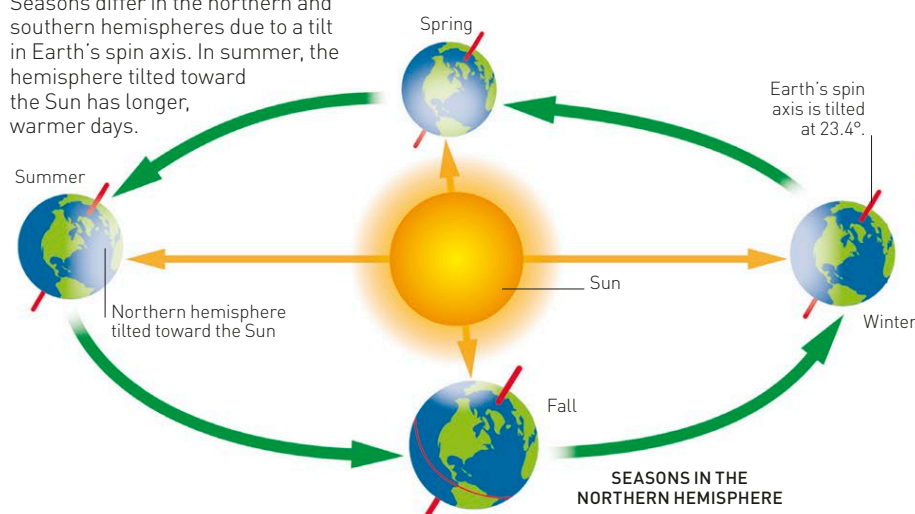
## WORLD'S CLIMATE

The world is divided into climate zones, each one with a pattern of temperature and rainfall and distinct vegetation. They range from a hot and wet climate near the equator to a cold and dry one at the poles.



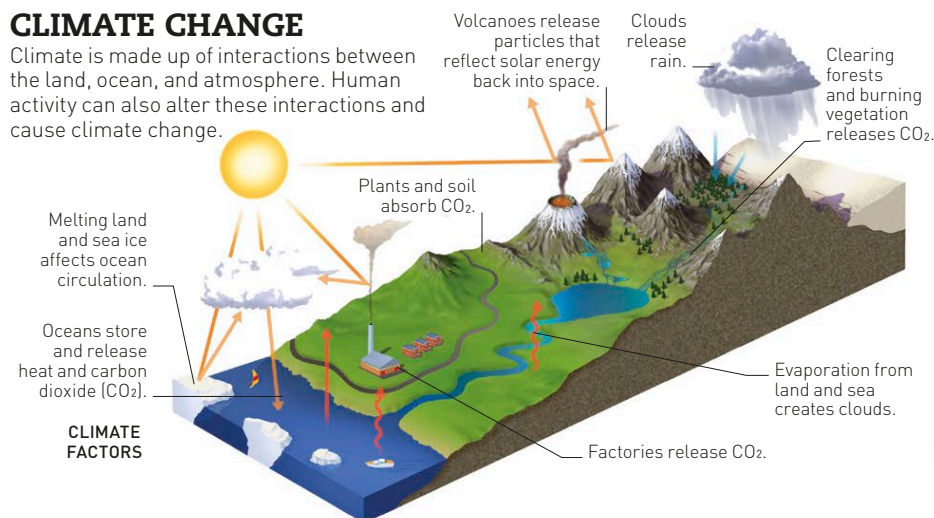
## SEASONS

Seasons differ in the northern and southern hemispheres due to a tilt in Earth's spin axis. In summer, the hemisphere tilted toward the Sun has longer, warmer days.



## CLIMATE CHANGE

Climate is made up of interactions between the land, ocean, and atmosphere. Human activity can also alter these interactions and cause climate change.



## WHAT IS CLIMATE?

A climate is the average weather pattern in an area, influenced by factors such as the region's distance from the equator.



### TEMPERATURE

Places tend to be colder the farther they are from the equator.



### PRECIPITATION

There are zones of high and low rainfall around Earth.

## WEATHER SYSTEMS

Local air masses have their own temperature, moisture content, density, and pressure. A weather front occurs when one air mass meets another.



### WARM FRONT

Cold air is replaced by warm air, which slowly rises to form clouds and then rain as the air cools.



### COLD FRONT

Cold air pushes into warm air, forcing it upward to create storm clouds and heavy rain.

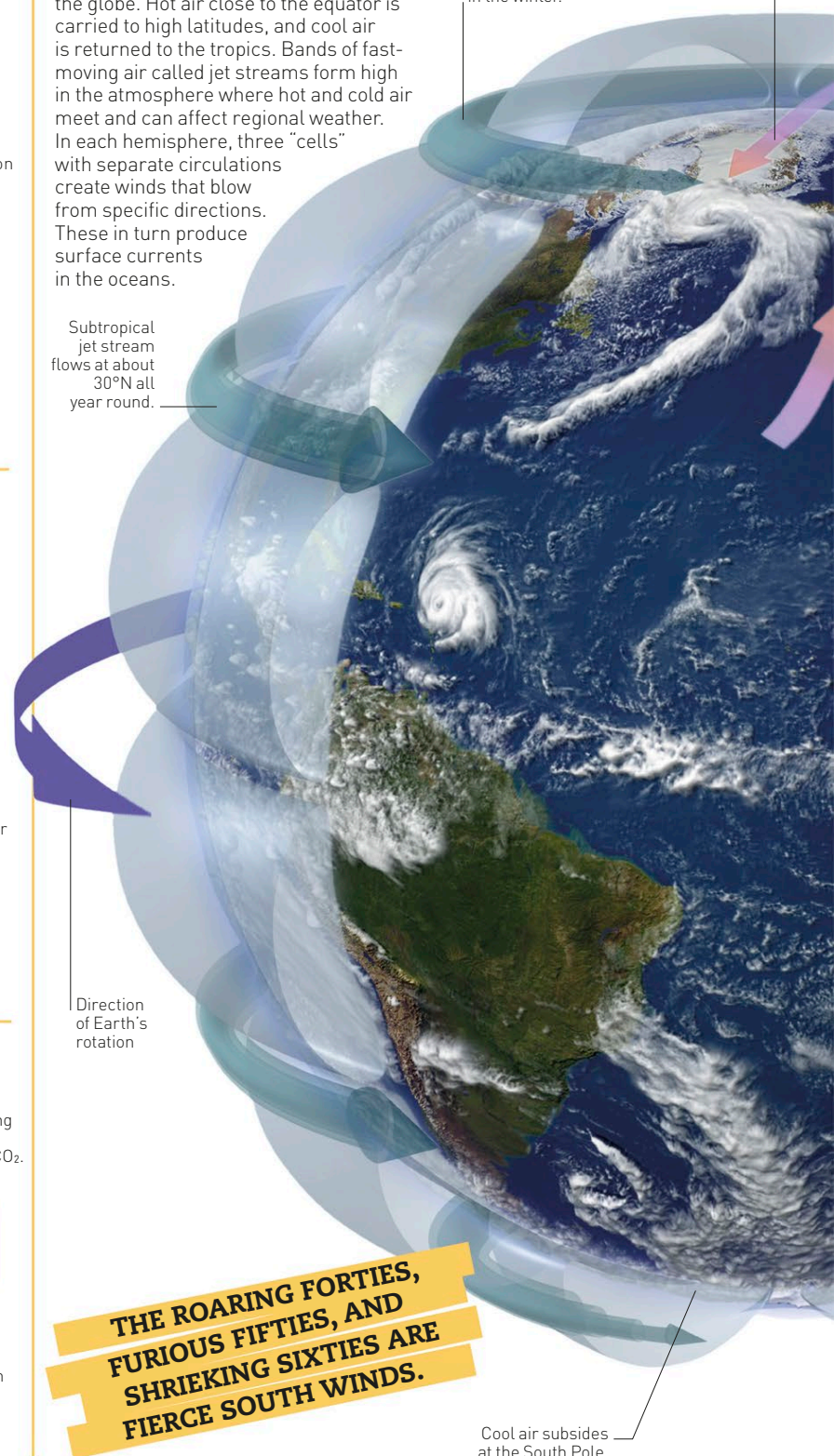
## ATMOSPHERIC CIRCULATION

Air is always on the move, and this creates the circulation of the atmosphere around the globe. Hot air close to the equator is carried to high latitudes, and cool air is returned to the tropics. Bands of fast-moving air called jet streams form high in the atmosphere where hot and cold air meet and can affect regional weather. In each hemisphere, three "cells" with separate circulations create winds that blow from specific directions. These in turn produce surface currents in the oceans.

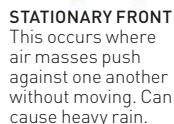
Subtropical jet stream flows at about 30°N all year round.

Polar-front jet stream moves farther south in the winter.

Polar easterlies blow away from the North Pole.







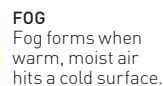
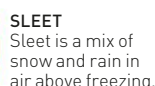
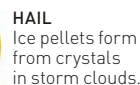
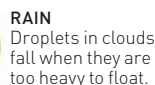
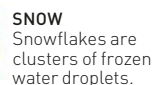
Fast-moving cold air overtakes a warm front and lifts the warm air mass. It can rain for days.



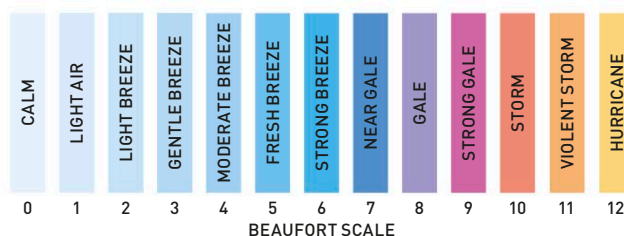
- Lines called isobars join points with the same pressure.

— An area with low pressure is called a depression.

All precipitation is simply falling moisture. Whether water falls from a cloud as rain, hail, or snow depends on how cold the air is.



Air moving between high and low pressure areas is called wind. Wind speed—from still air to a hurricane—is measured on the Beaufort scale.



All clouds fall into three main groups, although each type has many different shapes. Cumulus form pillowy heaps; stratus have flat layers; and cirrus are wispy streaks.

Some places have extreme climates or weather events that are talked about for years.

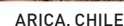
The fastest wind speed in a tornado was 318 mph (512 kph), recorded at Moore, Oklahoma City, OK, in 1999.

The hottest land-surface temperature ever recorded (by satellite measurement) was 159.3°F (70.7°C) in the Lut Desert, Iran, in 2005.

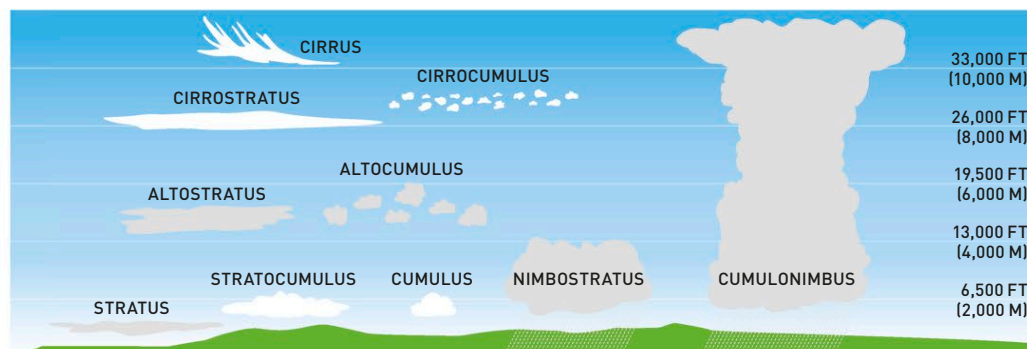
The coldest recorded temperature was  $-136^{\circ}\text{F}$  ( $-93^{\circ}\text{C}$ ), measured in Antarctica's eastern highlands in 2010.

The highest rainfall recorded in one day was 71.9 in (18.25 cm) in Foc-Foc, Reunion Island, in the Indian Ocean in 1966, during a tropical cyclone.

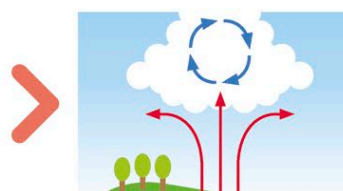
Arica, Chile, is the populated area with the lowest average annual rainfall in the world at 0.03 in (0.76 mm).



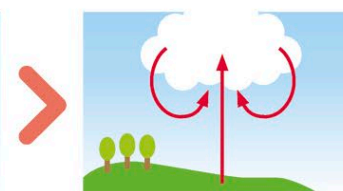
Clouds are named according to their size, shape, and height.



**1** When the Sun shines, moisture in the ground and sea rises into the air as water vapor.

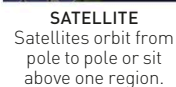
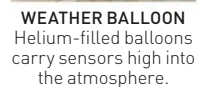
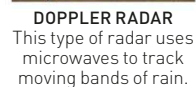


**2** As the vapor rises and cools, it condenses and forms clouds made of tiny water droplets.



**5** During cloud formation, heat is released into the surrounding air and lifts the cloud higher.

Weather stations are at work all over the world, gathering information about local and global weather patterns. They use a range of instruments from simple thermometers and rain gauges to weather balloons and satellites, which use sensors to monitor Earth's atmosphere.





# Extreme weather

Tornadoes, hurricanes, and flash floods destroy homes and countryside. Long dry spells cause water shortages and failed crops. There have always been episodes of extreme weather, but now it seems likely that the increase in freak events all around the world is due to climate change.

## CAUSES OF EXTREME WEATHER

The Sun's heat is a key factor, creating excessively high and low atmospheric pressure that can lead to extreme weather conditions. Dust from volcanoes can cause major disturbance, and global warming may play a part.



**GLOBAL WARMING**  
Since 1970, global temperatures have risen by 0.9°F (0.5°C), adding heat that may alter weather patterns.

## WHAT IS EXTREME WEATHER?

Many parts of the world experience wide variations in their weather, so when does it become extreme? In India, torrential monsoons are normal, as is a big freeze in the far North in the Arctic. Put simply, extreme weather is weather that has more energy than normal in the system, which is released in a variety of ways.

**THE US HAS THE MOST TORNADOES IN THE WORLD—ABOUT 1,000 EVERY YEAR.**



**THUNDERSTORM**  
Thunderclouds form in hot, humid weather and bring heavy rain, hail, lightning, and thunder.



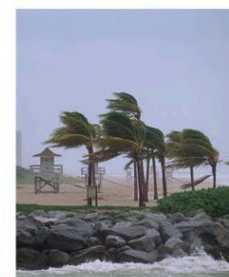
**MONSOON**  
These torrential rains that last for weeks are just seasonal weather in subtropical regions.



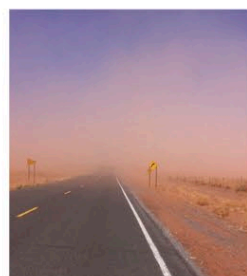
**FLOOD**  
Too much rain in a short time may cause flash floods in valleys and near rivers and the sea.



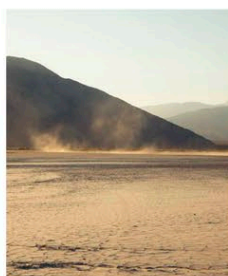
**TORNADO**  
These twisting columns of wind can flatten houses and pick up vehicles.



**HURRICANE**  
Earth's most powerful weather systems bring huge winds and rain.



**DUST STORM**  
In very dry places, sand and soil is picked up in the wind that grows into a suffocating dust storm.



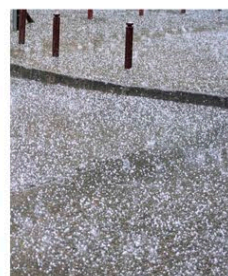
**HEATWAVE**  
During a heatwave, temperatures soar, reservoirs dry up, and water is in short supply.



**DROUGHT**  
If there is high pressure for long periods, no clouds form, and there is no rain. Vital crops fail.



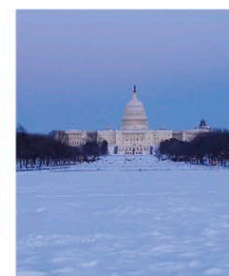
**SEVERE FOG**  
The thickest fogs occur in polluted areas. Tiny droplets of water settle on particles in the air.



**HAILSTORM**  
Showers of large hailstones can break glass and leave drifts of ice.



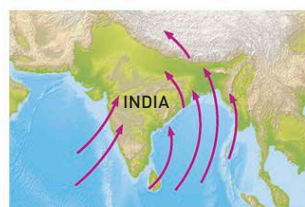
**SNOWSTORM**  
A snowstorm is a rapid fall of snow, 6 in (15 cm) deep or more, that disrupts daily life.



**COLD WAVE**  
This dramatic dip in temperature to well below freezing can threaten lives.

## MONSOON

Massive monsoon winds bring torrential rain to subtropical regions in summer. This rain is essential for crops to grow. The winds change direction in winter to bring dry, cooler weather.



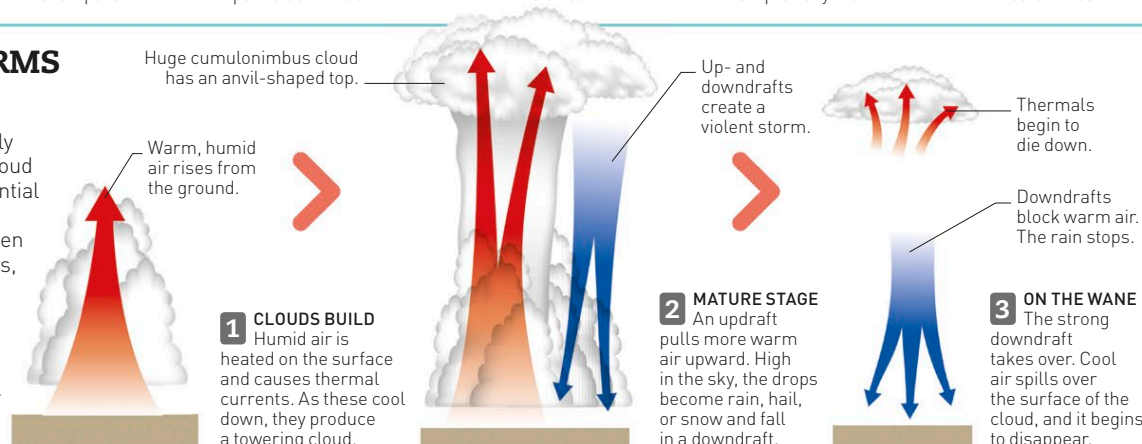
**SUMMER**  
The South Asian monsoon blows from the Indian Ocean, bringing rain across India.



**WINTER**  
Fine, dry weather spreads across India when the South Asian monsoon reverses.

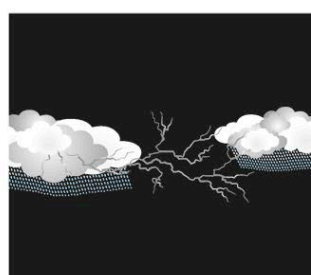
## THUNDERSTORMS

In hot, humid weather, an enormous cloud called a cumulonimbus can rapidly build up. This towering cloud brings gusty winds, torrential rain, hail, and lightning. Flashes of lightning happen after droplets, ice crystals, and hail in the cloud become electrically charged. The flashes superheat the air, creating claps of thunder.



## LIGHTNING STROKES

It takes a huge voltage of electricity to overcome the resistance of the air, but once the process starts, strokes of lightning zig-zag toward the ground. When a leader stroke makes contact with a high point like a tree, it lights up with a brighter stroke called the return stroke.



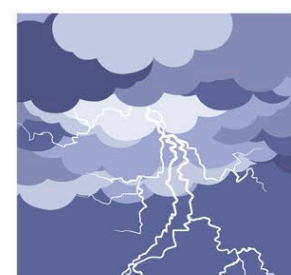
**CLOUD-TO-CLOUD LIGHTNING**  
This most common type of lightning flashes from cloud to cloud, then disappears in the air.



**CLOUD TO GROUND**  
Electricity in the lightning joins currents rising from the ground.



**RIBBON LIGHTNING**  
Return strokes flowing back up the first stroke create a ribbon effect.



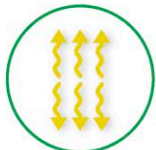
**SHEET LIGHTNING**  
Lightning flashing inside a cloud looks like a sheet of light.





#### SOLAR HEAT

The intensity of the Sun fluctuates day-to-day, and its heat causes changes in atmospheric pressure.



#### AIR PRESSURE

Low atmospheric pressure causes storms and strong winds. Prolonged high pressure can cause drought.

## EXCITING WEATHER PHENOMENA

Weather can produce some amazing phenomena and rare sights.

### SPRITES, ELVES, AND JETS

Sprites and elves are dancing red lightning flashes in the sky. Jets are cones of blue light on thunderclouds.

### BALL LIGHTNING

This glowing orb lasts for only seconds. It may be caused when elements in the soil vaporize and react with oxygen in the air.

### KATABATIC WINDS

These winds occur at night on mountain slopes. Dense, cold air is pushed down the slope by gravity.

### NONAQUEOUS RAIN

Spiders, frogs, and even jellyfish can be sucked up by rising air currents only to "rain" back down.

### ST. ELMO'S FIRE

This electric spark is like the glow in a plasma ball, but it occurs naturally on things like masts and lampposts during thunderstorms.

## GIANT HAILSTONE

This whopper fell in Vivian, South Dakota, during a July storm in 2010. Hailstones can gather ice layers as winds in storm clouds whip them upward again and again.

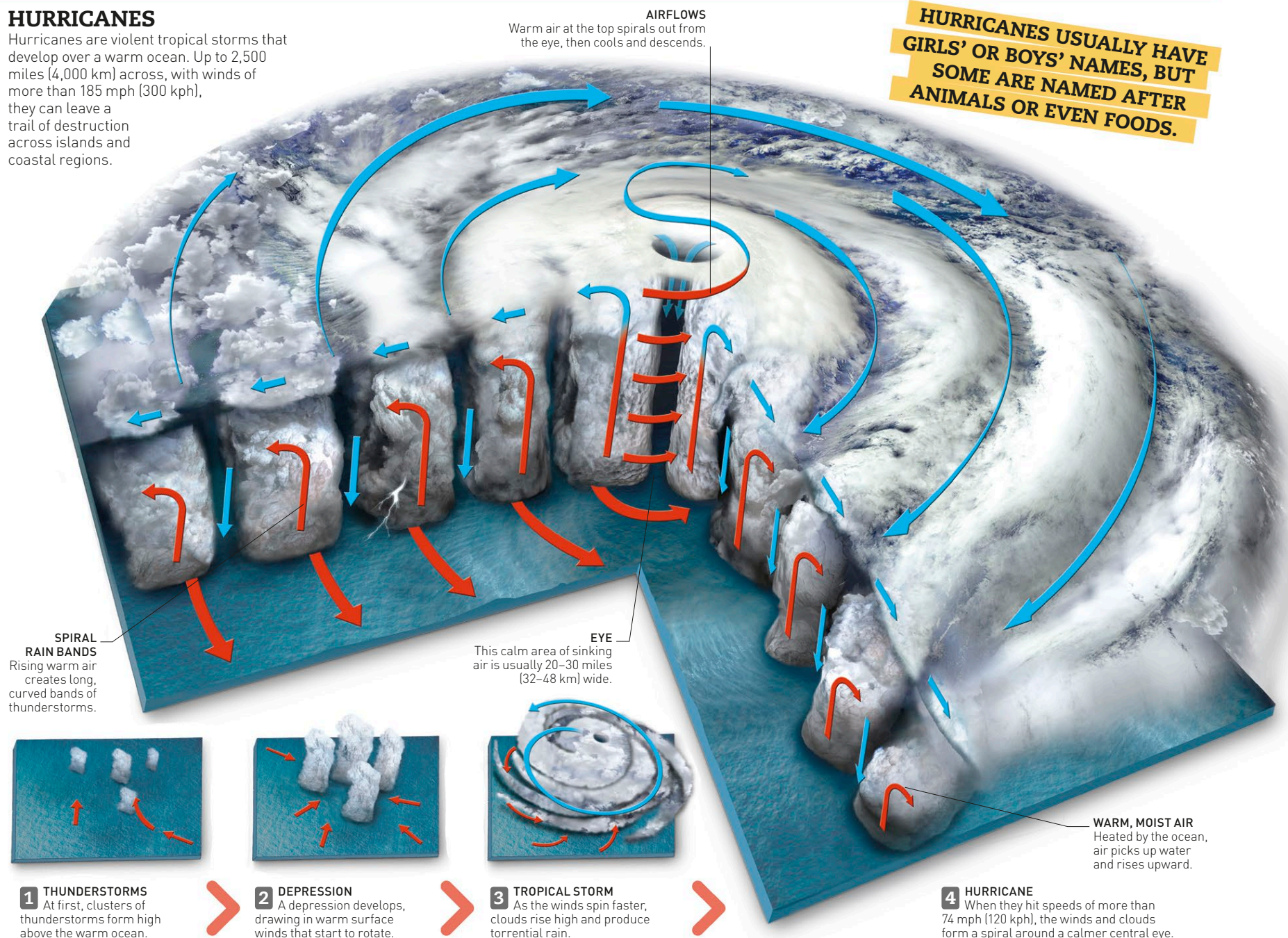


#### RECORD HAILSTONE

This hailstone weighed 2.2 lb (1 kg) and was 8 in (20 cm) across—three times the size of a tennis ball.

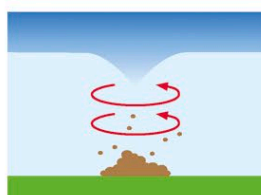
## HURRICANES

Hurricanes are violent tropical storms that develop over a warm ocean. Up to 2,500 miles (4,000 km) across, with winds of more than 185 mph (300 kph), they can leave a trail of destruction across islands and coastal regions.



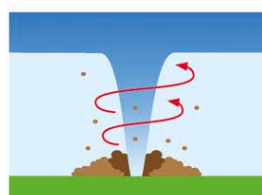
## TORNADOES

As warm air rises, it draws in more warm air from the ground, while cool air descends from the clouds above. This air mass begins to spin as a column and reaches from the clouds all the way down to the ground. Tornadoes are shaped like a funnel with a core of air that can spin at anything up to 300 mph (480 kph).



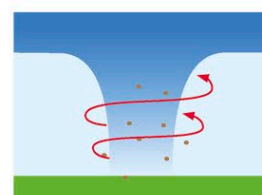
### 1 STEADY SPIN

As warm air rises from the ground, it starts to spin. The base of a cloud forms a funnel.



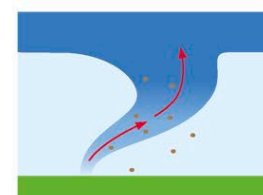
### 2 FUNNEL GROWS

When the funnel reaches the ground, it draws in more hot air and begins to spin faster.



### 3 PEAK PROGRESS

At its peak, the column can be several miles wide and destroy everything in its path.



### 4 COLUMN DIES

After a while, the column spins more slowly. It narrows and is drawn up into the cloud.

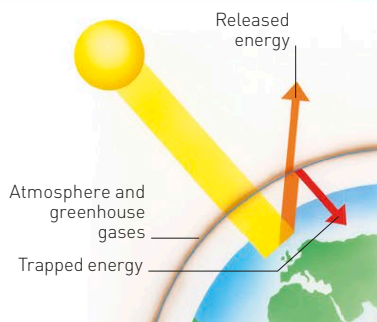


# Environment in danger

Earth's environments are fragile. Uncontrolled human activities, such as pollution, deforestation, and the burning of fossil fuels, are changing the environment and putting plants and animals at risk of extinction. The damage to the environment can be slowed down in different ways, from thinking carefully about what can be recycled to finding new, greener sources of energy.

## GREENHOUSE EFFECT

Some gases, such as carbon dioxide, make the atmosphere behave like the glass of a greenhouse, trapping solar heat. This process, which keeps Earth at a comfortable temperature, is called the "greenhouse effect."



### GLOBAL WARMING

Burning fossil fuels such as coal and oil releases more greenhouse gases into the atmosphere, making the planet even warmer.

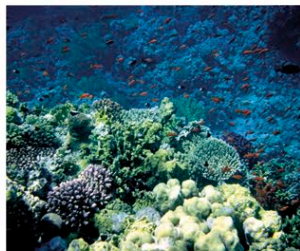
## GLOBAL WARMING

The warming up of the Earth may sound like a good thing at first, but it actually has severe consequences. Even a tiny shift of one or two degrees in temperature can change the balance of the planet and eventually lead to the loss of wildlife habitats, farmland, and even human lives.



### SEA-LEVEL RISES

As the ice in polar regions melts and sea levels rise, coastal land and homes will be lost.



### OCEAN BECOMES MORE ACIDIC

Sea creatures, including coral reefs, are dying as their environment changes.



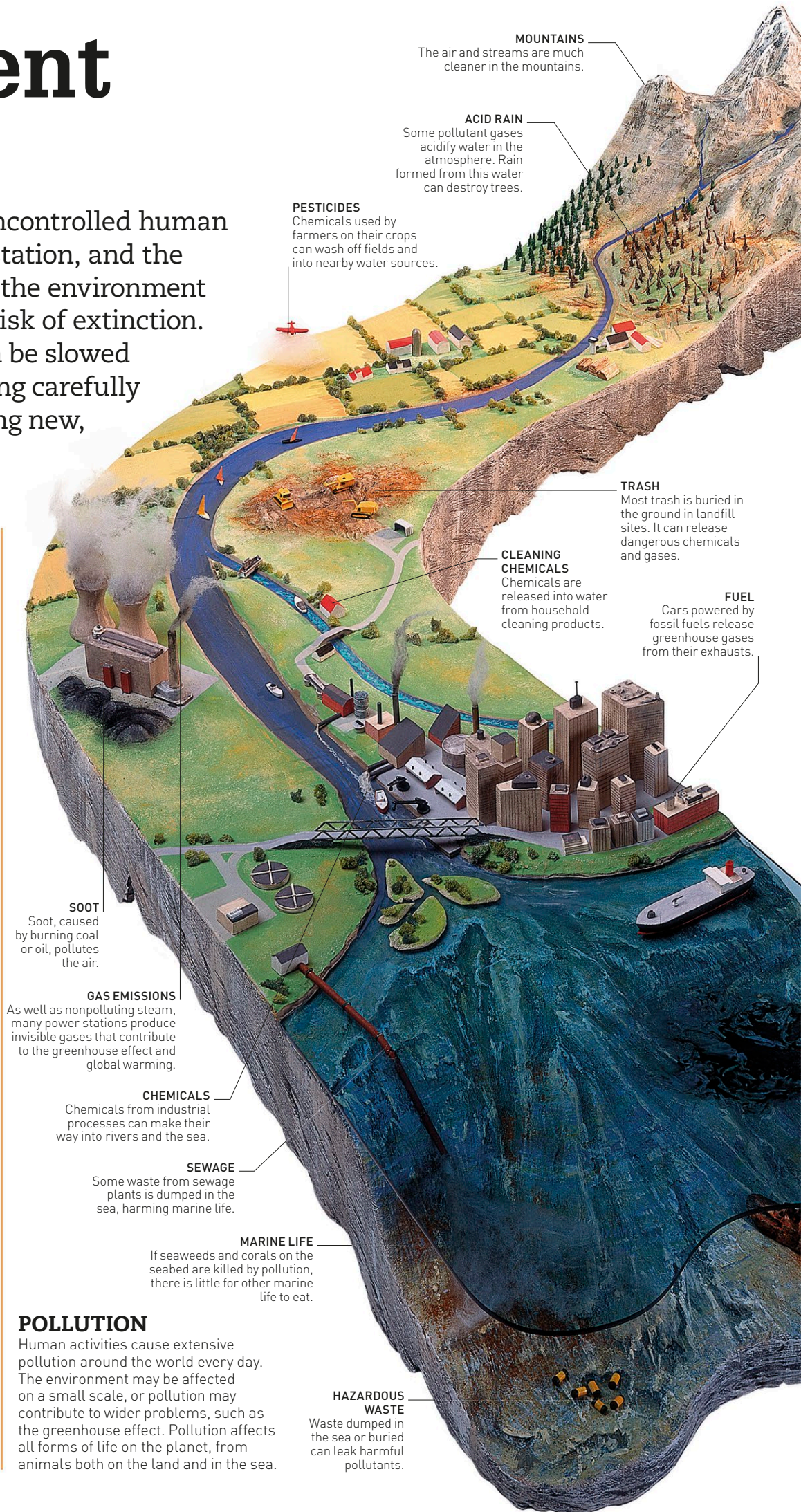
### EXTREME WEATHER

Global warming leads to destructive storms, floods, and droughts.



### DESERTS EXPAND

An increase in global temperature will lead to more desert areas, destroying habitats and farmland.



## POLLUTION

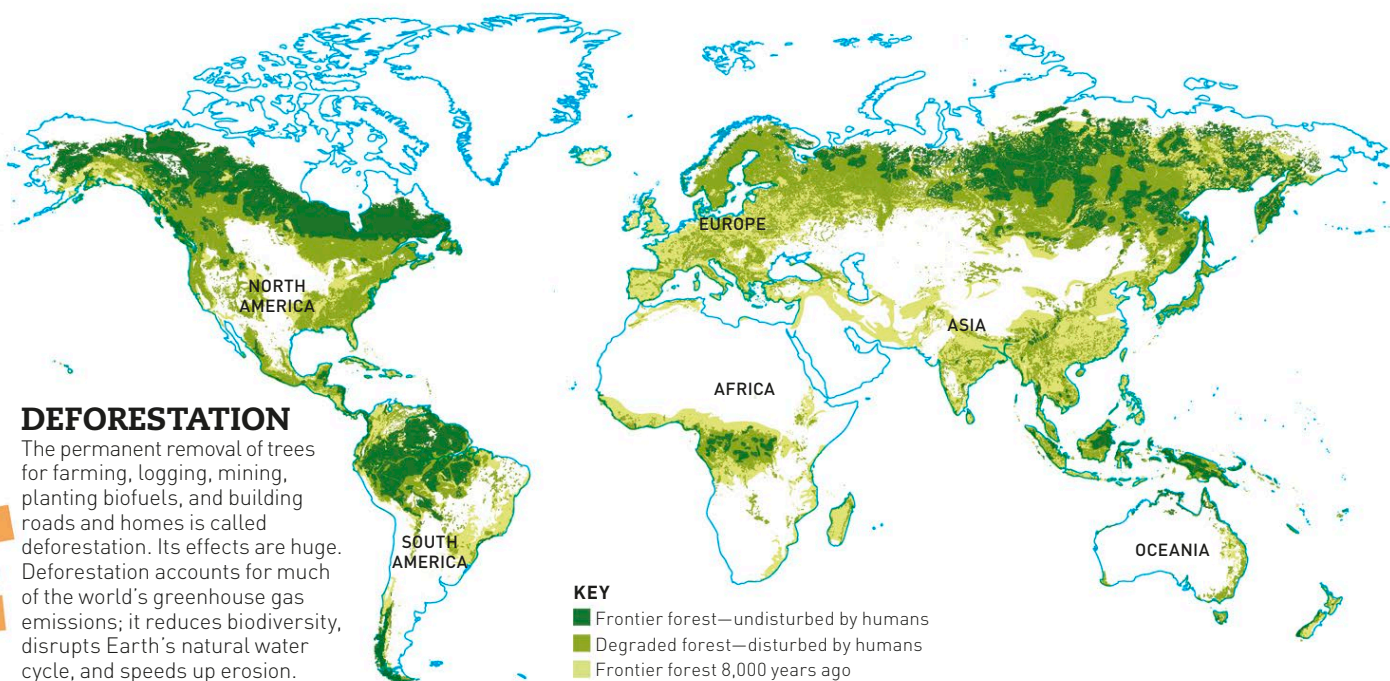
Human activities cause extensive pollution around the world every day. The environment may be affected on a small scale, or pollution may contribute to wider problems, such as the greenhouse effect. Pollution affects all forms of life on the planet, from animals both on the land and in the sea.



**APPROXIMATELY  
64 MILLION ACRES  
OF FOREST AROUND  
THE WORLD ARE  
DESTROYED EVERY YEAR.**

## DEFORESTATION

The permanent removal of trees for farming, logging, mining, planting biofuels, and building roads and homes is called deforestation. Its effects are huge. Deforestation accounts for much of the world's greenhouse gas emissions; it reduces biodiversity, disrupts Earth's natural water cycle, and speeds up erosion.



### KEY

- Frontier forest—undisturbed by humans
- Degraded forest—disturbed by humans
- Frontier forest 8,000 years ago

## ENDANGERED SPECIES

Habitat loss, disease, and hunting cause hundreds, or potentially thousands, of species to become extinct every year.



**PLANTS**  
There are more than 10,000 endangered plant species.



**REPTILES**  
About half of all turtle species are endangered.



**AMPHIBIANS**  
Around 41 percent of amphibians are threatened.



**BIRDS**  
About 14 percent of bird species are vulnerable.



**FISH**  
Millions of sharks are killed for their fins each year.



**MAMMALS**  
Around 25 percent of mammal species are threatened.

## EVERYDAY CONSUMERS

There are many things people use every day that can have a big impact on the environment. Using no plastic bags in a store might seem small, but if other people around the world do this also, the effects on the planet can be huge.



**COTTON**  
Cotton is treated with pesticides and harmful chemicals.



**BATTERIES**  
Batteries can release dangerous chemicals if they are not disposed of safely.



**PLASTIC BAGS**  
Millions of marine animals die each year from swallowing plastic bags.



**GADGETS**  
Fifty five million tons of electrical waste are thrown out every year.



**THE INTERNET**  
The Internet produces more than 1.1 billion tons of carbon dioxide each year.



**MEAT**  
More than 14 percent of all greenhouse gas emissions comes from producing meat.



**CHOCOLATE**  
About 6,604 gallons (25,000 liters) of water is needed to make just 2.2 lb (1 kg) of chocolate.



**WATER BOTTLES**  
More than 50 billion plastic water bottles are used each year in the US.

**OIL**  
Spills from tankers and oil rigs are life-threatening to sea creatures.



## RECYCLING

Materials like plastic and glass can take hundreds or thousands of years to break down in a landfill site. Recycling these items can save resources and energy while also being healthier for the environment.



**PLASTIC**  
Plastic can be recycled into park benches, drain pipes, or even fleece jackets.



**GLASS**  
Recycling 1.1 ton of glass releases 695 lb (315 kg) less carbon dioxide than the production of new glass.



**PAPER**  
Recycling paper uses 70 percent less energy than producing it from raw materials.



**ALUMINUM**  
Recycling aluminum uses just 5 percent of the energy needed to make new aluminum.

## RENEWABLE ENERGY

While nuclear power meets 10 percent of the world's energy needs, fossil fuels are still the major source of energy today. However, they have serious environmental impacts and will become scarce. Other sources of cleaner, renewable energy can be used instead.



**WIND**  
Wind can power turbines that convert the wind energy into electricity.



**SOLAR**  
Energy from the Sun is caught by solar panels and turned into electricity.



**TIDAL**  
As tides rise and fall, they move turbines that convert the movement into energy.



**HYDROELECTRIC**  
When water is channeled through a dam, turbines are turned, which creates energy.



**GEOHERMAL**  
Cool water is pumped underground through pipes to absorb Earth's heat.

**SHIPWRECK**  
Sunken ships on the seabed can release harmful material from their cargo.

## WAYS TO HELP THE PLANET

There are things we can all do to help reduce our impact on the planet. If everyone takes a few small steps, it can have a greatly positive effect overall.

- SWITCH OFF**  
Save electricity by turning off lights and computers when they are not in use.
- TRAVEL SMART**  
Try to walk, cycle, or use public transportation instead of cars.
- SAVE WATER**  
Ban baths, take shorter showers, and turn off the tap when brushing teeth.
- AVOID WASTE**  
Buy products with less packaging so it is not wasted. Avoid single-use plastic bottles.
- RECYCLE**  
Many things can be recycled, including paper, glass, and plastic.
- REUSE WASTE**  
Create compost from food waste.
- DON'T LITTER**  
Littering harms animals, and litter can end up in the ocean, where it stays for a very long time.
- PLANT A TREE**  
Trees and plants absorb carbon dioxide, a greenhouse gas.
- WATCH WHAT YOU EAT**  
Buy local and seasonal food. Eat less meat.
- SPREAD THE WORD**  
Encourage your friends and family to help the environment.

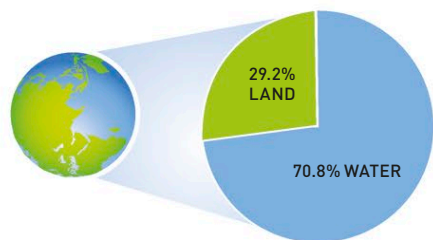


# Our physical world

Most of Earth's surface is covered in water. The rest is occupied by seven vast landmasses, called continents: Europe, Africa, North America, South America, Asia, Oceania, and Antarctica. The average height of continental land is 2,625 ft (800 m) above sea level, while the average depth of the oceans is 12,139 ft (3,700 m) below sea level.

## SURFACE AREA

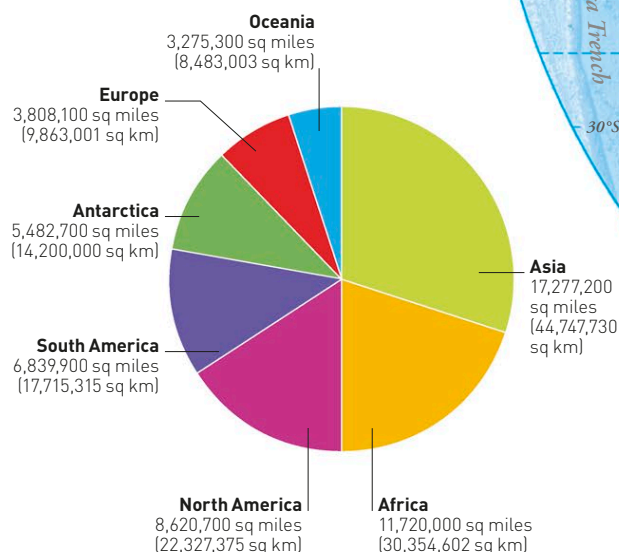
The entire surface of Earth is 510,066,000 sq km (196,937,000 sq miles). Water makes up more than 70 percent of the surface area, most of which is saltwater in the oceans.



**EARTH'S CIRCUMFERENCE AROUND THE EQUATOR IS 24,901 MILES (40,075 KM).**

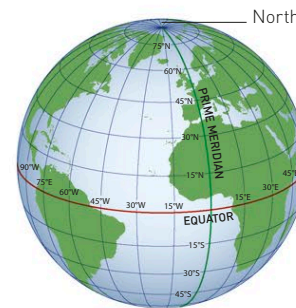
## CONTINENT SIZES

Tens of millions of years ago, all land on Earth was joined together in one huge continent called Pangea. Over time, this broke apart, and the continents we know today gradually moved to their present locations. The tectonic motion of plates in the crust slowly changes the size of the oceans and position of the continents.

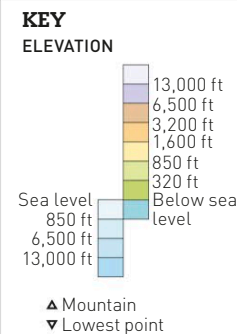


## LATITUDE AND LONGITUDE

The equator is an imaginary line that divides Earth into northern and southern hemispheres. Latitude shows how far north or south a location is in relation to the equator. Longitude gives the east/west position from the prime meridian, which runs between the North and South Poles through London, UK.



**COORDINATES**  
Combining latitude and longitude gives every location a coordinate. New York City, for example, is 40.7° N, 74° W.





EXTREME PLACES

The tilt of Earth's axis and its orbit of the Sun means that some places are much hotter and drier than others. The place with the hottest average temperature on Earth is Dallol in Ethiopia, at 93.9°F [34.4°C]. The place with the coldest average temperature, measuring -72.9°F [-58.3°C], is the highest point on the East Antarctic Ice Sheet, called Dome A. Mawsynram in India is the wettest place in the world, with an average annual rainfall of 467 in (1,187 cm). The driest place is the Dry Valleys in Antarctica, which receive no rain, snow, or hail.



DRIEST PLACE: DRY VALLEYS, ANTARCTICA



WETTEST PLACE: MAWSYNRAM, INDIA



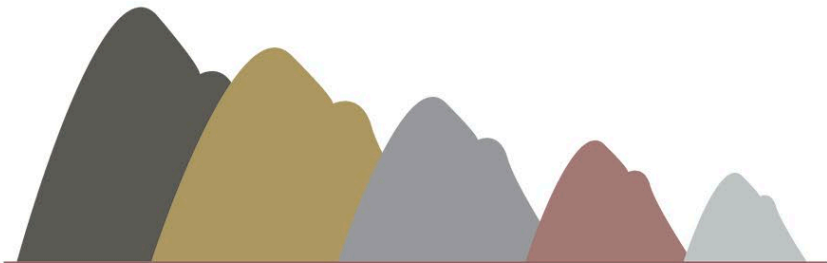
HOTTEST PLACE: DALLOL, ETHIOPIA



COLDEST PLACE: DOME A, ANTARCTICA

TALLEST MOUNTAINS

Slow but gigantic movements in Earth's crust form mountains. The tallest mountain range is the Himalayas in Asia, which contains the 10 highest mountains in the world. The longest mountain range is the Andes in South America, stretching for some 4,500 miles (7,200 km).



MT. EVEREST	K2	KANGCHENJUNGA	LHOTSE 1	MAKALU 1
29,029 ft (8,848 m)	28,251 ft (8,611 m)	28,169 ft (8,586 m)	27,940 ft (8,516 m)	27,766 ft (8,462 m)

TOP FIVE TALLEST MOUNTAINS (ABOVE SEA LEVEL)



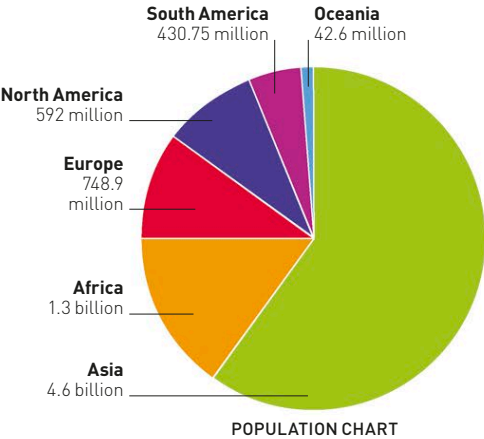


# Our political world

There are 196 independent countries in the world today, all differing from each other in size, shape, population, language, government, and culture. The size of a country, its boundaries, and its natural resources (such as oil and gas) are just some elements that affect both its internal organization and its relationship with other countries.

## POPULATION

There are more than 7 billion people in the world today. United Nations' estimates of what the population will be in 2050 range from about 9.4 to 10.1 billion. Some areas of the world are more populated than others because of their climate, terrain, and natural and economic resources. Over half the world's population live in cities, most in Asia, as a result of mass migration from rural areas in search of jobs. Antarctica has the lowest population density among all continents, with just a few thousand scientists and technicians scattered across its vast landscape.



## MEGACITIES

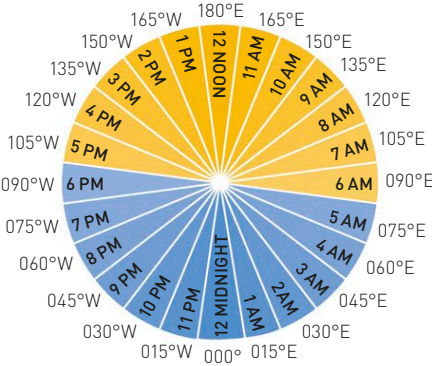
A megacity is an urban area with more than 10 million inhabitants. Three of the top five megacities by population are in Asia.

- |   |  |   |
|---|--|---|
| 1 | <b>TOKYO</b><br>Japan: 37,393,000        |  |
| 2 | <b>NEW DELHI</b><br>India: 30,291,000    |  |
| 3 | <b>SHANGHAI</b><br>China: 27,058,000     |  |
| 4 | <b>SÃO PAULO</b><br>Brazil: 22,043,000   |  |
| 5 | <b>MEXICO CITY</b><br>Mexico: 21,782,000 |  |

## TIME ZONES

The world is divided into more than 24 time zones by imaginary north-south lines called longitudes. From the prime meridian (0° longitude), which runs through Greenwich, London, for every 15° you move west or east, you generally lose or gain an hour. At the equator, day length (duration of daylight) is about 12 hours year round. Moving away from the equator, the day can lengthen or shorten. Countries on similar latitudes have the same day lengths.

**COUNTING TIME**  
The time zone change is counted at 15° intervals, because Earth rotates 15° each hour.







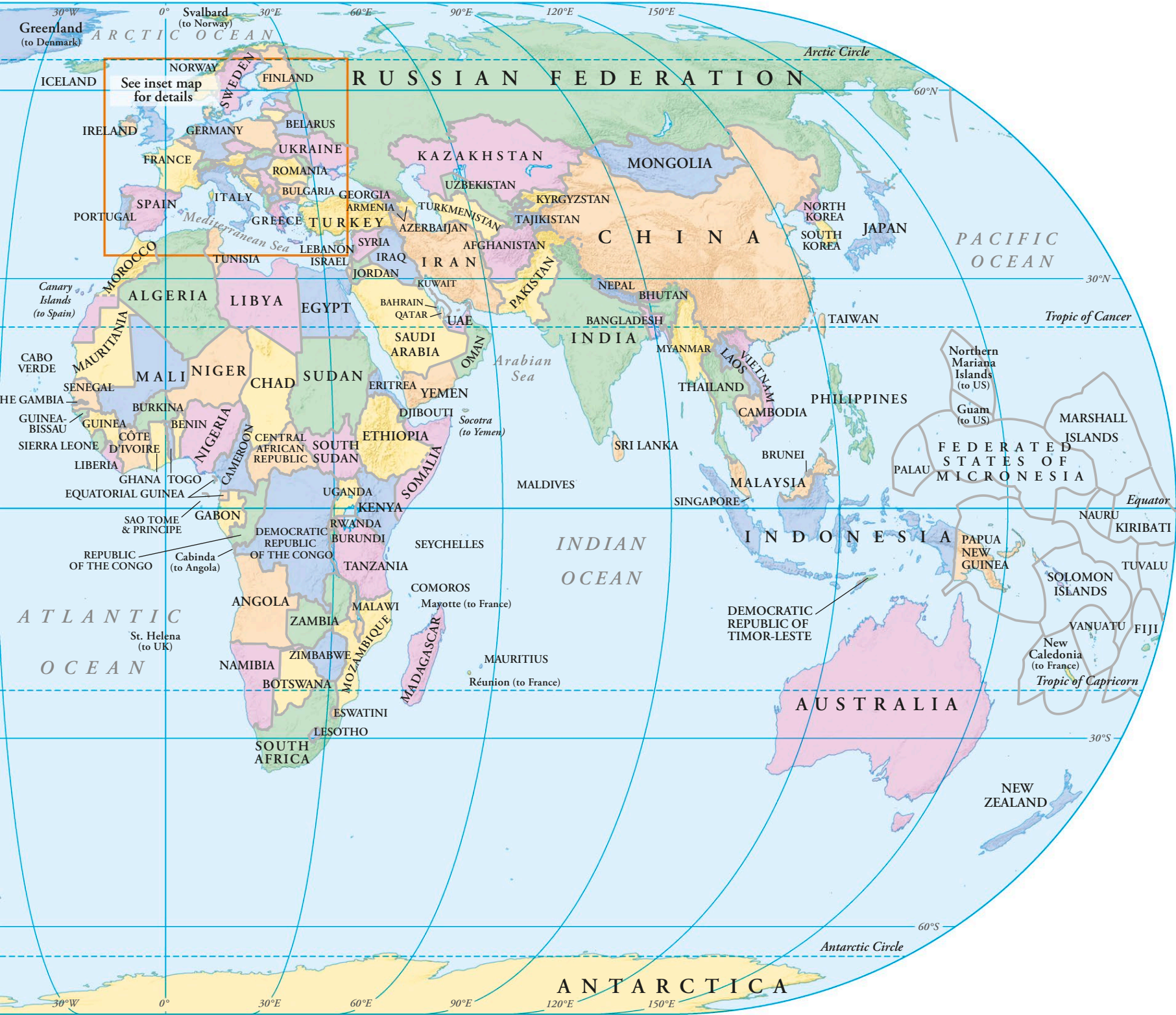
EUROPE

BIGGEST AND SMALLEST COUNTRIES

Covering a vast expanse of land, the Russian Federation is the world's largest country. It has 11 time zones and shares land borders with 14 other countries. Vatican City, the center of the Catholic Church, is located within the Italian city of Rome and is the world's smallest country.

BIGGEST COUNTRIES		
1	RUSSIAN FEDERATION	
2	CANADA	
3	UNITED STATES	
4	CHINA	
5	BRAZIL	

SMALLEST COUNTRIES		
1	VATICAN CITY	
2	MONACO	
3	NAURU	
4	TUVALU	
5	SAN MARINO	







# Asia

The largest of Earth's seven continents, Asia occupies one-third of the world's total landmass. It has tropical regions and climates with a high natural biodiversity of plants and animals, which support high densities of humans. More than 4 billion people live here, and it is home to the world's two most populous countries, China and India.

## PETRA, JORDAN

Once a thriving trading center, this unique city was carved into the pink sandstone rock face more than 2,000 years ago. Rediscovered in 1812, the city is now entered via the Siq, a long, narrow gorge flanked by high cliffs.



**IMMENSE CARVING**  
The "Monastery" at Petra is beautifully carved and so huge that even the doorway is several stories high.

## ANGKOR WAT, CAMBODIA

The temple complex of Angkor Wat is covered with exquisite carvings. Part of a vast city of sacred monuments spread over 155 sq miles (400 sq km), it was constructed between 1113 and 1150. Parts of the complex are now grown over by trees.

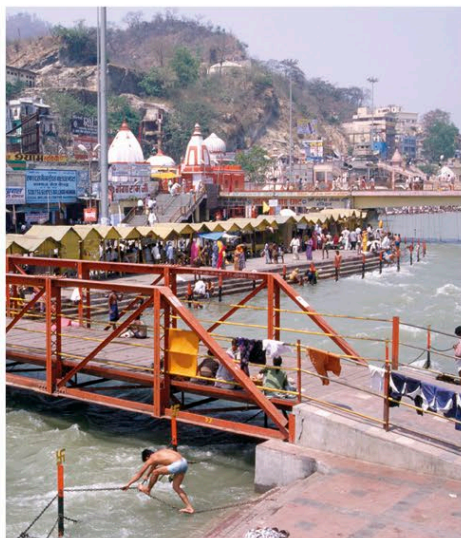


### HINDU COSMOS

The temple is an earthly representation of the Hindu cosmos. Its five towers, shaped like lotus buds, form a pyramidal structure symbolizing the mythical Mount Meru, home of the Hindu gods.

## RIVER GANGES, INDIA

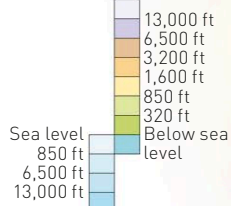
Starting in the Himalayas and finishing at the Bay of Bengal, the River Ganges is worshipped by Hindus as the goddess Ganga. The river is a lifeline for the people who live alongside it, but it has become heavily polluted by human and industrial waste.



### HOLY BATHING

Pilgrims gather to bathe in the River Ganges at Haridwar, the "Gateway to God." It is one of the seven holiest places for Hindus.

### KEY ELEVATION



▲ Mountain  
▼ Lowest point

### POPULATION

- Capital city
- Over 1 million
- 500,000 to 1 million
- 100,000 to 500,000
- below 100,000

## TAJ MAHAL

The Taj Mahal was commissioned by India's Mughal emperor Shah Jahan in 1632 to house the tomb of his beloved wife Mumtaz Mahal.

### MARBLE MONUMENT

Made of white marble, the color of the building appears to change depending on the time of day.



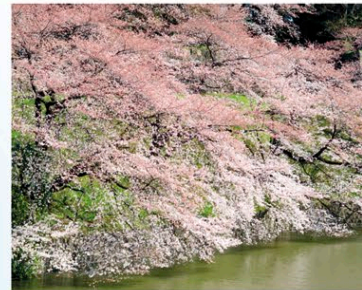
IT TOOK 22 YEARS AND MORE THAN 20,000 CRAFTSPEOPLE AND ARTISANS TO BUILD THE TAJ MAHAL.





## CHERRY BLOSSOM, JAPAN

Spring is celebrated in Japan with the arrival of the cherry blossom, a symbol of hope and renewal. Japanese people get together to marvel at these brilliant, fragrant displays of color. It is thought that the blossoms help us remember that lives should be lived to the fullest.



### BLOSSOMING SOUTH TO NORTH

The cherry blossom season begins in Okinawa in January and moves northward to Kyoto and Tokyo at the end of March.

## THE GREAT WALL OF CHINA

Built to protect against raids from the north, the Great Wall of China is made up of different sections, built by various Chinese dynasties. The longest structure ever built, much of the wall was constructed in the 14th century during the Ming Dynasty.



### BIG BUILD

The wall's two steep flanks were built with stone and fired bricks, and the inside was filled with rubble and mud. Sections were up to 25 ft (7.5 m) wide and stretched for thousands of miles.

## MOUNT EVEREST, NEPAL

At 29,029 ft (8,848 m) high, this is the highest mountain in the world. In 1953, climbers Edmund Hillary from New Zealand and Nepalese Sherpa Tenzing Norgay became the first people to reach the summit of Everest.



### TOUGH CLIMB

To date, more than 5,000 people have climbed Mount Everest. Climbers have to face avalanches, freezing temperatures, storms, altitude sickness, and a lack of oxygen.

### NEW HEIGHTS

With the movement of tectonic plates, Everest continues to increase in height by approximately 0.16 in (4 mm) every year.

## ORANGUTANS, BORNEO

Borneo is one of only two remaining natural habitats for orangutans. An endangered species, they live in the tropical canopy, eating fruit and sleeping in nests made of branches.



**SWING TIME**  
Orangutans have long arms and a strong grip.

## FAST FACTS

More than half the world's population lives in Asia. The biggest cities are also found here.

- **AREA:**  
17,277,200 sq miles (44,747,730 sq km)
- **POPULATION:**  
4.6 billion
- **NUMBER OF COUNTRIES:**  
48
- **LARGEST COUNTRY BY AREA:**  
Russian Federation 5,072,700 sq miles (13,138,242 sq km)
- **LARGEST COUNTRY BY POPULATION:**  
China 1,394,015,977
- **LARGEST CITY BY POPULATION:**  
Tokyo, Japan 37,393,000
- **HIGHEST POINT:**  
Mount Everest 29,029 ft (8,848 m)
- **LOWEST POINT:**  
Dead Sea, Israel -1,414 ft (-431 m)
- **LONGEST RIVER:**  
Yangtze, China 3,964 miles (6,378 km)



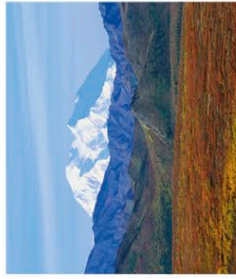


# North America

The third-largest continent stretches from the polar regions to the tropics and has a diverse range of climate and vegetation zones. To its north is the world's largest island, Greenland, while tropical rainforests in the Caribbean and Central America lie to the southeast.

## DENALI NATIONAL PARK

This national park in Alaska is 7,408 sq miles (19,187 sq km) of tranquil wilderness with taiga forest, alpine tundra, and more snowy mountains. Grizzly and black bears roam, and more than 100 bird species call the park home for the summer.



**DENALI**

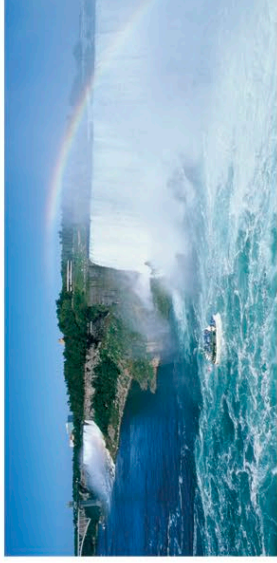
Situated near the Pacific Ocean and the Arctic Circle, Denali, formerly Mount McKinley, has some of the harshest weather conditions in the world.



**GRIZZLY BEAR**

## NIAGARA FALLS

Three waterfalls on the border of the United States and Canada are known as the Niagara Falls. They are renowned for their majestic beauty, and millions of people visit them every year. The combined force of their power is also a valuable source of hydroelectricity.

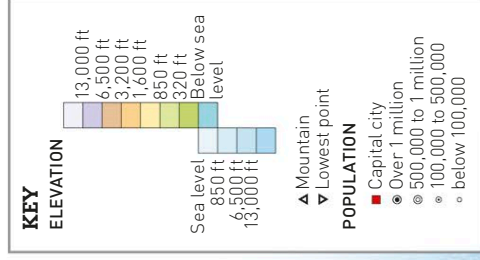


**FANTASTIC FALLS**  
Around 150,000 gallons (567,811 liters) of water flow over Niagara Falls every second.

## FAST FACTS

North America is bordered by three oceans: the Arctic, Pacific, and Atlantic. There are cities all along the coast and inland.

- **AREA:** 8,620,700 sq miles (22,327,375 sq km)
- **POPULATION:** 592 million
- **NUMBER OF COUNTRIES:** 23
- **LARGEST COUNTRY:** Canada 3,854,082 sq miles (9,984,670 sq km)
- **LARGEST COUNTRY BY POPULATION:** US c.329,579,700
- **LARGEST CITY BY POPULATION:** Mexico City, Mexico 21,782,000
- **HIGHEST POINT:** Denali, Alaska 20,320 ft (6,194 m)
- **LONGEST RIVER:** Mississippi-Missouri 3,710 miles (5,970 km)
- **LARGEST LAKE:** Lake Superior, Canada, US 31,700 sq miles (82,100 sq km)





## YELLOWSTONE

This US national park is best known for its collection of thermal features, including more than 500 geysers, and the active supervolcano the Yellowstone Caldera. It is also home to grizzly bears, bison, and elk.

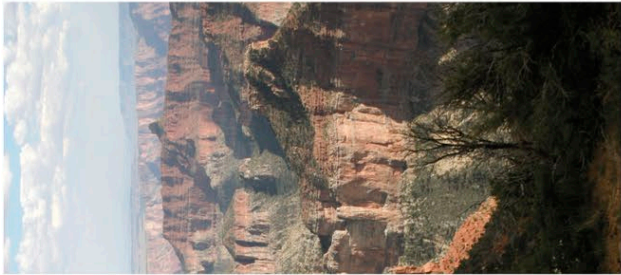


### LIKE CLOCKWORK

Old Faithful ejects hot water and steam every 35 to 120 minutes for 1.5 to 5 minutes at a time. It is the park's biggest regular geyser.

## GRAND CANYON

Carved by the Colorado River, the immense and dramatic Grand Canyon is 277 miles (446 km) long, up to 18 miles (29 km) wide, and 1 mile (1.6 km) deep.

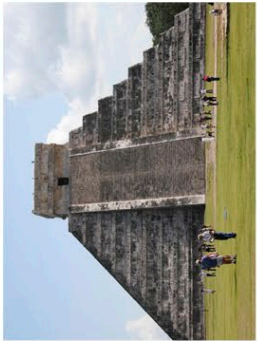


### NATURAL WONDER

Erosion has exposed many colorful rock layers, creating an inspirational landscape.

## CHICHÉN ITZÁ

The Native American Maya people built temples and monumental cities, such as Chichén Itzá, in the jungles of the Yucatán Peninsula in Mexico from c.200 ce.

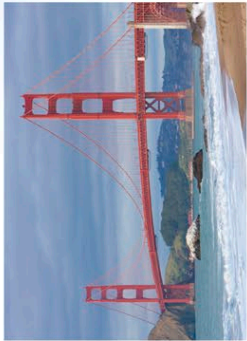


**EL CASTILLO**  
This pyramid temple stands in the center of Chichén Itzá.

**THE MAYA'S ASTRONOMICAL SKILLS WERE SO ADVANCED, THEY COULD EVEN PREDICT SOLAR ECLIPSES.**

## GOLDEN GATE

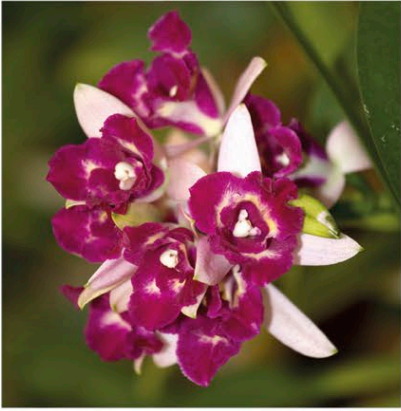
One of the top construction achievements of the 20th century, the Golden Gate Bridge in San Francisco opened in 1937. It is 1.7 miles (2.7 km) long and took four years to build.



**SUPER SUSPENSION**  
The Golden Gate Bridge is a suspension bridge with cables between towers to carry its weight.

## COSTA RICA RAINFOREST

In the Costa Rica rainforest in Central America, tall trees covered with orchids, vines, ferns, and moss rise into the sky. The rainforest teems with life and is home to many exotic animal and plant species.



**ORCHIDS**  
The Costa Rica rainforest supports a huge collection of orchids. There are more species here than anywhere else on Earth.



**TREE FROG**  
The red-eyed tree frog is one of 133 species of frogs and toads that are found in Costa Rica.



**BUTTERFLIES**  
The country has an assortment of butterflies, including this beautifully colored Metalmark butterfly.



**IN THE PINK**  
Flamingos turn pink from the color pigments in the algae and shrimp they eat.



**AMERICAN CROCODILE**

**WILDLIFE WATCHING**  
Alligators, turtles, and egrets are just some of the wildlife that can be seen.

## FLORIDA EVERGLADES

The Everglades are a vast area of semitropical wetland in the US, home to mangrove, mahogany, bay, and eucalyptus trees. The swampy conditions are perfect for alligators and crocodiles.







# South America

Most of this continent lies south of the equator, with vegetation and climate zones stretching down to the polar region. The continent became isolated from other landmasses over 200 million years ago, leading to the evolution of unique species of plants and animals.

## GALÁPAGOS ISLANDS

The 19 islands of the Galápagos were formed by volcanoes on the ocean floor. They are now strictly controlled to protect the many animal and bird species that live on them.



### GIANT TORTOISE

The Galápagos tortoise can weigh as much as 595 lb (270 kg) and grows up to 4 ft (1.2 m) in length.



### FRIGATEBIRD

Male frigatebirds have impressive red throat pouches, which they inflate to attract females.



### LAND IGUANA

The Galápagos land iguana may look ferocious, but it is actually a herbivore.

## ANGEL FALLS

Angel Falls is the world's highest uninterrupted waterfall at 3,212 ft (979 m). The falls lie on the Gauja River, in the Canaima National Park in Venezuela. The indigenous name for the falls is *Kerepakupai Vená*, which means "waterfalls of the deepest place."



### BEAUTY SPOT

Angel Falls is one of Venezuela's top tourist attractions.

## FAST FACTS

Most of the population of South America live around the coast. The wild inland areas are sparsely populated.

### AREA:

6,839,900 sq miles (17,715,315 sq km)

### POPULATION:

430.75 million

### NUMBER OF COUNTRIES:

12 independent countries  
3 dependent territories

### LARGEST COUNTRY:

Brazil (3,286,500 sq miles [8,511,965 sq km])

### LARGEST COUNTRY BY POPULATION:

Brazil (211,715,973)

### LARGEST CITY BY POPULATION:

São Paulo, Brazil (22,043,000)

### HIGHEST POINT:

Cerro Aconcagua, Andes Mountains, Argentina (22,833 ft [6,959 m])

### LONGEST RIVER:

Amazon (4,005 miles [6,450 km])

### LARGEST LAKE:

Lake Titicaca, Bolivia/Peru (3,220 sq miles [8,340 sq km])





## LAKE TITICACA

Situated between Peru and Bolivia, Lake Titicaca is the world's highest navigable lake, lying at a height of 12,507 ft (3,812 m) above sea level.

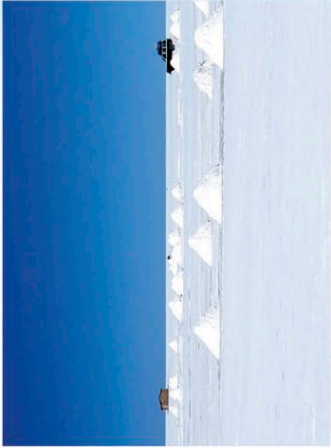


### FLOATING HOMES

The Uros people live on the lake on floating islands made out of reeds.

## SALT PLAINS

The Salar de Uyuni is the world's largest salt pan, an area of ground that is crusty and covered in salt and minerals. It is located in the Altiplano plateau in Bolivia.



### BATTERY POWER

As well as providing salt, the Salar de Uyuni is also the source of more than 50 percent of the world's lithium, which is used to power batteries and other devices.

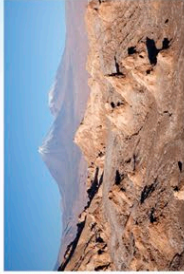
## THE ANDES MOUNTAINS

Running through seven countries in South America for some 4,500 miles (7,200 km), the Andes form the longest continental mountain range in the world. They contain the world's highest and most dangerous volcanoes.



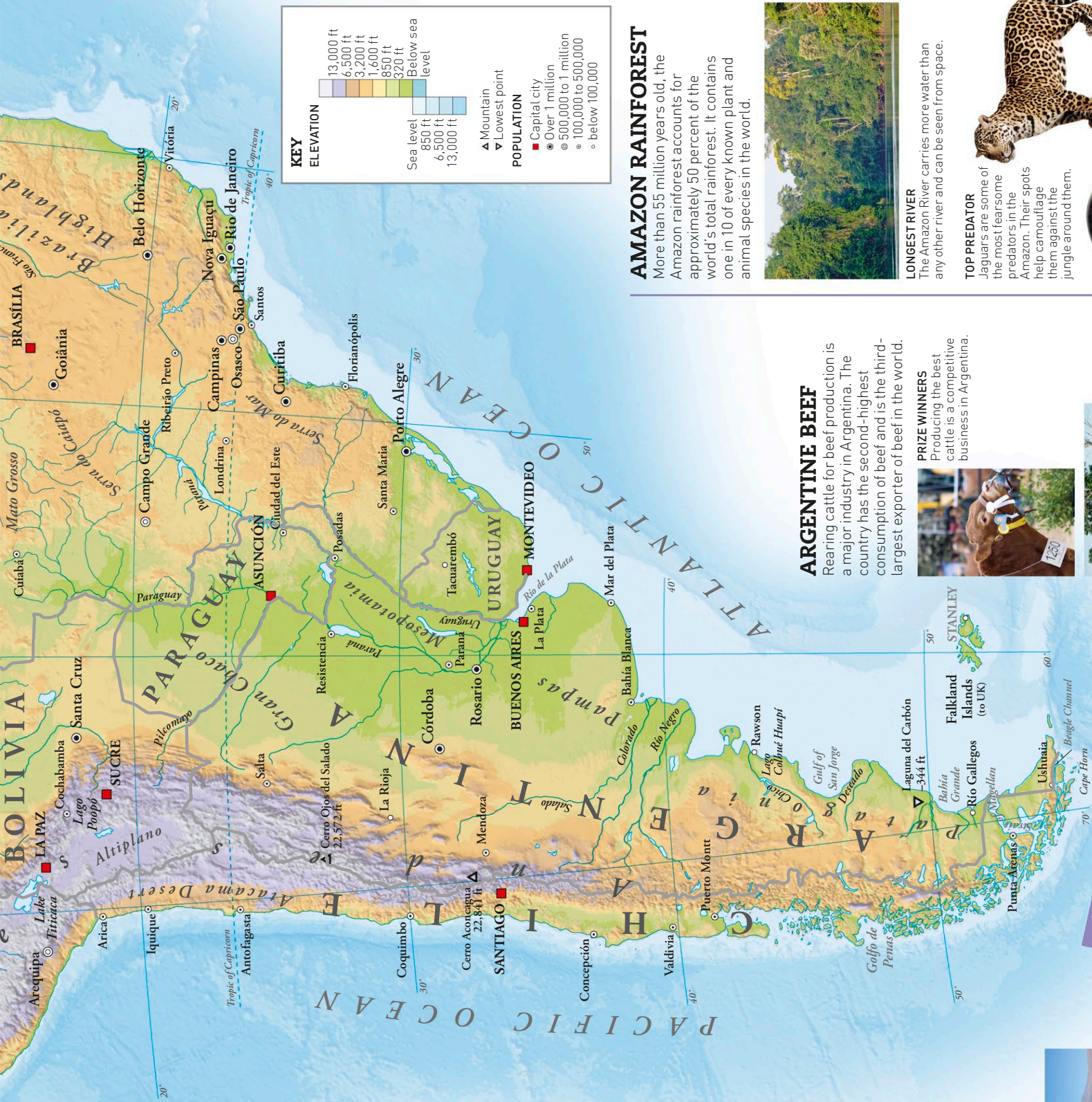
### WOOLLY WONDERS

There are many herds of alpacas in the Andes. They are bred for their wool, which is made into blankets, sweaters, and other clothes.

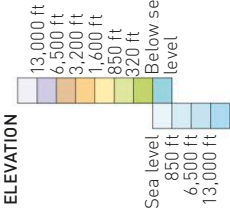


### DRY LAND

The Atacama Desert lies in a plateau west of the Andes and is the driest nonpolar desert in the world.



### KEY

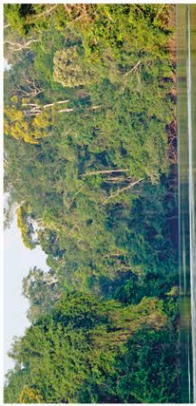


### POPULATION



## AMAZON RAINFOREST

More than 55 million years old, the Amazon rainforest accounts for approximately 50 percent of the world's total rainforest. It contains one in 10 of every known plant and animal species in the world.



### LONGEST RIVER

The Amazon River carries more water than any other river and can be seen from space.

### TOP PREDATOR

Jaguars are some of the most fearsome predators in the Amazon. Their spots help camouflage them against the jungle around them.



### ENORMOUS SNAKE

Anacondas keep growing their whole lives. They can reach lengths of up to 21 ft (6.5 m).



## ARGENTINE BEEF

Rearing cattle for beef production is a major industry in Argentina. The country has the second-highest consumption of beef and is the third-largest exporter of beef in the world.



### PRIZE WINNERS

Producing the best cattle is a competitive business in Argentina.



### GAUCHOS

In Argentina, cattle herders, or gauchos, live on the Pampas grasslands and look after the herds of cattle.

HUMANS FIRST  
SPREAD TO SOUTH  
AMERICA MORE THAN  
13,000 YEARS AGO.





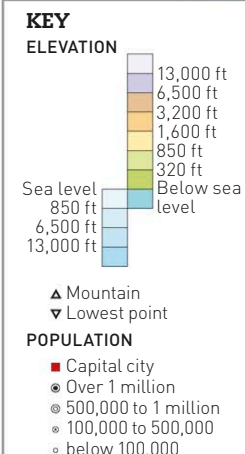
# Europe

The continent of Europe is rich in cultural diversity, with a history of wealth, industry, and empire building. There are 23 official languages spoken across the 46 European countries.

## FAST FACTS

Europe is the second smallest continent. It contains the world's smallest country, Vatican City, with a population of only 800.

- **AREA:**  
3,808,100 sq miles  
(9,863,001 sq km)
- **POPULATION:**  
748.9 million
- **NUMBER OF COUNTRIES:**  
46
- **LARGEST COUNTRY BY AREA:**  
Russian Federation 1,528,560 sq miles (3,960,000 sq km)
- **LARGEST COUNTRY BY POPULATION:**  
Russian Federation 110,000,000
- **LARGEST CITY BY POPULATION:**  
Istanbul, Turkey 15.190 million
- **HIGHEST POINT:**  
Mount El'brus, Russian Federation  
18,510 ft (5,642 m)
- **LONGEST RIVER:**  
Volga, Russian Federation  
2,293 miles (3,690 km)
- **LARGEST LAKE:**  
Lake Ladoga, Russian Federation  
7,100 sq miles (18,390 sq km)

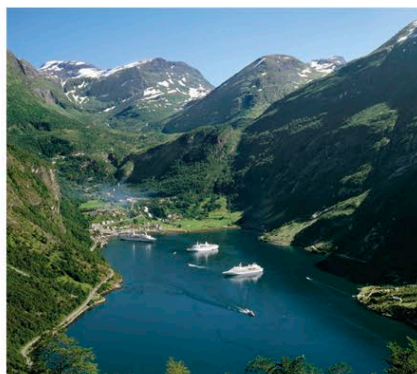






## NORWAY'S FJORDS

Norway has the world's highest concentration of fjords. These steep-sided valleys were carved out by glaciers during the last Ice Age. When the glaciers retreated, seawater flooded the valleys.



**DRAMATIC VIEW**  
Norway's fjords offer views of snow-capped mountains, ancient glaciers, and remote fishing villages.

## THE ALPS

The highest mountain range entirely within Europe is 750 miles (1,200 km) long. The Alps formed millions of years ago, when two tectonic plates collided. Mont Blanc, on the French-Italian border, is the Alps' highest mountain at 15,781 ft (4,810 m).



**ALPINE FUN**  
The Alps are a popular winter destination for skiing, with lots of ski slopes and resorts.

## RIVER DANUBE

The River Danube is the second longest river in Europe. It starts in the Black Forest mountains of Germany and flows 1,770 miles (2,850 km) to the Black Sea, passing through 10 countries on the way.



**RIVERSIDE CITIES**  
The Danube flows through four capital cities: Vienna, Bratislava, Budapest (shown here), and Belgrade.



**GREAT WHITE PELICAN**  
Over 50 percent of Eurasian great white pelicans live in the Danube delta.

## EIFFEL TOWER, FRANCE

The Eiffel Tower was built as part of the 1889 World Fair to celebrate 100 years since the French Revolution. An engineering achievement, it has become a cultural icon of Paris and France. It is 1,063 ft (324 m) high.



**RECORD-HOLDER**  
The tower was the world's tallest human-made structure for 41 years until the Chrysler Building in New York City was built in 1930.

## ROME, ITALY

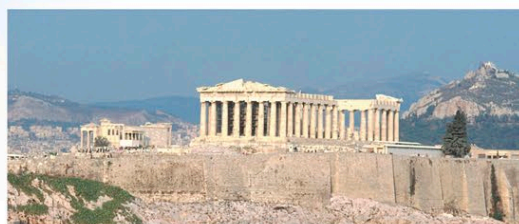
Once the center of the vast Roman Empire, Rome is one of Europe's most historical cities. With classical ruins, Renaissance buildings, and Baroque sculptures, the city is a showcase for many amazing engineering and artistic achievements.



**DRAMATIC SETTING**  
The Colosseum was built as an arena for all kinds of Roman entertainment: combats between gladiators, reenactments of battles, and even executions.

## THE ACROPOLIS, GREECE

The ancient ruins of the Acropolis sit above the city of Athens and are visited by millions of people each year. The Acropolis is said to symbolize the greatest achievements of the ancient Greeks.



**TEMPLE TO ATHENA**  
The Parthenon—one of the Acropolis's most famous buildings—was a temple built to honor Athena, the goddess of wisdom and knowledge. It once contained a huge statue of her.

## THE MEDITERRANEAN

This sea separates Europe from Africa. It has been a focal point for empires and civilizations, which is reflected in the diverse cultures of the people living in this coastal region. The region also has active geological faults and some volcanoes, which have produced many destructive earthquakes and eruptions.



**BEACH LIFE**  
With hot, dry summers and calm, blue sparkling sea, the Mediterranean region is a hugely popular tourist destination.





# Africa

The world's second largest continent, Africa is rich in history, language, culture, and geographic diversity. With a stunning collection of animals, reptiles, birds, and insects, it is also where human beings first evolved.

## PYRAMIDS AT GIZA

During the 4th Dynasty (2613–2494 BCE), Giza became a royal burial ground for the ancient Egyptians. Three pyramid complexes serve as tombs for their dead kings. The Sphinx was added to guard the pyramids, and each king's royal family and courts were buried nearby.



**THE SPHINX**  
The Sphinx is modeled on a mythical creature with the head of a human and the body of a lion.



**BUILDING BLOCKS**  
More than two million blocks of stone were used to build the Great Pyramid at Giza. It is 451 ft (137.5 m) high, and the largest building in history.

## SAHARA DESERT

The Sahara covers much of North Africa and is the world's largest hot desert. Constantly shaped by the wind, around 25 percent of the desert is sand dunes. The rest is made up of a barren, rocky landscape with very little water. The highest peak is Emi Koussi (11,294 ft/3,145 m) in the Tibesti Mountains.



**CAMELS IN THE SAHARA**  
Camels' feet allow them to move quickly and easily through sand. Camels can last up to 17 days without food or water.

## FAST FACTS

Africa makes up around 20 percent of Earth's land mass. It contains the world's longest river—the Nile.

- **AREA:** 11,720,000 sq miles (30,354,602 sq km)
- **POPULATION:** 1.3 billion
- **NUMBER OF COUNTRIES:** 54
- **LARGEST COUNTRY:** Algeria 919,595 sq miles (2,381,740 sq km)
- **LARGEST COUNTRY BY POPULATION:** Nigeria 214,028,302
- **LARGEST CITY BY POPULATION:** Lagos, Nigeria 14.368 million
- **HIGHEST POINT:** Mount Kilimanjaro, Tanzania 19,336 ft (5,895 m)
- **LONGEST RIVER:** Nile River 4,160 miles (6,695 km)
- **LARGEST LAKE:** Lake Victoria, Uganda, Kenya, Tanzania 26,595 sq miles (68,880 sq km)





## MAASAI MARA

Between July and October, wildebeest migrate from Tanzania's Serengeti to the Maasai Mara nature reserve in Kenya. They are hunted by lions, cheetahs, leopards, and hyenas. The plains are also full of zebras, impalas, giraffes, hippos, and gazelles. Many tourists visit to view the wildlife.



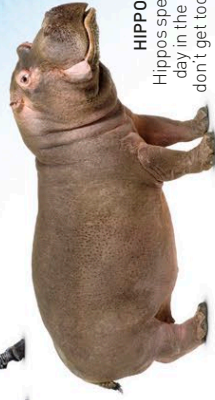
### ZEBRA

No two zebras have the same pattern of stripes.



### WILDEBEEST

A type of antelope, wildebeest keep together in huge herds. They eat constantly.



### HIPPOPOTAMUS

Hippos spend most of the day in the water, so they don't get too hot in the Sun.

## OKAVANGO DELTA

Starting in the mountains of Angola, the Okavango River flows into the Kalahari Desert, forming a great inland wetland that is home to a variety of wildlife. Seasonal flooding swells the size of the delta, attracting animals from far away to this oasis. It is a perfect wildlife-viewing destination: herds of antelopes, zebras, buffaloes, elephants, crocodiles, hippopotamuses, lions, and cheetahs all thrive here.

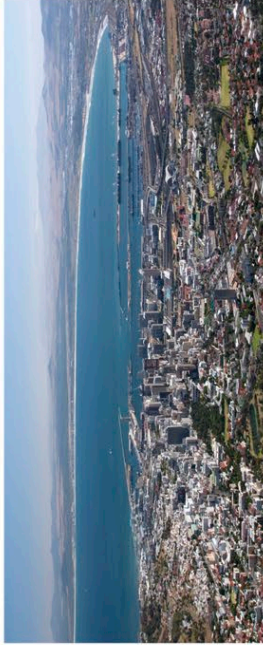


### LIFE SUPPORT

Situated in the region of Botswana that is dry for much of the year, this large inland delta attracts lots of wildlife.

## CAPE TOWN

Founded in 1652 by Dutch settlers, Cape Town is now one of the most popular African cities for tourists to visit. It is famous for its huge harbor. The big, flat-topped Table Mountain overlooks the city.



### ACTIVE HARBOR

Cape Town harbor is one of the busiest ports in South Africa.

## VICTORIA FALLS

Forming the border between Zambia and Zimbabwe, the Zambezi River is transformed into a ferocious torrent as it thunders over a wide, basalt cliff, forming Victoria Falls. Columns of spray can be seen from miles away as the river plummets over the edge into a gorge over 360 ft (108 m) below.

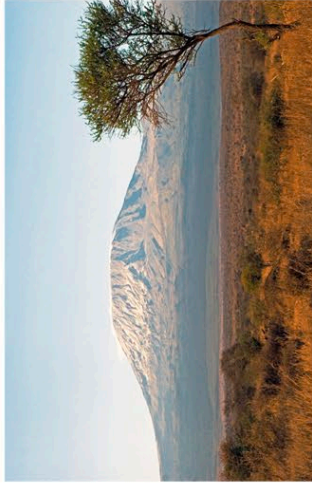


### GIANT FALLS

The combination of its great height and enormous width make Victoria Falls the world's largest sheet of falling water.

## MOUNT KILIMANJARO

The highest peak in Africa and the tallest free-standing mountain in the world, Mount Kilimanjaro rises to 19,336 ft (5,895 m) in Tanzania. It is a dormant volcano with three volcanic cones. Around 50,000 visitors trek up its slopes each year.



### AFRICA'S PEAK

The snow-capped summit of Mount Kilimanjaro is surrounded by dry, flat shrubland. The mountain's snowcap, one of the very few in the tropics, may disappear in the near future, due to rising global temperatures.

## CATTLE HERDERS

Living in Kenya, the Samburu people are traditionally cattle herders and may also keep sheep, goats, and camels. Cattle are highly prized, and ownership determines status and wealth.



### NOMADIC HERDERS

The Samburu often graze their herds far from settlements in order to find water and vegetation.

ABOUT 65 PERCENT OF  
THE WORLD'S  
DIAMONDS COME FROM  
MINERAL-RICH AFRICA.





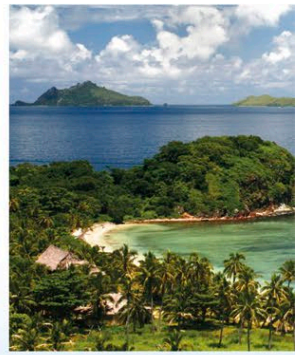


# Oceania

Oceania is the collective name for Australia, New Zealand, and the island groups in the Pacific Ocean, including Melanesia, Micronesia, and Polynesia. Australia dominates the region in size, population, and economic strength.

## PACIFIC ISLANDS

There are more than 20,000 islands in the Pacific Ocean. These palm-covered paradises are either volcanic or part of natural reefs. While they may look similar, they are very diverse in human culture.



**ISLAND PARADISE**  
The Fijian archipelago (group of islands) is made up of more than 330 beautiful islands.

## ABORIGINAL CULTURE

Aboriginal people have been living in Australia for more than 50,000 years. They have a tribal culture of storytelling and art and a strong spiritual belief tying them to the land. Many still live in the Australian outback, where rocks feature their paintings. There were more than 250 Aboriginal languages in Australia at one time, but only 13 are still being taught to children today.



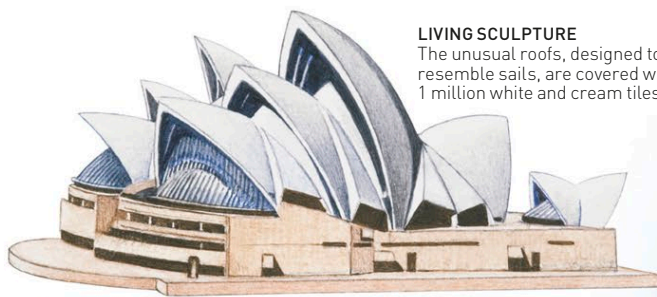
**ROCK ART**  
Some of the oldest Aboriginal paintings are more than 20,000 years old.



**ULURU**  
Particularly sacred to the Anangu Aboriginal people, this massive red monolith dominates the surrounding landscape.

## SYDNEY OPERA HOUSE

The Sydney Opera House is a performing arts center designed by Danish architect Jorn Utzon in 1957 in Sydney, Australia. It opened in 1973, and is visited by more than 10 million people every year.



**LIVING SCULPTURE**  
The unusual roofs, designed to resemble sails, are covered with 1 million white and cream tiles.

## SURFING

Australia is a first-class surfing destination, famous for both the quality and the variety of its waves. The coastline has plenty of beach, reef, and point breaks to challenge the experienced surfer and easy rolling swells for beginners.



**SURF CULTURE**  
With its world-renowned beaches, surfing and beach culture is a popular part of Australian life.

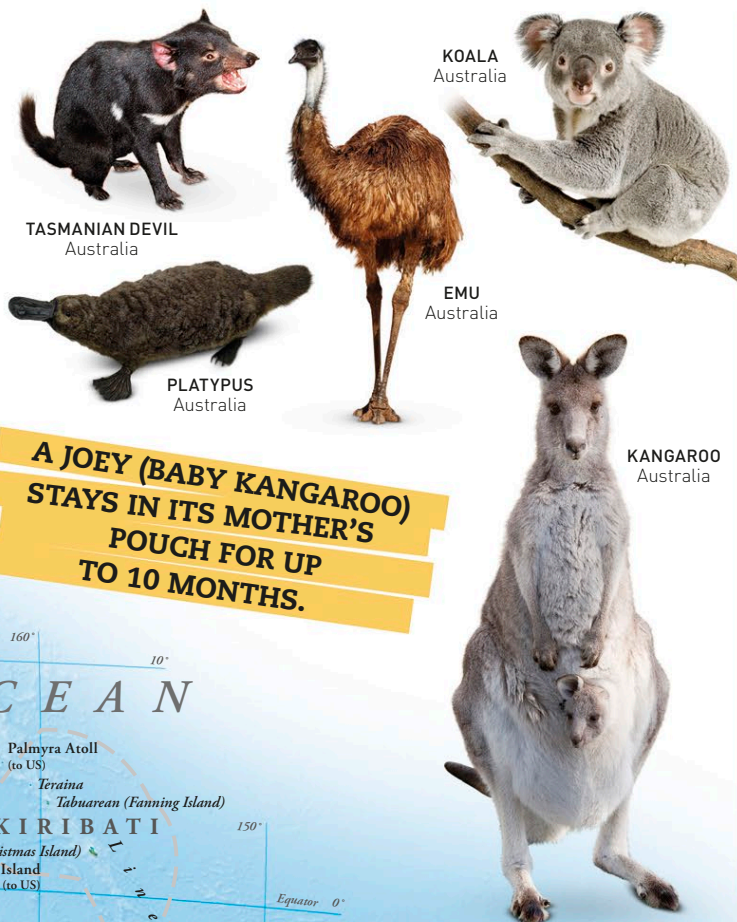






## WILDLIFE

The islands of Oceania are a long way from other landmasses, so they contain a diverse range of animals, many of which are not found anywhere else in the world. Some birds, such as the emu and kiwi, evolved into flightless species due to the lack of predators.



**A JOEY (BABY KANGAROO) STAYS IN ITS MOTHER'S POUCH FOR UP TO 10 MONTHS.**

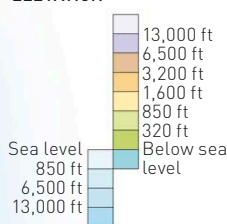


## FAST FACTS

A widespread area, there are 28 languages spoken across Oceania.

- **AREA:**  
3,275,300 sq miles (8,483,003 sq km)
- **POPULATION:**  
42.6 million
- **NUMBER OF COUNTRIES:**  
14
- **LARGEST COUNTRY BY AREA:**  
Australia 2,967,900 sq miles (7,686,850 sq km)
- **LARGEST COUNTRY BY POPULATION:**  
Australia 25,466,459
- **LARGEST CITY BY POPULATION:**  
Melbourne, Australia 4.968 million
- **HIGHEST POINT:**  
Mount Wilhelm, Papua New Guinea 14,795 ft (4,509 m)
- **LONGEST RIVER:**  
Murray-Darling, Australia 1,570 miles (2,520 km)
- **LARGEST LAKE:**  
Lake Eyre, Australia 3,430 sq miles (8,884 sq km)

## KEY



- ▲ Mountain
- ▼ Lowest point
- POPULATION**
- Capital city
- Over 1 million
- 500,000 to 1 million
- 100,000 to 500,000
- below 100,000

## ROTORUA

Rotorua on New Zealand's North Island is famous for its geysers, steam clouds, bubbling mud pools, and soothing hot springs to bathe in. It is an area of great geothermal activity, where Earth's inner heat rises to the surface.



### CHAMPAGNE POOL

Tiny bubbles of carbon dioxide rising from the Earth make this hot spring look like a warm glass of champagne.

## GREAT BARRIER REEF

The world's largest coral reef is in Australia. It is made up of around 3,000 individual reefs and hundreds of islands. It supports lots of marine life, including more than 1,500 species of fish.



### HUGE REEF

The Great Barrier Reef is more than 1,430 miles (2,300 km) long. It is so big that it can be seen from space.





# Antarctica

The world's southernmost continent is covered by a vast ice sheet. This ice holds 80 percent of Earth's fresh water. Beneath it lies a continent of valleys, mountains, and lakes, but only about 2 percent is visible above the ice. The only people in Antarctica are scientists and staff working in research stations and tourists.

## EARLY EXPEDITIONS

By the late 19th century, Antarctica remained the last unexplored continent, and the race was on to reach the most remote spot on Earth—the South Pole. In 1909, Ernest Shackleton got within 111 miles (180 km) of the Pole before having to turn back. It was finally reached by explorers Roald Amundsen and Robert Scott in 1911 and 1912.



SHACKLETON'S HOOD



COMPASS, SCOTT'S EXPEDITION



TELESCOPE, SCOTT'S EXPEDITION



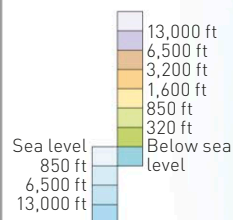
### KEY

- Amundsen's route
- Scott's route
- Ice shelves

### RACE TO THE POLE

The Norwegian Roald Amundsen reached the South Pole on December 15, 1911, beating the Englishman Robert Scott by 33 days.

### KEY ELEVATION



- ▲ Mountain
- ▼ Lowest point
- Research station

## ICY FEATURES

Antarctica is covered in ice. It has a huge mass of glacial ice known as an ice sheet that is nearly 3 miles (5 km) thick in some places. Floating areas of ice called ice shelves form where the ice sheet meets the ocean. The edges of these shelves can break away, forming smaller lumps of floating ice called icebergs.



### COLLAPSE

Impressive crevasses from the glacier of the melting Larsen B ice shelf, which collapsed in 2002.



### ICEBERGS

Immense flat-topped icebergs are formed when blocks of ice break away from the main ice shelf.





**ANTARCTICA IS THE COLDEST, DRIEST, WINDIEST, AND HIGHEST CONTINENT ON EARTH.**

## GETTING AROUND

Working and living in Antarctica is a tough experience, as it is one of the most extreme environments on the planet. Most residents stay on Antarctica for the summer only, from November to March or April.

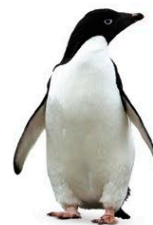


### DRIVING CONDITIONS

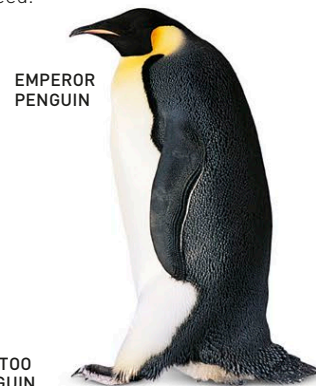
Vehicles built to withstand extreme temperatures over long distances are used in Antarctica.

## WILDLIFE

The Southern Ocean and the seas around Antarctica teem with life. They, rather than the land in Antarctica, support the most wildlife. The continent can be inhospitable to life. It is home to the Emperor and Adélie penguins, and three other types of penguin breed on the northern tip of the Antarctic Peninsula, but return to the marine waters to feed.



ADÉLIE PENGUIN



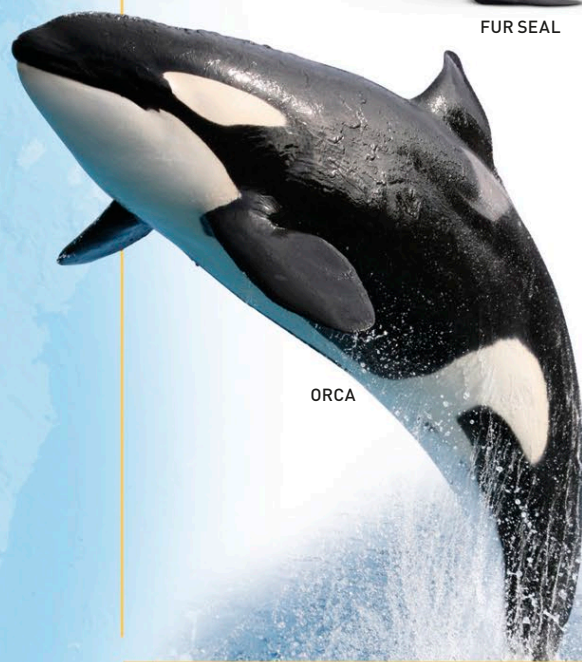
EMPEROR PENGUIN



GENTOO PENGUIN



FUR SEAL



ORCA

## FAST FACTS

No one country owns Antarctica. The international Antarctic Treaty provides agreement for the care and use of the continent.

- **AREA:**  
5,482,700 sq miles (14,200,000 sq km)
- **POPULATION:**  
No permanent residents
- **HIGHEST POINT:**  
Vinson Massif 16,066 ft (4,897 m)
- **LONGEST RIVER:**  
Onyx 25 miles (40 km)
- **LARGEST KNOWN LAKE:**  
Lake Vostok 6,100 sq miles (15,690 sq km)



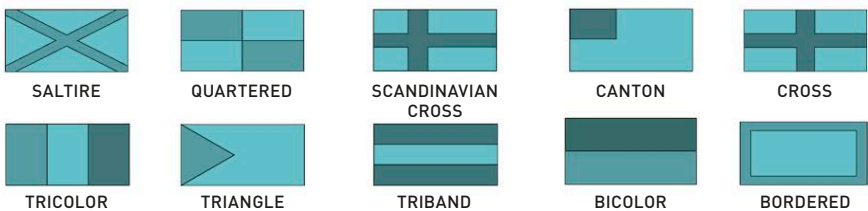


# Flags

Every country in the world has a unique flag. Each nation picks its own patterns and colors, which are usually of historical or political significance. A flag is a powerful symbol. It fosters pride in a country or cause and unites people in times of war and peace.

## TYPES OF FLAGS

Variations on common flag patterns such as stripes and crosses turn up again and again all over the world. Often, the only difference between one flag and another is its color. These are some of the common patterns.



## ANCIENT SYMBOLS

Flags have been displayed since ancient times as symbols of loyalty to a country or person. In battle, a flag rallied the troops. Early flags were made of wood or metal. The oldest preserved cloth flag is of Roman origin.



## NORTH AMERICA



## SOUTH AMERICA



## AFRICA





## THE JOLLY ROGER

The pirate flag known as the "Jolly Roger" was used widely in the 18th century. With its ghoulish designs, it was meant to terrorize a victim into handing over their ship without a fight. The flags belonging to four famous pirates are shown here.



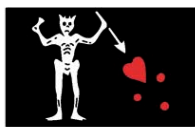
HENRY EVERY



"BLACK SAM"  
BELLAMY



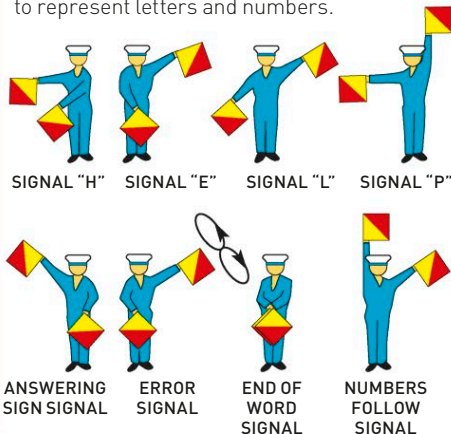
"CALICO JACK"  
RACKHAM



BLACKBEARD

## FLAG SIGNALS

Before modern technology, ships at sea "talked" to one another by signaling with flags. They used semaphore, a code in which flags are held in different patterns to represent letters and numbers.



THERE ARE SIX  
AMERICAN FLAGS  
ON THE MOON.

## PLANTING FLAGS

For centuries, flags have been used by explorers to claim ownership of new land. The national flags planted at such places as the South Pole, the summit of Mount Everest, and even on the Moon all proclaimed "We were here first."



### THE MOON

In 1969, the first humans to reach the Moon, astronauts Neil Armstrong and Buzz Aldrin planted the US flag at their landing site.



### SOUTH POLE

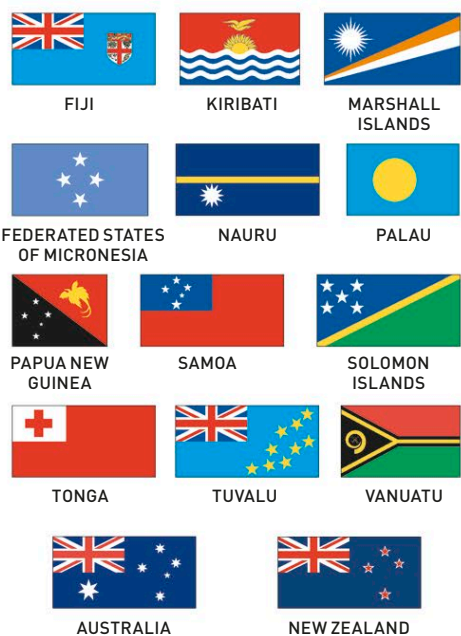
Norwegian explorer Roald Amundsen led the first expedition to reach the South Pole in 1911. He left his country's flag on the top of a tent.

**MOUNT EVEREST**  
In 1953, Edmund Hillary and Tenzing Norgay, the first people to stand on top of Mt. Everest, planted the flags of the United Nations, United Kingdom, Nepal, and India.

## EUROPE



## OCEANIA



## ASIA





# Where food comes from

Long ago, people only ate what could be hunted or grown locally. Today, with modern transportation, people in richer countries can find food from all around the world—such as coffee from Brazil, rice from India, and olives from Italy—in supermarkets. Tropical places export crops such as mangoes and bananas, while countries with huge farmlands supply the world with cereals.

## BASIC FOOD CROPS

Crops such as canola and sugar cane are grown in vast amounts because they can be used in many different ways, not just as foods, but also for products such as fuel. After they are harvested, they are usually processed and sent to manufacturers to make other foods or goods.



**SUGAR CANE**  
After sugar cane is harvested, it is processed to extract sucrose (ordinary sugar). It can be chewed as it is, but more often is used to sweeten other foods.



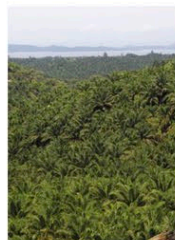
**SUGAR BEET**  
The sugar syrup extracted from sugar beets is used in many products, including drinks, feed for animals, and even fuels known as biofuels.



**SOY BEANS**  
A great source of protein and vitamins, soy beans can be used to make milk, textured vegetable protein, tofu, and flavorings such as soy sauce.



**CANOLA**  
Fields of yellow canola produce canola, which is usually turned into oil for cooking or used in food products. It is also used in animal feed and biofuels.



**PALM OIL**  
Palm oil is semi-solid at room temperature. It is used in everything from ice cream to pizza dough, as well as in products such as soap and cosmetics.



**SUNFLOWER SEEDS**  
We can snack on raw sunflower seeds, but most of the crop is processed to produce oil for cooking or to be turned into spreads such as margarine.

## CEREALS

Plants producing grains used as food are called cereals. Most grains are ground into flour or turned into flakes, which are then used to make food such as muesli and oatmeal, or bread, cakes, and cookies.



RICE



WHEAT



MAIZE (CORN)



MILLET



OATS



TRITICALE



SORGHUM



BARLEY



RYE

## VEGETABLES

Although many people like to grow vegetables in their garden, most of us buy them at farmer's markets and supermarkets. Potatoes are popular in many parts of the world because they can be used in many ways. Vegetables such as cassava and yams are part of a traditional diet in Africa but are now exported to countries with multicultural populations.



POTATOES



CASSAVA



SWEET POTATOES



CABBAGES AND OTHER BRASSICAS



PEAS



LETTUCE



BEANS



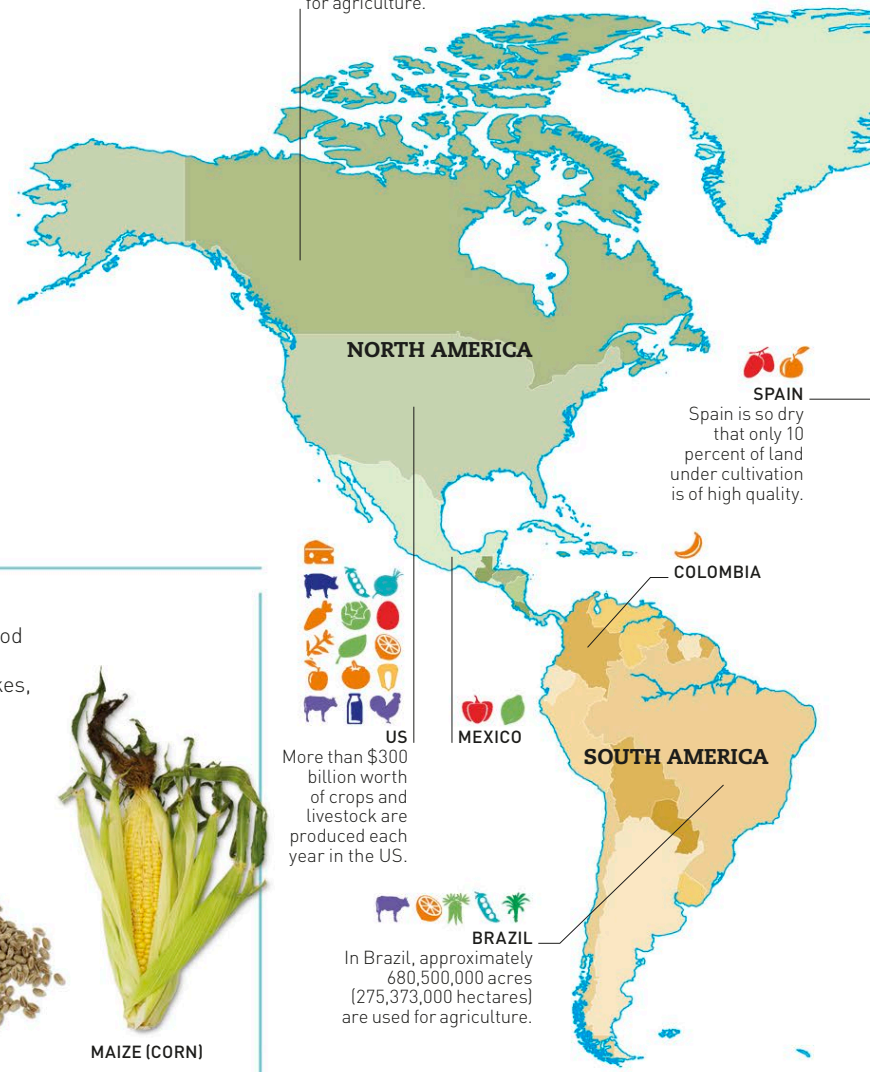
SPINACH



GARLIC



**CANADA**  
Although Canada is the second largest country in the world by area, only 6.8 percent is used for agriculture.



## DAIRY

The most popular milk produced around the world is cow's milk. It is used in drinks and in cooking and also to produce cheese, butter, ghee, and yogurt. Water buffalo milk, used in Italy to make mozzarella cheese, is the second most popular milk globally.



COW'S MILK



MOZZARELLA (FROM WATER BUFFALO MILK)

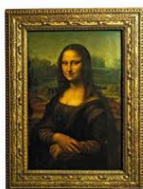
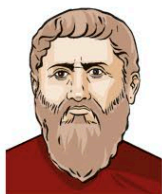


CHEESE













# Culture





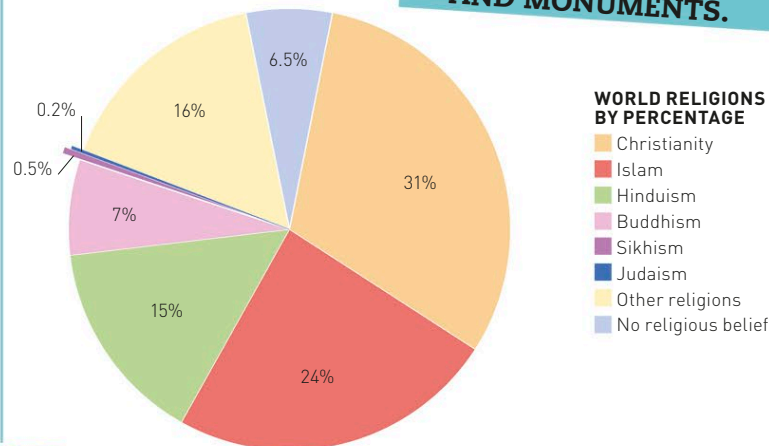
# World religions

A religion is a collection of beliefs that attempts to explain the meaning of life. Most religions recognize a supreme power, usually a god or gods. There are many different faiths worldwide, most with their own laws and history set down in sacred books. The followers of a faith unite through prayer, rituals, and beliefs.

## WHICH FAITH?

Christianity is the largest of the world religions. The number of followers of any religion changes all the time, as people decide to join or leave a faith or to convert from one to another.

RELIGION CAN BE TRACED BACK TO THE STONE AGE THROUGH SUCH EVIDENCE AS BURIAL SITES, TOTEMS, AND MONUMENTS.



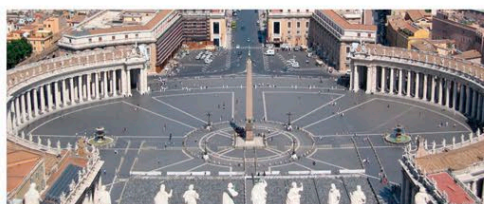
**SYMBOL**  
Cross

## CHRISTIANITY

Christians believe in one God and in his son, Jesus Christ. Their holy text, the Bible, tells how Jesus was born on Earth to be the savior of humankind. His teachings gave rise to Christianity, of which there are various branches. These include the Protestant, Roman Catholic, and Orthodox churches. Each has a different form of worship, but they all pray to the same God.



**ICONS**  
The Orthodox Christian church uses icons—often paintings such as this one of the infant Christ with his mother Mary—as a focus for prayers.



**ST. PETER'S SQUARE**  
The square lies at the heart of the Vatican City, in Rome, where the Pope, head of the Catholic Church, lives.



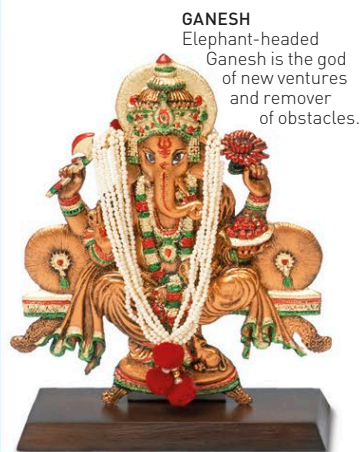
**CANTERBURY CATHEDRAL**  
This English cathedral is one of the oldest and most important Christian buildings in the world.



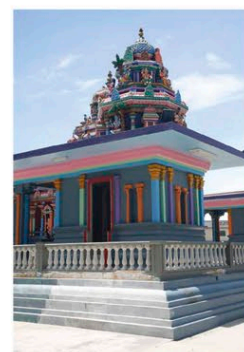
**SYMBOL**  
Letter for the sacred sound "OM"

## HINDUISM

There are hundreds of millions of Hindus worldwide. Hinduism includes many gods and goddesses, the greatest being the deities Brahma, Vishnu, and Shiva. Hindus believe in reincarnation: the cycle of life, death, and rebirth that continues until the soul is set free. Many Hindus worship by saying individual prayers and do not attend communal services, although they may join together during prayers at temples and at festivals.



**GANESH**  
Elephant-headed  
Ganesh is the god of new ventures and remover of obstacles.



**SRI SIVA SUBRAMANIYA TEMPLE**  
Hindu temples are built in many styles. This one is in Fiji.



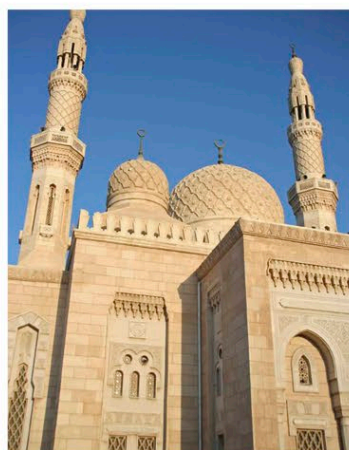
**KRISHNA**  
Usually shown with blue skin, Krishna is one of the best-loved Hindu gods.



**SYMBOL**  
Crescent and star

## ISLAM

The people who belong to this religion are called Muslims. They live according to the Five Pillars of Islam: faith, prayer, fasting, alms-giving, and pilgrimage. Their holy book is the Qur'an, which contains the word of the one Muslim God, Allah, as told to the Prophet Muhammad. Muslims pray at five set times every day. On Fridays, Muslims gather for prayers at a mosque.



**FACING MECCA**  
At prayer, Muslims kneel facing the direction of the holy city of Mecca, to which all aim to make a pilgrimage.

**JUMEIRAH MOSQUE, DUBAI**  
The mosque is the religious center of a Muslim community—a place for people to pray, meditate, and learn.



**QUR'AN**  
In this copy of the Qur'an, the text is surrounded by ornate borders.



**SYMBOL**  
Wheel of law

## BUDDHISM

Buddhists do not worship a single, creator god. They follow a way of thinking based on the teachings of Siddhartha Gautama, an Indian prince born in c. 6th century BCE, who became known as the Buddha. Through recurring lifecycles, Buddhists hope to reach a state called Nirvana—freedom from all suffering.



**STUPA**  
Dome-shaped mounds called stupas were built all over Asia to house Buddhist relics. This one is in Sri Lanka.

**GIANT BUDDHA**  
This giant-sized statue of the Buddha in Uva Province, Sri Lanka, is carved from solid rock.



**BUDDHIST NOVICE**  
Boys as young as 7 years old may enter Buddhist monasteries as trainees, or novices.



**PRAYER FLAGS**  
Buddhist flags, fluttering in the mountains of Nepal, are believed to carry prayers into the wind.





**SYMBOL**  
Hand and wheel



**SHRI DIGAMBAR JAIN LAL MANDIR**  
Built in 1656, this is one of the oldest temples in New Delhi, India. Within the ornate buildings, there is also a hospital for birds.

## JAINISM

Followers of this faith, who are called Jains, mostly live in India. They believe, in common with members of many other religions, that we die and are reborn in a repeating cycle. If a person can become truly spiritual, the soul becomes free. Jains respect all life, including plants and insects, and reject violence.



**SYMBOL**  
Sacred gate

## SHINTO

Arising out of Japanese folklore, Shinto developed as a religion more than 2,000 years ago. Followers believe in the existence of divine spirits, or *kami*. At Shinto places of worship, called shrines, people pay respect to the *kami* and honor them with many rites and festivals.



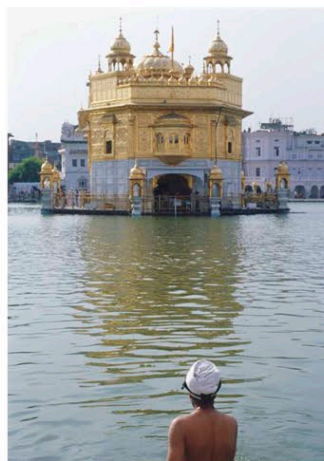
**GATEWAY**  
The gateway, known as a *torii*, to the Shinto shrine on Miyajima Island in Japan stands in the sea.



**SYMBOL**  
Circle and swords

## SIKHISM

The faith was founded in northern India, where many Sikhs today live or have family links. In Sikhism, there is one God, who makes his will known through gurus (teachers). Believers worship regularly in temples known as *gurdwaras*. At a Sikh service, there are prayers, a sermon, and hymns from the sacred Sikh book called the Guru Granth Sahib. Meditation is an important part of the religion.



**DRESS RULES**  
Male Sikhs always have a beard. Their long hair, which is never cut, is fastened in a bun and covered with a turban.

**GOLDEN TEMPLE**  
Built in the state of Punjab, northern India, at the beginning of the 17th century, this famous Sikh temple is located in the middle of a pool.



**THE GURU GRANTH SAHIB**  
The Sikh holy text contains hymns written or collected by gurus.



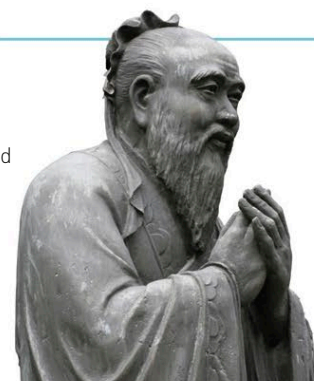
**SYMBOL**  
Guardian angel



**ZOROASTER**  
The prophet believed that his God, Ahura Mazda, had appeared to him in visions.

## ZOROASTRIANISM

Founded by Zoroaster, a prophet who lived in ancient Persia (now Iran), Zoroastrianism is more than 2,500 years old. Followers believe in Ahura Mazda, the Supreme Creator of the world, and the eternal struggle between good and evil. Their holy book is called the Avesta. Zoroastrians worship in temples, where they hold many ceremonies.



**SYMBOL**  
The Chinese character for water (a life source) is sometimes used.

## CONFUCIANISM

This religious philosophy comes from the teachings of Confucius, a 6th-century Chinese thinker and reformer. Kindness, honorable behavior, and respect for family are key beliefs.

**GREAT THINKER**  
A statue of Confucius stands at the entrance to the Confucian Temple in Shanghai, China.



**SYMBOL**  
Star of David

## JUDAISM

This is the religion of the Jewish people, who can trace their roots back to the Hebrews who lived in the Middle East almost 4,000 years ago. Judaism has one God. Followers worship in buildings known as synagogues under the guidance of spiritual leaders called rabbis. Teachings on Judaism are found in the Torah, or Hebrew Bible, and the Talmud, which is the Jewish code of law.



**THE WESTERN WALL**  
Also known as the Wailing Wall, this stone wall in the city of Jerusalem is considered a holy site by Jewish people.

**TORAH SCROLL**  
The scroll, which contains the Torah handwritten in Hebrew, is read in the synagogue.

**MENORAH**  
The menorah, or seven-branched candlestick, is an important Jewish symbol.



**SYMBOL**  
Divine Eye

## CAO DAI

Originating in Vietnam, Cao Dai was founded in 1926. The faith takes some of its practices from other religions, including Roman Catholicism and Buddhism. Followers of Cao Dai would like to see all people living at peace with each other. They worship a Supreme Being and honor many saints.



**TAY NINH TEMPLE**  
This elaborate building at Tay Ninh in Vietnam is the most important temple of the Cao Dai faith.

## INDIGENOUS RELIGIONS

From Africa to the Americas, indigenous religions are found among remote peoples untouched by the major faiths. These religions, which include the widespread practice of shamanism, often involve contact with the spirits.

**BELIEF IN PROTECTION**  
Followers of indigenous religions often carry objects—like this African nutshell doll—as protection against harm.





# World celebrations

Throughout the year, in nearly every country or community, people celebrate special events with festivals. Many of these events are religious, with some falling on a different date (or month) every year, or have historic links to the farming seasons. Often, a festival is a joyful holiday with music, processions, food, and sometimes gifts.

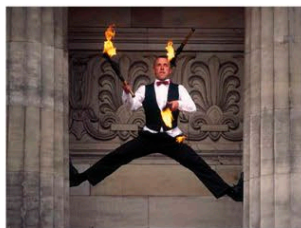


**FESTIVAL OF THE PIG, FRANCE**  
One of the funniest festivals is found in the French Pyrénées. People dress as pigs, race piglets, and challenge each other to make the most lifelike pig noises.

**TOMATO BATTLE, SPAIN**  
*La Tomatina*, as it is called in Spain, takes place at the town of Buñol, near Valencia. Thousands gather for a mock fight with tons of squishy tomatoes.



In August, it's holiday time for many. Pigs and a very messy tomato fight are among the fun events on offer. There are also arts festivals to enjoy. One of the most important is held in Edinburgh, Scotland.



**EDINBURGH FESTIVAL**  
Drama, dance, music, and comedy are just some of the events at this Scottish cultural festival.

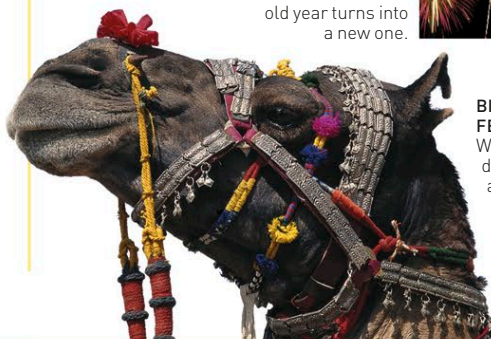
## AUGUST

## JANUARY

On December 31, people around the world are eager to party as they welcome in a new year. In Rajasthan, India, January is the time for the world-famous annual Camel Festival that takes place in the desert town of Bikaner.



**NEW YEAR'S EVE**  
Firework displays light up cities all over the world as the old year turns into a new one.



**BIKANER CAMEL FESTIVAL, INDIA**  
Wearing a colorfully decorated bridle, a camel waits to perform. Camels are a much-valued part of everyday life in Rajasthan.

## FEBRUARY

There are two big carnivals this month in Rio de Janeiro, Brazil, and in Venice, Italy. It's also Chinese New Year (starts between late January and late February), with two weeks of celebrations and family gatherings.



**RIO CARNIVAL, BRAZIL**  
Costume parades, dancing competitions, loud music, and feasting last for five riotous days.

## JULY

The US's Independence Day on July 4 celebrates the day in 1776 when the US declared its independence from Great Britain. In Siena, Italy, a historic horserace takes place twice, in July and August. A body-painting festival in Austria is a popular modern event.



**INDEPENDENCE DAY, US**  
Decorated with the American Stars and Stripes flag, a festive cake takes center stage at a Fourth of July celebration.



**BODY-PAINTING FESTIVAL, AUSTRIA**  
At this event, human bodies are transformed into amazing works of art. The festival includes competitions and displays from around the world.



**PALIO HORSERACE, SIENA**  
Bareback riders race through the streets of Siena. Each wears colors representing a district of the city.



## SEPTEMBER

Midautumn Festival, Moon Festival, Harvest Festival: these are some of the names for feasts all over Southeast Asia at full Moon. The celebrations were once held to give thanks for the rice harvest. Harvest celebrations are also an informal part of the Christian calendar.

**HARVEST FESTIVAL**  
Flowers, fruits, and other farm produce decorate a Christian church for Harvest Festival.



**MOON FESTIVAL, CHINA**  
Rich pastries known as mooncakes are made for the fall Moon Festival in China and other parts of Southeast Asia.



**TET TRUNG THU, VIETNAM**  
Scary masks and dancing in the streets are for children to enjoy in Vietnam's version of the Midautumn Festival.



## OCTOBER

Homes light up in October. Diwali, the "festival of lights," is a big occasion in the Hindu calendar. The date varies but often falls in October. On October 31, things get spooky when grinning pumpkin lanterns appear for Halloween.

**DIWALI**  
Hindu people light their houses with candles and oil lamps to symbolize the triumph of good over evil.



**HALLOWEEN**  
Carving a lantern from a pumpkin is traditional at Halloween. The festival has ancient roots and developed from ceremonies held to honor the dead.







**CHINESE NEW YEAR**  
Hidden beneath the costume of a fantastic lion with huge swiveling eyes, performers dance to bring good luck for the new year.



**VENICE CARNIVAL**  
On the last day of this annual two-week public event in Venice, people crowd the streets wearing elaborate masks and costumes.



## MARCH

The feast of St. Patrick, patron saint of Ireland, falls on March 17. The day of Holi, the Hindu spring festival, changes each year. The Jewish holiday of Purim varies, too, from one year to the next.



**ST. PATRICK'S DAY**  
Many Irish people wear green on their saint's day and celebrate with music and parades.



**HOLI**  
Whatever the date of Holi, the fun is the same as people bombard each other with colored powders and water.

**PURIM**  
Shaking a wooden rattle is part of the religious service for Purim. The day remembers how Jewish people in ancient Persia escaped a deadly plot against them.



## APRIL

Beware of practical jokers on April 1, a day for making "April Fools" of everyone—or "April Fish" in France. More solemn are the major events of the Christian and Jewish calendars.



**PASSOVER**  
This festival remembers the freeing of the Jewish people from slavery 3,000 years ago. People recite the story of the Passover at a special meal, which also includes symbolic foods, such as a burnt egg and a lamb bone.



**POISSON D'AVRIL (APRIL FISH)**  
On April 1, children in France pin pictures of fish on their friends' backs for a joke.

## EASTER

The Christian holiday celebrates Jesus Christ's resurrection after his crucifixion. Gifts of chocolate or sugar eggs symbolize rebirth.



## JUNE



**RAMADAN AND EID AL-FITR**  
A Moroccan shopkeeper sells trays of pastries baked for Eid. This holiday of sweet treats ends a month of fasting during Ramadan.

In northern regions, midsummer's day falls between June 20 and 22. Many people mark the date with celebrations at sunrise. The start of the Muslim holy period of Ramadan depends on the rising of a new Moon. It can be in June, or in other months of the year.

**MIDSUMMER**  
The prehistoric monument of Stonehenge, on Salisbury Plain in Wiltshire, England, is a traditional place to watch the Sun rise as midsummer's day dawns.



**APPLE FLOWER FESTIVAL, DENMARK**  
Held on the small Danish island of Lilleø, this tiny festival celebrates the blossoming of the fruit trees.



**WHITE NIGHTS FESTIVAL, ST. PETERSBURG**  
An eagerly awaited highlight of the festival is the appearance on the Neva River of a sailing ship with bright scarlet sails.

People have long celebrated the warmer days and spring growth that come with May. During the three-week White Nights festival in St. Petersburg, Russia, revelers can stay up as late as they like—the nights are never completely dark at this time of year.

**MAY DAY**  
In an age-old ritual, many British village communities erect a maypole on May 1. The ribbons are wound around the pole as part of a dance.



**MAY DAY WAS FIRST CELEBRATED BY THE ANCIENT ROMANS IN HONOR OF FLORA, GODDESS OF FLOWERS.**

## NOVEMBER

On Thanksgiving Day, Americans follow the tradition of the early European settlers, who gave thanks for the harvest every year. Today, Thanksgiving is mainly a family feast. In Mexico, people think of loved ones on *Día de Muertos*, or the Day of the Dead—a time for happy memories.

**DAY OF THE DEAD, MEXICO**  
During this festival on November 2, people buy paper skeletons and eat sugar skulls.



**THANKSGIVING**  
Figures from early American history parade in New York on Thanksgiving Day.



## DECEMBER

In many countries and cultures, Christmas, Christ's birthday, is the time that children most look forward to, as they can expect presents and special food. There are also presents, games, and feasts at Hanukkah, the Jewish Festival of Lights, which often falls in December.

**HANUKKAH**  
One candle is lit on each day of this eight-day Jewish festival.



**CHRISTMAS**  
A tree has been part of traditional Christmas celebrations for possibly hundreds of years.





# World languages

Spoken and written language allows us to communicate with one another. More than 6,000 languages are spoken across the world, and many people speak more than one language.

## GREETINGS

In all languages, there is a way to greet someone. Here is how to greet someone in some of the world's most widely spoken languages. Not all languages are written using the same alphabet—a large number of scripts are used across the world.

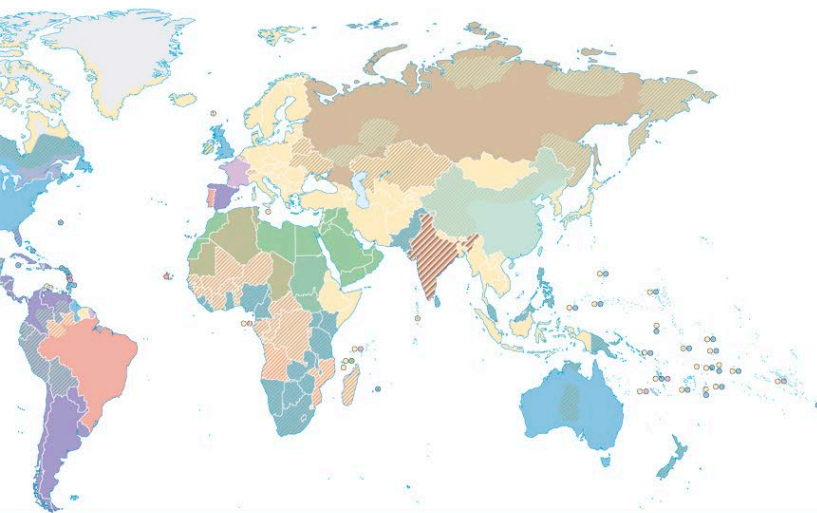
## LANGUAGES

The three most widely used languages are spoken by nearly half of the world.

- 1 **ENGLISH**  
1,268 million speakers worldwide
- 2 **MANDARIN**  
1,120 million speakers worldwide
- 3 **HINDI**  
637 million speakers worldwide
- 4 **SPANISH**  
538 million speakers worldwide
- 5 **FRENCH**  
277 million speakers worldwide







# WHO SPEAKS WHAT?

Some languages are spoken in many countries around the globe. Major languages also have many dialects (variations).

## KEY

Chinese (Mandarin, Cantonese, etc)	Arabic/French
Spanish	French/other
Arabic	English/other
Hindi	Arabic/other
English	Hindi/English/other
French	Chinese/other
Russian	Russian/other
Portuguese	English/French
English/Spanish	Portuguese/other
Spanish/other	Other language
	Uninhabited land

# SIGN LANGUAGE

People who cannot hear spoken language use hand signals to communicate. This is known as sign language. There are many different types of sign language.



HOW TO SAY "HELLO" IN BRITISH SIGN LANGUAGE

नमस्ते

nuh-muh-stay, **HINDI**

halo

halo, **JAVANESE**

السلام عليكم

as-salām-alaykum, **SINDHI**

assalomu alaykum  
as-salam alay-keum, **UZBEK**

안녕하세요

ahn-nyeong-ha-se-yo, **KOREAN**

నమస్కారం

namaskārām, **TELUGU**

ਸਤਿ ਸ੍ਰੀ ਅਕਾਲ

sat-sri-akal, **PUNJABI**

salam əleykūm  
salām-alaykum, **AZERBAIJANI**

प्रणाम

pra-naam, **MAITHILI**

cześć!

cheshch, **POLISH**

akkam

ak-kam, **OROMO**

olá

oh-lah, **PORTUGUESE**

hello

ENGLISH

kumusta

coo-moos-tah, **TAGALOG**

Привіт

priveet, **UKRAINIAN**

здравствуй

zdrast-wui-tyeh, **RUSSIAN**

kedu

kay-doo, **IGBO**

bonjour

boh-zhoo, **FRENCH**

hallo

ha-low, **GERMAN**

no ngoola daa

no-ngoola-daa, **FULA**

ciao

chow, **ITALIAN**

jambo

ja-m-boh, **SWAHILI**

salut

sah-loot, **ROMANIAN**

hola

o-la, **SPANISH**

bawo ni

bah-wo nee, **YORUBA**

ቴና ሂስቲኒ

tena-yste-lle'gn, **AMHARIC**

sannu

san-nu, **HAUSA**



# The story of art

From the beginning of civilization, people in different cultures have produced art in many forms. They have used paint, stone, wood, metal, clay, and even their own bodies to show religious devotion, express ideas, or simply reflect the world around them.

▶ c.42,000–2500 BCE

## PREHISTORIC ART

Early humans used charcoal and rock pigments to paint animals and figures on cave walls. Some made spray handprints by blowing paint through hollow bones. They also carved figures out of stone and animal tusks.



BONE SCULPTURE OF A MAMMOTH



PREHISTORIC FIGURE



CAVE PAINTING, FRANCE



DRAWING OF A CAVE ARTIST

▶ c.3000–539 BCE

## OLDEST CIVILIZATIONS

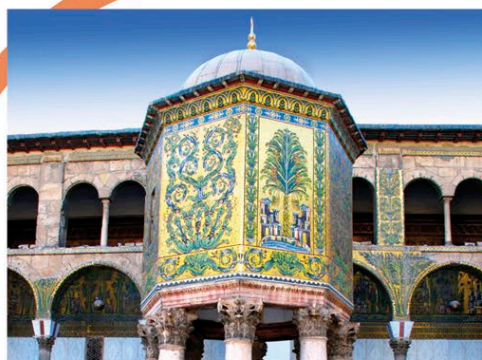
Many beautiful examples of art have been found at the Royal Cemetery of Ur, which is in modern-day Iraq. They were created by skilled sculptors and jewelry makers in Mesopotamia, one of the oldest and longest-lasting civilizations in our distant past.



GOLD ORNAMENT

GOLD AND BEAD WREATH

◀ c.622–1450



UMAYYAD MOSQUE, SYRIA

## ISLAMIC

Islamic artists decorated mosques with intricate patterns using tiles and mosaics. Modern Islam uses a similar approach—places of worship are beautifully patterned, but they never include images of people or animals.

◀ c.500–1450

## MEDIEVAL AND BYZANTINE

Metal and enamel work, carvings, and embroidery were prized in medieval Europe. Manuscripts were illuminated—lit up with decorations in bright pigments and gold leaf. Earlier Byzantine Christians produced icons of figures and frescoes of religious scenes.



ILLUMINATED MANUSCRIPT



BYZANTINE APSE MOSAIC



SILVER CHALICE (CUP)



MOSAIC OF VIRGIN MARY, ISTANBUL

◀ c.650 BCE–1900 CE

## EASTERN

For more than 2,000 years, artists from India, China, and Japan have created beautiful objects using stone, ceramics, precious stones, and metals. Colorful Indian temples were lavishly decorated with figures of gods and goddesses. Serene Japanese prints on silk and parchment were known as “pictures of the floating world.”

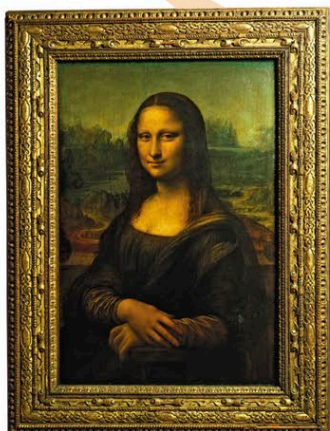


ORNATE FIGURE OF AN ELEPHANT, CHINA

▶ c.1350–1600

## RENAISSANCE

Beginning in Italy, the Renaissance was a time when most forms of art flourished. Artists were inspired by ancient Greek and Roman works and produced fine paintings and sculptures that were full of grandeur, personality, and beauty. Venice became a center for exquisite glasswork.



MONA LISA BY LEONARDO DA VINCI



PORTRAIT BY TITIAN



ITALIAN GOBLET



RENAISSANCE PENDANT

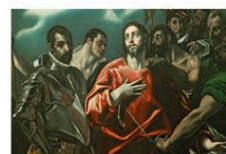


THE DEPOSITION BY MICHELANGELO

▶ c.1600–1750

## BAROQUE AND ROCOCO

Baroque painting was all about drama. Artists painted realistic emotional scenes with intense color and dramatic lighting. Originating in France, Rococo was a lighter style of architecture, furniture, and art that was elegant, graceful, and highly decorative.



EL GRECO PAINTING IN BAROQUE STYLE



ORGAN WITH ROCOCO DECORATION



ROCOCO FOUNTAIN

▶ c.1850–1900

## REALISM AND IMPRESSIONISM

Realist painters wanted to create pictures of modern life and made ordinary working people the subject of their paintings. Impressionist artists tried to capture a moment, using delicate brushstrokes and dabs of color to give fleeting impressions of flowers, landscapes, picnics, and parties.



RENOIR'S LUNCHEON OF THE BOATING PARTY





GOLD BULL'S HEAD WITH SHELL INLAY

c.3000–330 BCE

## ANCIENT EGYPTIAN

The ancient Egyptians filled elaborate tombs inside pyramids with statues, painted mummy cases, frescoes, and picture scrolls to help the dead in their afterlife. Painters wanted to show complete human forms, so every figure combines a front and side view.



TOMB PAINTING



MODEL OF A GRANARY



RITUAL WATER JAR



HIGHLY DECORATED TOMB FIGURES



c.2000–146 BCE

## ANCIENT GREEK

The earliest frescoes and pottery, found in a Minoan palace on the island of Crete, are painted with colorful scenes of everyday life. Temples in ancient Greece were decorated with marble friezes showing processions and beautifully carved columns.



FRESCO OF A LEAPING BULL



PAINTED VASE



DORIC COLUMN



IONIC COLUMN



CORINTHIAN COLUMN

c.750 BCE–476 CE

## ANCIENT ROMAN

Statues and busts (just the head) of emperors, famous people from the past, and gods and goddesses were popular in ancient Rome. Wealthy people had gold jewelry, decorated pottery, and ornate glassware. The finest houses were decorated with mosaic floors and panels and painted frescoes.



TERRACOTTA (CLAY) BUST



BWARE OF THE DOG MOSAIC, POMPEII



FRESCO ON VILLA WALL, POMPEII

c.1000 BCE–PRESENT

## NATIVE AMERICAN

In Native American tribes, practical items such as blankets and bags were so skillfully decorated with beads, feathers, and shells, they became works of art. People also made tiny animal talismans and towering tree-trunk sculptures called totem poles carved with faces, animals, and birds. These arts continue today.



TURQUOISE ANIMALS

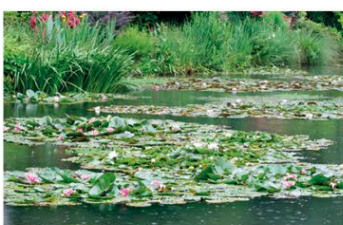


QUILLWORK BAG

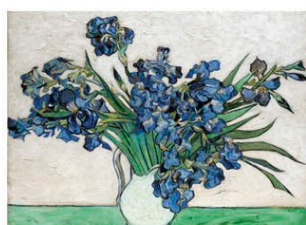


CARVED FACE ON TOTEM POLE

1880–1905



MONET'S GARDEN  
Monet's paintings of his lily ponds captured changes in the light and seasons.



IRISES BY VAN GOGH

## POST-IMPRESSIONISM

Painting got bolder, brighter, and freer in this period. Vincent Van Gogh poured his feelings into swirling images created with thick brushstrokes and heavy paint. Others developed new techniques. Seurat's pointillist pictures were painted with millions of tiny dots of color that blended together.



FIGURE BY RODIN  
Rodin produced lifelike figures that portrayed powerful emotions.



NATURAL LIGHT  
Using new portable easels and tubes of paint, artists left their studio to paint outdoors.

c.1900–1950

## EXPRESSIONISM AND SURREALISM

Expressionist painters used vivid colors and stark images, often squeezing the paint straight from the tube on to the canvas. Their pictures were not intended to show real life but to express ideas and moods. Surrealist art turned the world upside down. Artists produced dreamlike paintings and absurd objects such as furry teacups and spiky irons.

**"IF YOU UNDERSTAND A PAINTING BEFOREHAND, YOU MIGHT AS WELL NOT PAINT IT."**

SALVADOR DALÍ, SURREALIST ARTIST

1907–1960s

## MODERN ART

Artists rejected tradition for experimentation. Leading artist Pablo Picasso created figures with angular shapes that broke all the rules of color, form, and perspective. Many years later in the US, abstract expressionist artists, such as Jackson Pollock, invented action painting—splashing, smearing, or dribbling paint onto the canvas.

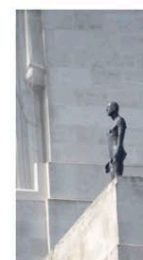


INSPIRED BY JACKSON POLLOCK

1970s–PRESENT

## CONTEMPORARY

In contemporary art, anything goes. Painters use styles from the past and often rework and mix them together to show new ideas. Art can take many different forms. It can be a shed blown apart with all its pieces suspended in midair; a skull studded with diamonds; or lonely figures perched on buildings across a city skyline.



ANTONY GORMLEY'S EVENT HORIZON



MILLENNIUM PARK FOUNTAIN, CHICAGO



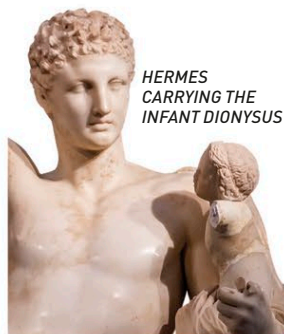
# Great artists

Prehistoric people painted animals on cave walls, possibly to document their hunts. Later artists used art to tell their own stories. Throughout history, great painters, sculptors, and photographers have created inspirational works of art, and some have sparked whole new artistic styles.

▶ c.395–330 BCE

## PRAXITELES

Considered to be one of the most accomplished sculptors of ancient Greece, Praxiteles's sculpture of *Hermes carrying the infant Dionysus* showed a graceful posture and a smooth finish, which became the norm for later artists.

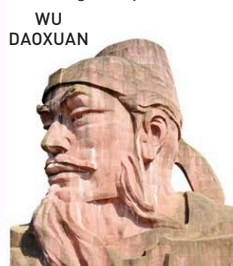


HERMES  
CARRYING THE  
INFANT DIONYSUS

▶ 680–c.740 CE

## WU DAOZI

Although few of his works survive, this Chinese master's art from the Tang Dynasty lives on in legend. Later known as Daoxuan, he is said to have painted astonishingly lifelike scenes on temple and palace walls, able to complete vast vistas in a single day.

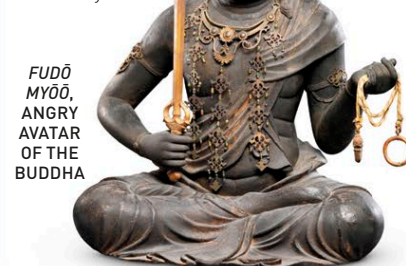


WU  
DAOXUAN

▶ EARLY 13TH CENTURY

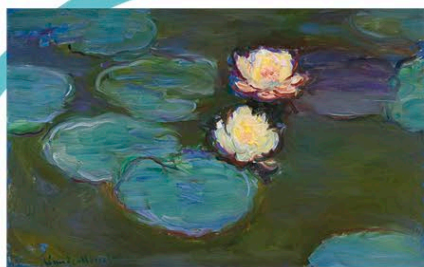
## KAIKEI

This Buddhist master sculptor, or *Busshi*, lived during Japan's Kamakura Period (1185–1333 CE). He set the standards for the traditional styles of Buddhist sculpture in the country. Kaikei's sculpture style came to be called *Anna-miyō*.



FUDŌ  
MYŌŌ,  
ANGRY  
AVATAR  
OF THE  
BUDDHA

◀ 1840–1926



WATER LILIES

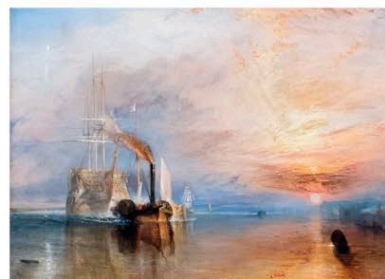
## CLAUDE MONET

Monet was a key figure of the French impressionist movement. He used free brushstrokes and dabs of color to paint the same subject at different times of the day to capture the changing light. Among his best known works are about 250 oil paintings of water lilies from his garden.

◀ 1775–1851

## J. M. W. TURNER

This English Romantic painter started at a young age, painting a series of landscapes and seascapes in water color and oils, wonderfully capturing the varying effects of weather and light. His later work became more abstract. When he died, some 300 of his oil paintings were given to the Tate Gallery in London, UK.



THE FIGHTING TEMERAIRE

◀ 1760–1849

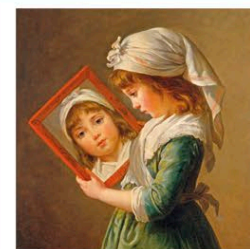


SEASIDE VILLAGE IN WINTER

## KATSUSHIKA HOKUSAI

While most of his fellow artists in Japan painted samurais, geishas, and the nobles, Hokusai turned to landscapes and country life for inspiration. His best-known work, *The Great Wave off Kanagawa*, is famous across the world. It was one of a series of prints that went on to influence Western artists.

◀ 1755–1842

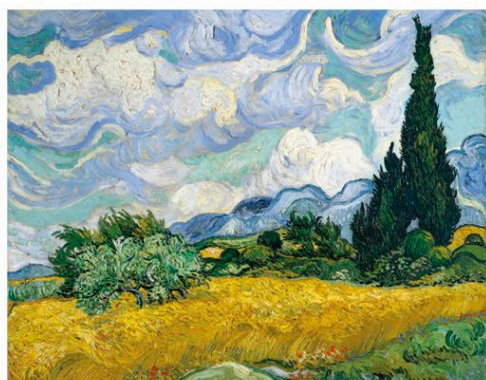


JULIE LEBRUN LOOKING  
IN A MIRROR

## ÉLISABETH VIGÉE-LEBRUN

A French painter, Élisabeth Vigée-Lebrun was most popular for her vibrant portraits of French nobility. She painted her subjects in natural poses against plain backgrounds to focus on their expressions.

▶ 1853–1890



WHEAT FIELD WITH CYPRESSES

## VINCENT VAN GOGH

Dutch-born van Gogh tried to express his feelings and ideas through his brushstrokes and his choice of color and form. His career produced the most extraordinary postimpressionist paintings, despite his mental illness and poverty. He died of a self-inflicted gunshot wound, and the genius of his work was only recognized long after his death.

▶ 1881–1973

**"IT TOOK ME FOUR YEARS TO PAINT LIKE RAPHAEL, BUT A LIFETIME TO PAINT LIKE A CHILD."**

## PABLO PICASSO

Spanish-born Pablo Picasso has more than 20,000 artworks to his name, including paintings, sculptures, and drawings. He is credited with starting many art movements and is considered one of the most influential artists of the 20th century. He pioneered the Cubism movement in which conventional subjects, such as still life or landscape, were broken down to look almost like jigsaw pieces.

▶ 1887–1986

## GEORGIA O'KEEFFE

Best known for her large paintings of exotic flowers and desert landscapes, Georgia O'Keeffe played an important role in the development of modern art in America. She used a unique combination of the abstract and the realistic to paint both natural and human-made forms in a way that showed how they made her feel.

**"I found I could say things with color and shapes that I couldn't say any other way."**

▶ 1895–1965



PEA PICKERS LINE UP ON EDGE  
OF FIELD AT WEIGH SCALE

## DOROTHEA LANGE

American photographer Dorothea Lange produced powerful images of migrant workers and rural poverty during the Great Depression (1929–1933). Her work was widely published in newspapers, and Lange used her fame to raise awareness for issues of social justice.

▶ 1904–1989

## SALVADOR DALÍ

This Spanish artist explored hidden imagery in his art through the art movement called Surrealism. His depiction of dream worlds where regular objects were deformed or reimagined in bizarre ways made him one of the most influential artists of his time.

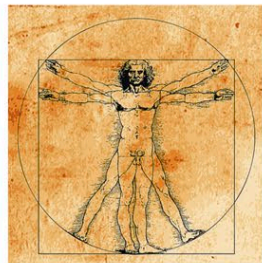
**"Those who do not want to imitate anything produce nothing."**



▶ 1452–1519

## LEONARDO DA VINCI

Da Vinci is widely regarded as Italy's greatest painter. His *Mona Lisa* is one of the world's most viewed paintings. The pen-and-ink *Vitruvian Man* shows his mastery of human anatomy.



VITRUVIAN MAN

▶ 1470–1559



VIEW OF LAKE TAI

## WEN ZHENGMING

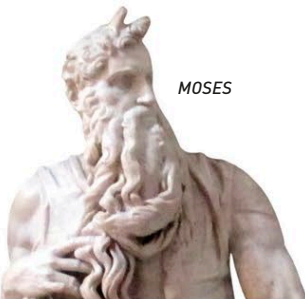
Chinese painter Wen Zhengming was one of the great artists of the Wu School of painting. He became well known for his style of landscape painting in ink. He decorated the fan above with a lake scene and verses describing its beauty in springtime

▶ 1475–1564

## MICHELANGELO

This Italian master created some of the most iconic works of the Renaissance period.

His sculptures include the statues of Moses, David, and other biblical figures, while his paintings in the Sistine Chapel in the Vatican, Rome, are unsurpassed.



MOSES

▶ c.1510–1576

## LEVINA TEERLING

Flemish (Belgian) Renaissance painter Levina Teerlinc became the royal portrait painter at the English Tudor court in 1545. She specialized in miniature portraits and became the most important miniaturist at the court in the era between fellow artists Hans Holbein the Younger and Nicholas Hilliard. However, her paintings were mostly personal gifts and commissions, and very few survive today.

▶ c.1500–c.1593

## ABD AL-SAMAD

Persian (Iranian) miniaturist and calligrapher Abd Al Samad moved to India under the patronage of the Mughal emperors. He developed the Mughal school of miniature painting, which took inspiration from the royal court, nature, and mythology.

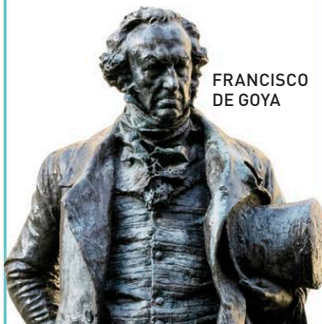


THE ASSASSINATION OF KHUSRAU PARVIZ, A PAINTING BY AL-SAMAD

◀ 1746–1828

## FRANCISCO DE GOYA

Spanish artist Goya created stunning portraits and dark, inventive paintings depicting violence. His war paintings show the devastating effects of conflict.



FRANCISCO DE GOYA

◀ 1741–1807

## ANGELICA KAUFFMANN

Born in Switzerland, Angelica Kauffmann was a child prodigy. As an artist, this neoclassical painter traveled across Europe, living in various cities. During her time in London, she helped found the Royal Academy of Arts in 1768.



THE SORROW OF TELEMACHUS

◀ 1606–1669



SELF-PORTRAIT

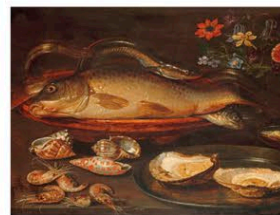
## REMBRANDT VAN RIJN

This Dutch painter is considered to be a master of light and shade. His work included scenes from the Bible, myths, historical events, and a vast number of self-portraits.

◀ c.1594–c.1657

## CLARA PEETERS

In the early 17th century, Flemish painter Clara Peeters was the only well-known female artist excelling in still life painting. She painstakingly created detailed and elaborate still lifes, painting food and drink, exotic flowers, or even valuable objects like goblets and gold coins.



STILL LIFE WITH FISH, OYSTERS, AND SHRIMPS

◀ 1593–1653



ESTHER BEFORE AHASUERUS

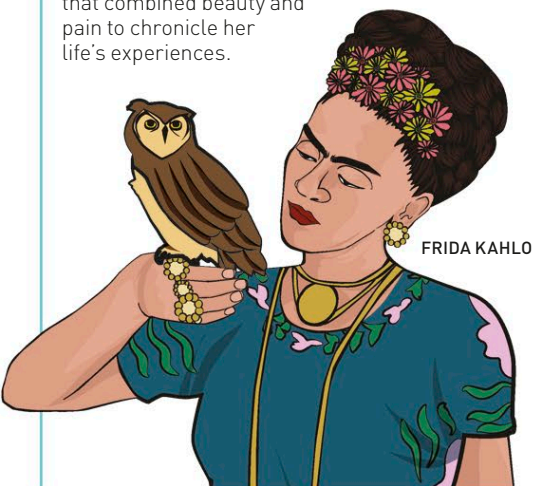
## ARTEMISIA GENTILESCHI

One of the leading artists of the Baroque movement of the 17th century, Italian painter Artemisia Gentileschi was also the first woman to join Florence's prestigious Academy of Design. Many of her surviving works depict biblical stories with a focus on women as their main characters.

▶ 1907–1954

## FRIDA KAHLO

A prolific Mexican artist and feminist icon, Frida Kahlo refused to let her physical ailments limit her and painted even when bed-ridden. Kahlo is best known for her self-portraits, as she would often use herself as a subject to paint scenes that combined beauty and pain to chronicle her life's experiences.



FRIDA KAHLO

▶ 1913–1941

## AMRITA SHER-GIL

Indian-Hungarian painter Amrita Sher-Gil was an important avant-garde artist of the 20th century. Apart from self-portraits, a lot of her work focused on Indian village life and people who were ignored by society. She died young at the age of 28.

**"I can only paint in India. Europe belongs to Picasso, Matisse, Braque. India belongs only to me."**

▶ 1928–1987

**"ART IS WHAT YOU CAN GET AWAY WITH."**

## ANDY WARHOL

American commercial artist Andy Warhol became a leading light in a new movement in 20th century art. By applying garish colors to familiar images, such as pictures of consumer goods and portraits of celebrities, he helped develop "pop art." This work challenged existing ideas about art, blending fine art with popular culture.

▶ c.1935–2017

## YANNIMA TOMMY WATSON

Watson was one of Australia's foremost Aboriginal artists. He was a desert nomad for many years before he became well known. His vivid and colorful paintings portray stories of "Dreamtime"—the creation period of Aboriginal mythology. His abstract paintings celebrate the combination of Aboriginal culture and the Australian landscape.

▶ 1956–

**"... It hasn't worked out the way I imagined. People who thought they were superior before haven't really changed ..."**

## WILLIE BESTER

Born and raised during the apartheid regime (1948–1991) in South Africa, Willie Bester emerged as an important socio-political artist. His collages and sculptures—made with photographs, scrap materials, and oil paints—convey the racist brutality of apartheid (Afrikaans for apartness) and how its effects continue to this day.



# Musical instruments

From very early times, people have enjoyed making music by beating, plucking, rattling, or blowing into instruments. Different groups of instruments are known as “families.” In an orchestra, many of them come together to combine their sounds.

## WOODWIND

These wind instruments are made of metal and plastic, as well as wood. Holes in the pipe are opened and closed with the fingers to change the notes. Some woodwind instruments use a vibrating strip, called a reed, as a mouthpiece.



## INTERNATIONAL INSTRUMENTS

Around the world, music-making involves a huge variety of traditional instruments. Many are unique to particular countries or cultures.



## THE ORCHESTRA

Large orchestras have followed the same seating arrangement for their musicians since the 18th century. The various instruments are positioned according to type.



KEY	
Conductor	Bassoons
First violins	Horns
Second violins	Trumpets
Violas	Trombones and tubas
Cellos	Harp
Double basses	Drums
Flutes	Other percussion
Oboes	Piano
Clarinets	

## BRASS

The brass section of an orchestra makes some of the loudest sounds. When brass players blow air into their instruments, they put their lips close to the mouthpiece to create vibrations. Many types of brass have buttonlike valves that are pressed down to alter notes.





## PERCUSSION

A percussion instrument is struck or shaken to keep a rhythm or create a tune. Percussionists usually play more than one instrument.



GLOCKENSPIEL



XYLOPHONE



TAMBOURINE



TRIANGLE



GONG



SNARE DRUM



TIMPANI



MARACAS

## STRINGS

Several types and sizes of instruments are played with a bow drawn across a set of tightly stretched strings. They all have hollow wooden bodies that let the sounds vibrate.

Neck, where fingers press strings to create notes

MORE THAN 70 DIFFERENT  
PIECES OF WOOD ARE  
PUT TOGETHER TO FORM  
THE MODERN VIOLIN.

Tuning pegs to adjust strings



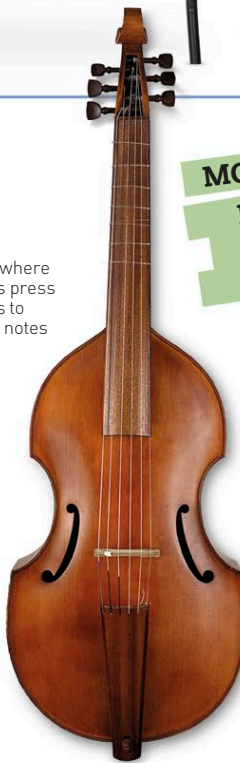
PICCOLO VIOLIN



VIOLA D'AMORE



TENOR VIOL



BASS VIOL



VIOLIN



VIOLA



CELLO



DOUBLE BASS

## KEYBOARDS

The piano is the most popular of a large group of instruments that are played by pressing keys or buttons. On a keyboard, a musician can play many notes at the same time.

Strings struck by hammer when keys pressed.



Keys

Pedals soften or lengthen notes.

GRAND PIANO



Bellows

ACCORDION



ELECTRONIC KEYBOARD

## GUITAR FAMILY

A subset of the string family, guitars may have as many as 18 strings, but most have six. The strings are played with the fingers or a small tool called a pick.



MEXICAN MARIACHI GUITAR



BALALAIKA



MANDOLIN



UKULELE



CLASSICAL GUITAR



ELECTRIC BASS GUITAR

Attachment point for strings



ELECTRIC GUITAR



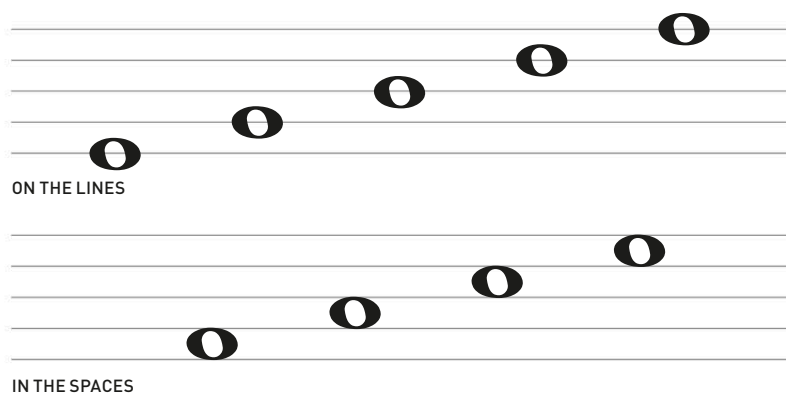
# How music works

Understanding how music works—music theory—is a vital part of learning how to read music and play an instrument. To play music, you need to understand its language—notes, pitch, rhythm, and harmony.

**THE FIRST KNOWN MUSIC WAS WRITTEN IN AN ANCIENT SCRIPT CALLED CUNEIFORM, 3,400 YEARS AGO.**

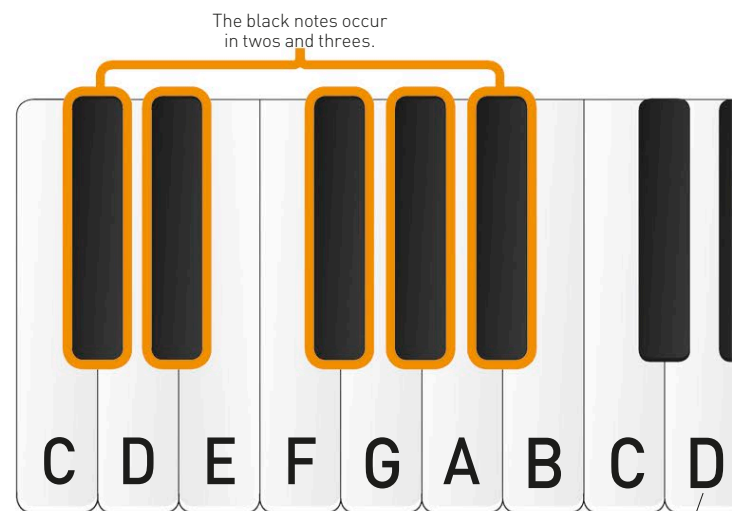
## WRITING MUSIC

Music is usually written on five parallel lines known as a staff. Notes are placed on the lines or in the spaces between them. The higher a note is placed, the higher its pitch.



## THE PIANO KEYBOARD

Each octave on the piano keyboard has seven white notes—A B C D E F G—and five black notes, grouped in twos and threes. A full-sized keyboard usually has around seven octaves. Its central C is called Middle C.



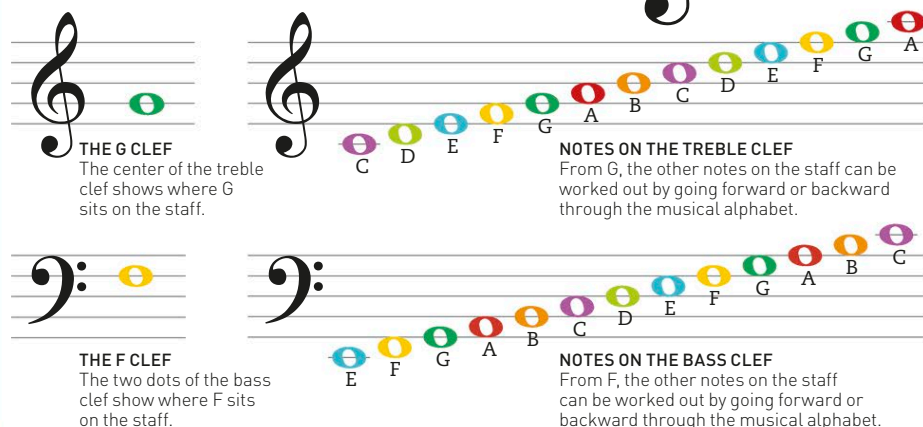
## THE PIANO

With its unique layout, the piano is a useful instrument for learning music theory. The pattern of black and white keys shows the relationships between notes.

The white note between a pair of black notes grouped in twos is always D.

## CLEFS

A clef is normally written at the start—the left-hand end—of every staff on the page. It fixes the pitches of the lines and spaces. The two most common clefs are the treble (or G) clef and the bass (or F) clef.

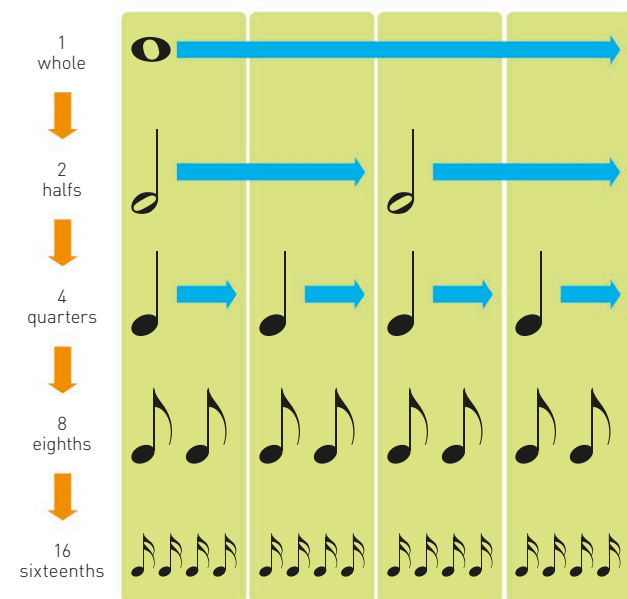


## NOTE VALUES

A note value is how long a note lasts for. It is measured in relation to other notes. Shown below—in descending order of length—are the five most common note values: whole, half, quarter, eighth, and sixteenth.

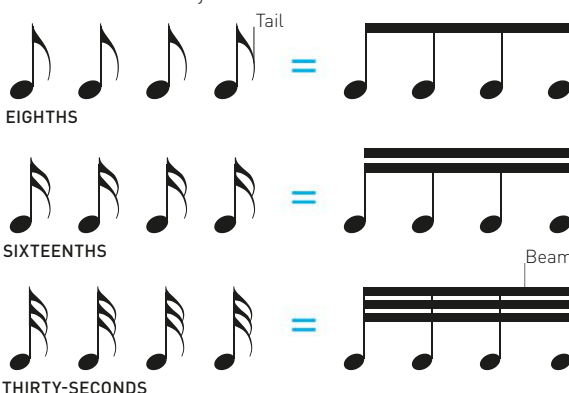
## TIME VALUES

The chart below shows how the note values relate to each other. Each column represents one quarter, so a whole note lasts as long as four quarter notes.



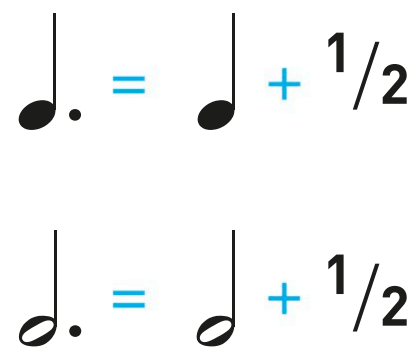
## BEAMS

Two or more consecutive eighths can be joined together with a thick line called a beam, which replaces the individual tails. Sixteenths or thirty-seconds can be joined in the same way. Beams make the rhythm easier to read.



## DOTTED NOTES

When a note is followed by a dot, it makes the note half as long again. The dotted quarter below is 1½ times longer than a quarter note, and the dotted half is 1½ times longer than a half note.

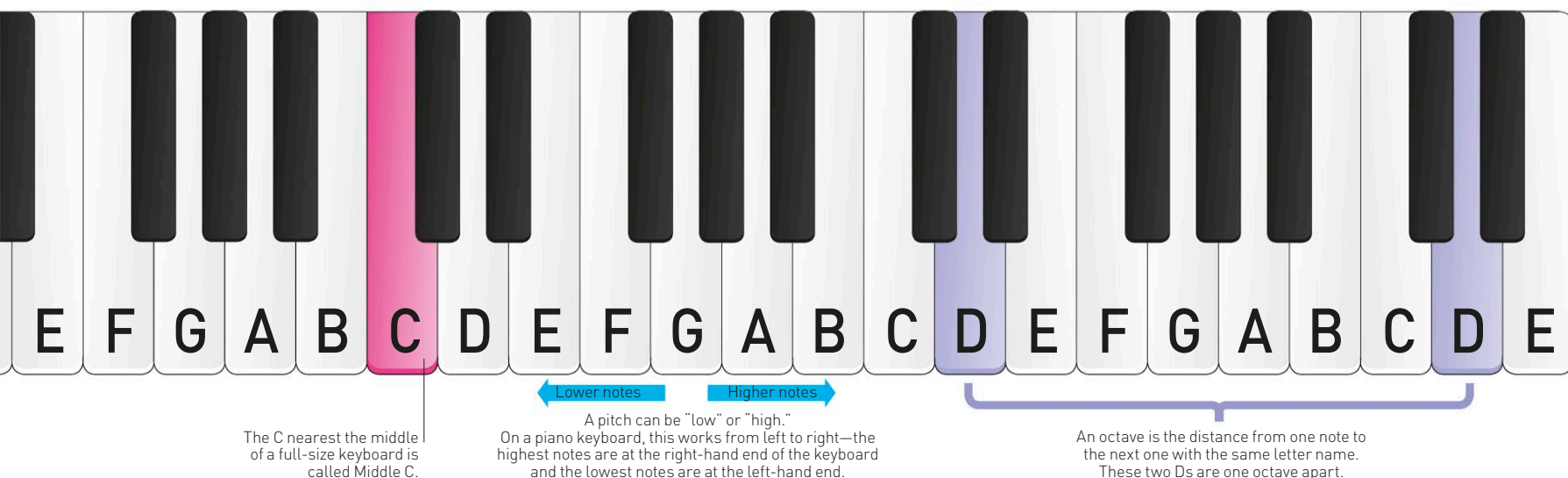


## TIME SIGNATURES

Time signatures appear at the beginning of a piece of music. The top number indicates the number of beats in a bar, and the bottom number shows the note value of each beat: 2 = half, 4 = quarter, 8 = eighth, and 16 = sixteenth.

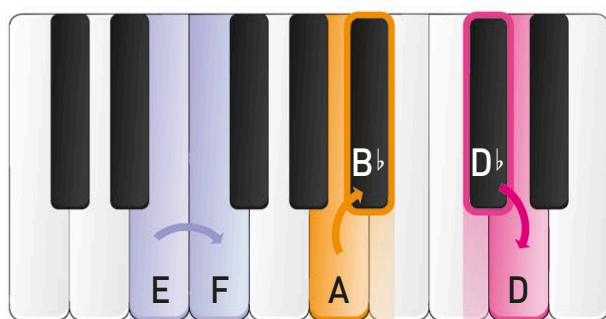




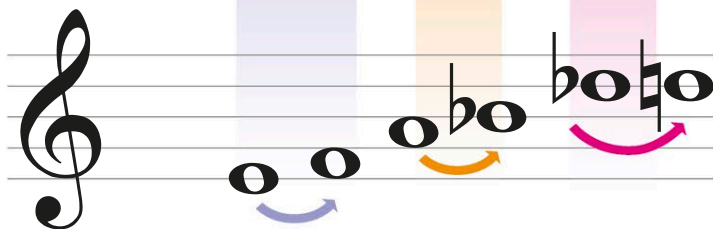


## SEMITONES

A semitone is the musical term for the interval, or gap, between notes that are immediately next to each other on the keyboard. A semitone means "half a tone" and represents a half step on the keyboard.

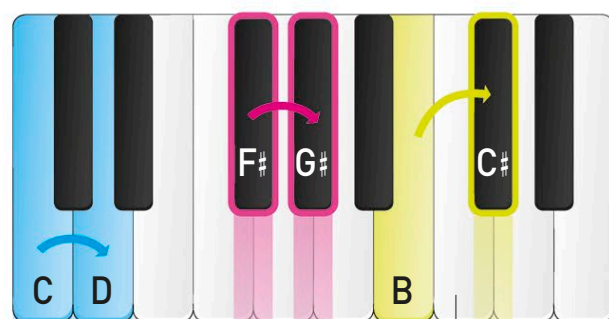


**ON THE STAFF**  
This is how the three semitones shown on the keyboard are written on the staff.

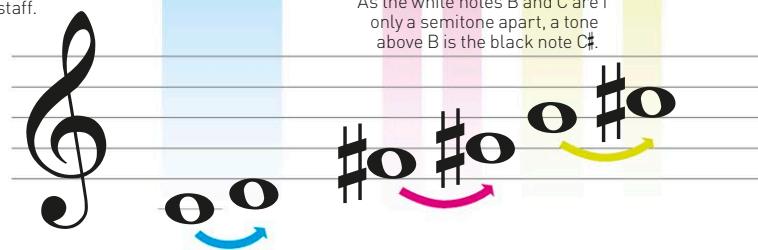


## TONES

A tone is the equivalent of two semitones. If two notes have just one note between them on the keyboard, they are a tone apart.



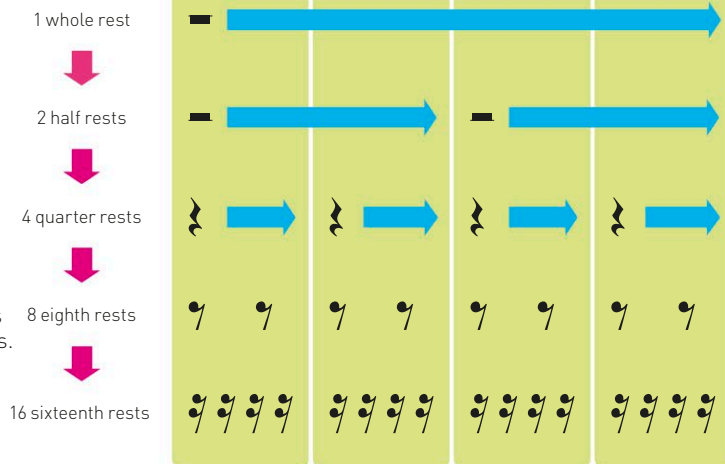
**ON THE STAFF**  
This is how the three tones shown on the keyboard are written on the staff.



## RESTS

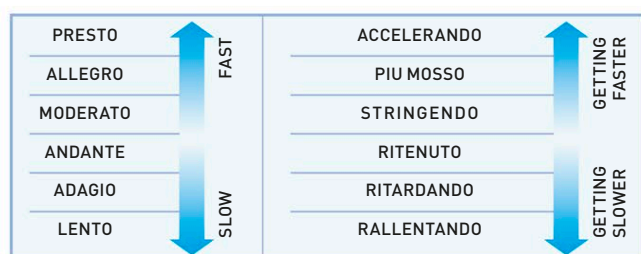
Rests assign a time value to silences—gaps in the music during which a player or singer does not produce any sound. They work just like notes and have the same time values. When performing (singing as well as playing) or writing music, the rests are as important as the notes.

**TIME VALUES**  
The chart shows rests and how their time values relate to each other.



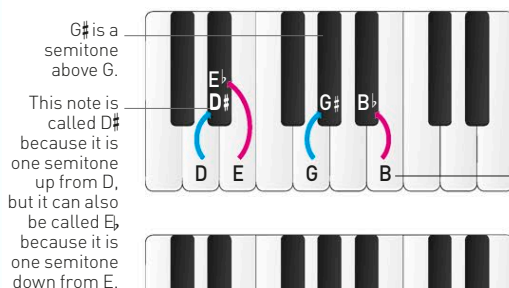
## TEMPO

The speed at which music is played is known as tempo. Tempo is usually indicated by descriptive terms. Shown here are some of the most common Italian terms for tempo and tempo changes.



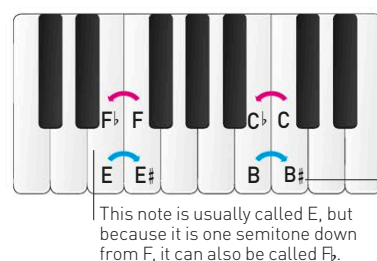
## SHARPS AND FLATS

Sharps and flats are symbols that raise or lower notes on the keyboard. Sharps raise a note by one semitone, and flats lower a note by one semitone. Notes that are not sharpened or flattened are called naturals.



**SHARPS AND FLATS ON BLACK NOTES**  
The black notes are sharps or flats depending on whether the white notes are above or below them.

**SHARPS AND FLATS ON WHITE NOTES**  
The white notes on the keyboard have different names. They can be known as naturals, sharps, or flats.



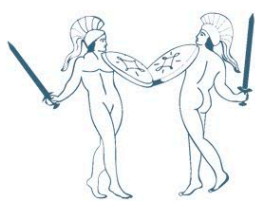


# Dance

All over the world and in every culture, people enjoy dancing—moving their bodies to music with a partner, in groups, or solo. People dance to tell stories, express their faith, show their patriotism, keep fit, get ready for battle or sports, celebrate an important event, compete, or purely for fun.

## SACRED DANCE

Dance plays an important part in many religions. People include dance in their religious ceremonies or to communicate with their gods.



### CORYBANTES

In ancient Greek myths, these sons of Apollo danced and drummed in armor.



### BUDDHISM

Dancing figures are often used to decorate Buddhist shrines.



### MUSLIM DERVISHES

Spin themselves into a state of ecstasy so they can feel closer to God.



### NATIVE AMERICANS

Danced to ask the gods for such things as rain or a good harvest.



### SHIVA NATARAJA

Hindu god Shiva is often shown dancing at the creation of the world.

## FOLK DANCING

People perform folk dances at festivals and celebrations. The dances are often accompanied by traditional music and are passed down through generations.



### FLAMENCO

A dramatic, rhythmic dance that originated in southern Spain.



### ROMA DANCE

Often performed at family weddings and christenings.



### LATVIAN DANCE

The Latvian Song and Dance Festival is a huge annual event.



### ARABIC DANCE

Middle Eastern belly dance, usually performed by a solo woman.



### IRISH DANCE

Often performed at competitions, either solo or in teams.



### AFRICAN DANCE

African dance is often accompanied by drums and voices.

## CLASSICAL DANCE

Classical dance is performed by trained or professional dancers. The focus is on formal steps and poses. These dances usually tell stories from literature or legend.



### INDONESIAN

This style, called *bedhaya*, is performed only by women.



### CAMBODIAN

A slow style, with smooth, wavelike movements.



### KATHAKALI

South Indian dance-drama performed in elaborate make-up.



### KABUKI

Japanese theatrical dance performed in colorful costumes.



### BALLET

The classical dance form of most Western countries.



### BALINESE

A story-telling dance form, always performed barefoot.

## DANCE CRAZES

Some dance crazes caused outrage when they first appeared. In the 1780s, people were shocked by the waltz because men and women embraced as they danced.

### CANCAN

The cancan was a lively, high-kicking dance that became wildly popular in the ballrooms and music halls of Paris, France, in the 1830s.

### JITTERBUG

An energetic, acrobatic couples' dance that originated in the US in the 1930s. It spread to Europe via American servicemen during World War II.

### TWIST

The twist was a 1960s craze. There were no steps to learn and no partner needed—dancers just wriggled and twisted along to the music.

### LINE DANCING

Dancers line up in a row and perform a pattern of steps together to country music. Line dancing started in the US in the 1970s but became a worldwide craze in the 1990s.

### GANGNAM STYLE

An overnight dance sensation in 2012, when a video of Korean musician Psy performing his song of the same name went viral.



### CANCAN



### JITTERBUG



### TWIST



### LINE DANCING

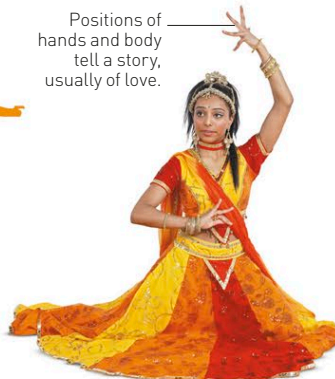


### GANGNAM

## BOLLYWOOD DANCE

Films made in Bollywood (the Hindi film industry centered in Mumbai, India) are famous for song-and-dance routines. In early films, dancers just acted out song lyrics, but the style is now a rich mix that includes different Indian styles.

Positions of hands and body tell a story, usually of love.



### BHARATANATYAM

A classical dance from south India, which features expressive hand movements and poses.



### BHANGRA

A folk dance from the state of Punjab, usually accompanied by a strong drum beat.

Both arms are raised during the dance.

Kicks and jumps are often used.





Jeweled headpiece

## COSTUMES

The costume enhances a dancer's movements or helps set the scene of a story. Costumes are a traditional element of many dance forms, and their design has changed little over time.



### IRISH DANCER

Dresses have long sleeves and a short skirt to emphasize leg movements.



### BALLET

A short, sleeveless tutu shows off a dancer's form and technique.



### INDIAN

Bharatanatyam costumes are based on Hindu temple sculptures.



### BELLY DANCER

The *bedlah* consists of a fitted bikini top, hip belt, and long skirt.



### BALLROOM

Long dress with full, flowing skirt to enhance a dancer's movements.

## BALLROOM DANCING

Ballroom dancing is both a popular hobby and a competitive, professional sport. The two main categories in competition dance are ballroom dances such as the waltz and foxtrot and Latin dances such as the tango.

Jangling bracelets draw attention to arm movements.

**THE SAMBA IS TRADITIONALLY DANCED AT THE RIO CARNIVAL, A FAMOUS FESTIVAL IN BRAZIL.**



### SAMBA

A fast, rhythmic dance from Brazil.



### RUMBA

The slowest of the Latin dances.



### CHA-CHA

Originated in Cuba via the West Indies.



### WALTZ

A popular, gliding dance from Austria.



### TANGO

Dramatic dance from Buenos Aires, Argentina.



### SALSA

Latin dance popular with amateurs.



### PASO DOBLE

Inspired by Spanish bullfighters' moves.

## STREET DANCE

New dance styles are always emerging from the streets of the world's cities. Breakdancing, or b-boying, came out of New York City in the 1970s and is still one of the most popular forms of street dance.



### ONE-HAND ELBOW LEVER

Balance on one bent arm, holding the body straight.



### FLARE

Breaker swings legs around him in a wide circle.



### WINDMILL

Breaker rotates while swinging legs in a V shape.



### HEADSPIN

Breaker balances on his head and spins rapidly.



### HANDSTAND FREEZE

Breaker balances, then holds the position.



Facial expressions help tell the story.



Intricate hand movements



### ARABIC

Arabic dance uses quick, vibrating movements of the body and requires a lot of stamina.

### TRADITIONAL BOLLYWOOD

Early Bollywood dance routines focused on acting out the lyrics of a song.

### DANDIYA

A folk dance from the state of Gujarat where dancers hit *dandiya* (sticks) together.

### KATHAK

A classical dance from Uttar Pradesh in northern India.

## DANCING SHOES

From the stomping drama of flamenco to the exquisite grace of ballet en pointe, wearing the correct footwear is essential.



BALLET



MALE TANGO



FEMALE TANGO



FLAMENCO



TAP



IRISH



BALLROOM

**BEFORE MATCHES, THE NEW ZEALAND RUGBY TEAM PERFORMS A MAORI WAR DANCE CALLED A HAKA.**

## SPORTS DANCE

Before a fight, Thai boxers perform a ritual dance called *Wai Khru Ram Muay* to pay respect to their trainers and apologize in advance for their brutality.



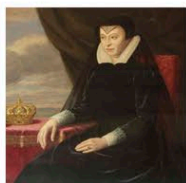
Mongkhon (headband)



# Ballet

Ballet started as an entertainment in the royal courts of Europe and has grown into a breathtaking art form enjoyed all over the world. Professional dancers work hard to reach the highest levels of fitness and artistry.

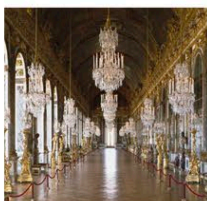
**1547**  
Italian Catherine de Medici becomes queen of France and brings an Italian style of dancing to the French court.



**Catherine de Medici**

**1661**  
First dance institution set up in Paris—l'Académie Royale de Danse.

**1680**  
King Louis XIV starts staging regular operaballets at Versailles.



**Palace of Versailles**

**1841**  
First performance of *Giselle*, danced by Italian ballerina Carlotta Grisi, takes place in Paris.

**1877**  
*Swan Lake*, with music by Tchaikovsky, is performed by the Bolshoi Ballet in Moscow, Russia.

**1913**  
*The Rite of Spring*, choreographed by Vaslav Nijinsky, causes outrage at its premiere in Paris.

**1964**  
Dancers Margot Fonteyn and Rudolf Nureyev receive a record 89 curtain calls after performing *Swan Lake* in Vienna, Austria.

## THE STORY OF BALLET

Ballet developed in France, which is why all the steps still have French names. It became a huge attraction in the great theaters of France, Italy, Russia, Scandinavia, and England.



**Statue of Louis XIV of France**

**1653**  
King Louis XIV dances the role of Apollo, the Sun god, in *Le Ballet de la Nuit* (The Dance of the Night).

**1669**  
Dancer and director Pierre Beauchamps develops the five basic positions of the feet and arms.



**Third position**

**1738**  
Imperial Russian Ballet School is founded in St. Petersburg, Russia.

**1832**  
*La Sylphide*, choreographed by Filippo Taglioni, opens in Paris, France.



**Mariinsky Theatre, home of the Russian Imperial Ballet from 1860**

**1890**  
The premiere of *Sleeping Beauty* is performed at the Mariinsky Theatre, St. Petersburg.

**1909**  
Ballet impresario, or organizer, Sergei Diaghilev forms the *Ballets Russes* company in Paris.

**1931**  
The Sadler's Wells Ballet (renamed the Royal Ballet in 1959) is formed in London.



**Sculpture outside the Royal Opera House, home of the Royal Ballet**

**2006**  
Director Wayne McGregor's *Chroma*—a mix of classical ballet and contemporary rock music—is performed at London's Royal Opera House and is a great success.

## YEARS OF TRAINING

Most professional dancers start young. After 8–10 years of dedicated training, only a few of the most talented students will join a ballet company. The best dancers might progress to become a soloist or principal dancer.



### BEGINNER

Dancers begin around age 5, taking classes at a local studio.

### BALLET SCHOOL

At the age of 11, the dancer is accepted at a ballet school.

### APPRENTICE

At 16, the most promising students go on to three more years' study.

### CORPS DE BALLET

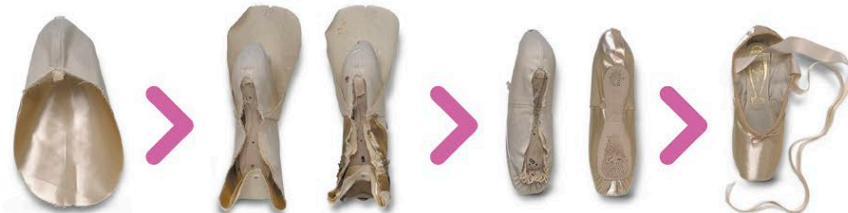
The dancer joins a company's corps de ballet (a group of ballet dancers that perform minor roles).

### PRINCIPAL

At this highest rank, a dancer performs all the leading roles.

## MAKING A POINTE SHOE

Female dancers wear special reinforced shoes so they can dance on the tips of their toes, a technique called en pointe. Dancers often embroider the toe area to make shoes last longer and to help prevent slipping.



### 1 SHAPING THE UPPER

Layers of satin and stiff canvas are stitched together.

### 2 ADDING TOE BLOCKS

A leather sole is inserted, then layers of card, paper, and stiff fabric are pasted around the toe area to form a block.

### 3 SHAPING THE SHOE

The sole is stitched to the upper with thread. The shoe is then shaped with a special hammer.

### 4 ADDING RIBBONS

Traditionally, a dancer sews the ribbons on to her shoes herself.

## CLASSIC BALLET

The fashion for full-length ballets reached its height at the end of the 19th century. Many of the ballets from that time are still popular today.

### ○ GISELLE, 1841, ADAPTED 1884

A young girl is betrayed by the man she loves. She dies of grief, then comes back as a ghost and saves the life of the man who broke her heart.

### ○ COPPÉLIA, 1870

A light-hearted tale of a young man who falls for a life-sized doll before realizing that his true love is the real, live girl next door.

### ○ SWAN LAKE, 1877

A handsome prince falls in love with a mysterious girl, only to discover that an evil magician has cast a spell on her.

### ○ THE NUTCRACKER, 1892

Toys magically come to life and take their owner on a journey to the Kingdom of Sweets, where the Sugar Plum Fairy lives, in this Christmas story.

### ○ THE FIREBIRD, 1910

Based on several Russian folk tales, it tells the story of how Prince Ivan and the magical Firebird overcome an evil magician called Koschei.

## COSTUME DESIGN

Costumes tell the audience about a character but must also allow a dancer to move freely. Below is the costume for a character from Greek myth called Eurydice, who is taken to the gloomy Underworld when she dies.



Fabric swatches

Color samples

### FROM SKETCHPAD TO STAGE

When Eurydice first appears, she is weighed down by a heavy cloak. The costume is designed so that she can remove it easily after she makes her dramatic entrance.

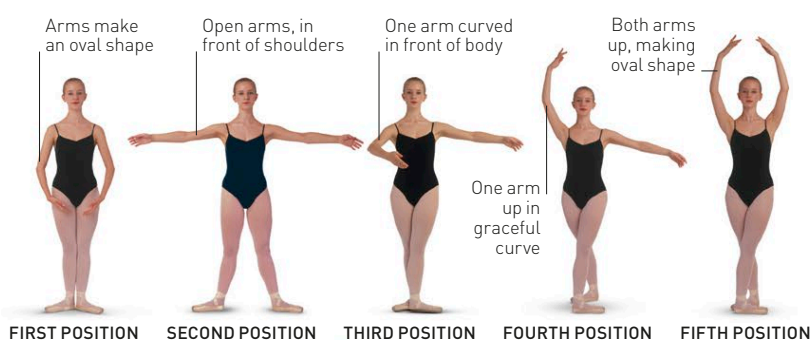
Wispy chiffon skirt suggests the spirit world.

Cloak will be removed and hung up to become part of the set.



## THE BASIC POSITIONS

All the positions and steps in ballet are based on the five basic positions of the feet and arms. For all five, the feet are flat on the floor and turned out (pointing in opposite directions).



FIRST POSITION SECOND POSITION THIRD POSITION FOURTH POSITION FIFTH POSITION

## AT THE BARRE

The barre is a handrail in the studio. Dancers hold on lightly to the barre so they can keep their balance while they concentrate on moves and positions.



**DEMI-PLIÉ**  
Half-bend the legs, heels flat on the floor.  
**ATTITUDE DEVANT**  
Stand on one leg and raise the other leg in front, with knee bent.  
**RELEVÉ DEVANT**  
Balance on the ball of one foot and bend the other leg at the knee.

## CHANGEMENT

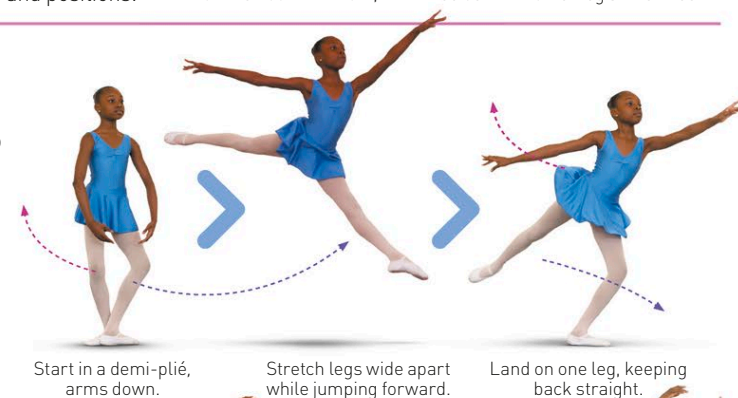
This jump goes straight up and down, with the front foot changing to the back in midair. The movement should be done with an easy bounce—this is called ballon. Practicing several in a row will build up a stronger jump.



Start in the demi-plié position. Jump, swap feet positions in the air. Land softly in a deep demi-plié.

## SISSONE OUVERTE EN AVANT

A sissone is a jump starting from two feet. There are different kinds, but in this version, the legs open wide in the air, then the dancer lands on one leg.

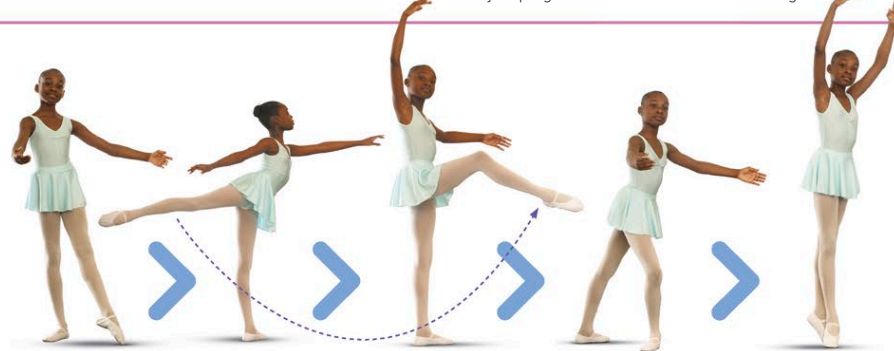


Start in a demi-plié, arms down. Stretch legs wide apart while jumping forward. Land on one leg, keeping back straight.

**A PROFESSIONAL BALLET DANCER CAN USE UP TO 10 PAIRS OF BALLET SHOES IN A WEEK.**

## ADAGE

Adage means "moving smoothly." Dancers put together a series of positions to make an exercise that improves balance and strengthens muscles.



**TENDU DEVANT**  
Look to the front of the room.  
**ARABESQUE**  
Supporting leg is turned out.  
**ATTITUDE**  
Leg passes through first position.  
**CHASSÉ**  
Foot placed in wide fourth position.  
**RELEVÉ FIFTH**  
Feet in demi-pointe and arms lifted.

## PAS DE CHAT

This means "cat step" in French. To perform it properly, a dancer must spring quickly and land lightly and quietly, just like a cat.



Start in third position with demi-plié. Push up from the floor, lifting one leg smoothly. Spring into the air, bringing the feet together. Land on the back foot, softly and quietly. Bring the front foot down quickly into third position.

## PAS DE DEUX

A pas de deux is a dance for two people, usually a man and a woman. It is a musical, physical, and artistic partnership between two dancers that can result in the most breathtaking moments in a performance.



**SUPPORTING ACT**  
The male dancer supports the ballerina so she can balance en pointe for longer.  
**FISH DIVE**  
A lift in which the ballerina is supported with her back arched and arms outstretched.

**EXPRESSING EMOTION**  
The pas de deux often portrays a romantic vision of love.

Strong knees and thighs are essential for supporting and lifting.

Male dancers always gaze at the ballerina.



# Great buildings

The first great buildings were constructed for worship or for protection from invaders. In more recent times, many grand buildings are public spaces such as galleries and museums or towering skyscrapers of offices and hotels.

c.2560 BCE

## GREAT PYRAMID AND SPHINX

The Great Pyramid was built as a tomb for Egyptian Pharaoh Khufu, and the Sphinx for his son, Khafre. Both were originally covered with smooth white limestone and would have glittered in the sunlight.



THE GREAT PYRAMID AND SPHINX AT GIZA, EGYPT

c.1900 BCE

## PALACE OF KNOSSOS

This was the largest center of the Minoan civilization on the Greek island of Crete. Here, religious ceremonies may have been performed and political issues debated. By uncovering the remains, experts have worked out what the buildings would have looked like.



ARTIST'S IMPRESSION OF THE PALACE BUILDINGS

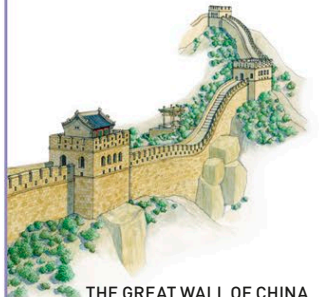


COPY OF A FRESCO FOUND AT KNOSSOS

c.700 BCE

## GREAT WALL

The Great Wall of China was built to keep out invaders. Various Chinese rulers extended it over hundreds of years, and it now stretches for an incredible 13,170 miles (21,197 km).



THE GREAT WALL OF CHINA DURING THE RULE OF THE MING DYNASTY (1368-1644)

1883

## SAGRADA FAMILIA

This Roman Catholic church is Barcelona's most famous building. It was designed by the Spanish architect Antoni Gaudi, who died in 1926, when only a quarter of the church was built. It is expected to be completed by 2026.

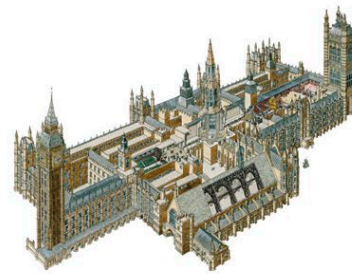


SAGRADA FAMILIA, BARCELONA, SPAIN

1840

## HOUSES OF PARLIAMENT

The United Kingdom's center of government was built on the site of a palace, which burned down in 1834. The remains were incorporated into the new Gothic-style building. Construction took 30 years, and its architects died before completion.



THE HOUSES OF PARLIAMENT, LONDON, UK

1714

## CHRIST CHURCH

This London church is one of six designed by Nicholas Hawksmoor in a style called English Baroque. It fell into disrepair in the 20th century but has been restored to its original glory, and its white stone facing gleams in the sunshine.



CHRIST CHURCH, LONDON, UK

1632

## TAJ MAHAL

The Taj was built to be an elaborate jeweled tomb for Mumtaz Mahal, the beloved wife of Mughal emperor Shah Jahan. Framed by four elegant minarets, it is known for its perfect symmetry: it is exactly as wide as it is high.

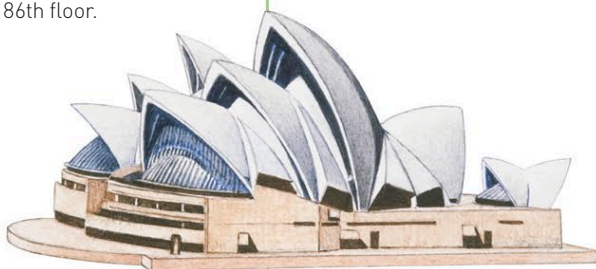


THE TAJ MAHAL, AGRA, INDIA

1930

## EMPIRE STATE BUILDING

It took around 3,400 workers to complete the construction of this 103-floor Art Deco skyscraper in just 410 days. It was the world's tallest building until 1972, and remains New York City's most famous landmark. Every year, there is a race to the 86th floor.



SYDNEY OPERA HOUSE, AUSTRALIA

1959

## SYDNEY OPERA HOUSE

A multivenue performing arts center, Sydney Opera House was designed by Danish architect Jorn Utzon in a style called Modern Expressionism. The building's distinctive sail-like roof structures are covered in 1 million self-cleaning, glazed white tiles.

1971

## POMPIDOU CENTRE

Housing a library, a museum of modern art, and a center for music research, the Pompidou is a high-tech arts center. The different-colored parts are not just ornamental: green pipes indicate plumbing; blue ducts are for climate control; elevators, escalators, and staircases are red.



POMPIDOU CENTRE, PARIS, FRANCE

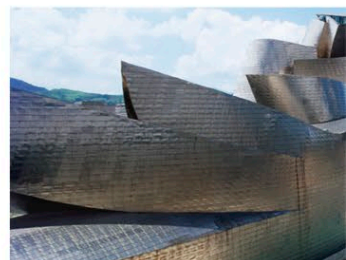


MODEL OF THE POMPIDOU

1993

## GUGGENHEIM MUSEUM

The Guggenheim in Bilbao, Spain, is one of the world's most admired and popular buildings. Its architect, Canadian Frank Gehry, intended its shiny curves to appear random and sculpturelike.



THE GUGGENHEIM, BILBAO, SPAIN

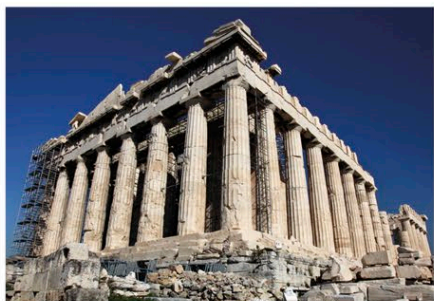
EMPIRE STATE BUILDING, NEW YORK CITY



▶ **432 BCE**

## PARTHENON

The Parthenon's architects decided to make their temple to the goddess Athena the most impressive in ancient Greece, and today it is one of the great monuments of the ancient world. The Parthenon has many columns and is decorated with carved panels and a sculpture frieze.

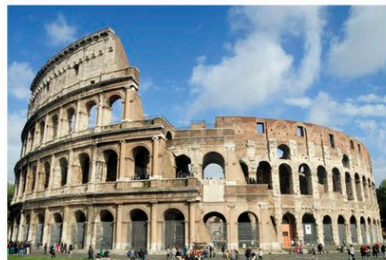


THE PARTHENON,  
ATHENS, GREECE

▶ **80 CE**

## COLOSSEUM

This was the greatest amphitheater in ancient Rome. As many as 50,000 people gathered here to watch dramas, gruesome gladiator battles, and amazing spectacles. In the arena were passages, trapdoors, and hidden elevators to allow animals and fighters to appear from beneath the ground.

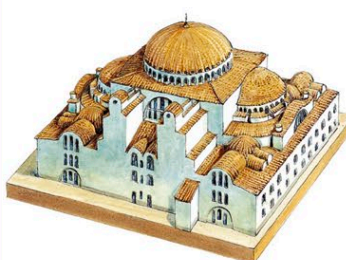


THE COLOSSEUM,  
ROME, ITALY

▶ **537 CE**

## HAGIA SOPHIA

The cathedral church in Constantinople (now Istanbul) was the largest in the world for 1,000 years. This Byzantine masterpiece is famous for its massive dome and for the ornate mosaics and marble pillars inside. Today, Hagia Sophia is a museum.



HAGIA SOPHIA,  
ISTANBUL, TURKEY

▶ **1113–1150**

## ANGKOR WAT

Meaning "City of Temples," Angkor Wat is the largest temple complex in the world. It was built to symbolize the home of the Hindu gods, Mount Meru. Its five towers represent the five peaks of the mountain, the walls its mountain ranges, and the moat the ocean.

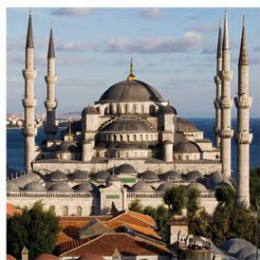


ANGKOR WAT, SIEM REAP,  
CAMBODIA

◀ **1609**

## BLUE MOSQUE

This mosque was built as an Islamic place of worship that would match the brilliance of the Hagia Sophia cathedral. Its design mixes traditional Islamic and Byzantine Christian architecture. It is named for its blue-tiled interior.

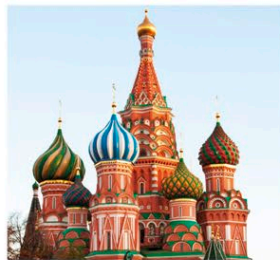


BLUE MOSQUE,  
ISTANBUL, TURKEY

◀ **1552**

## ST. BASIL'S CATHEDRAL

Built under the reign of Ivan the Terrible, this cathedral was designed to look like the flames of a bonfire rising up to the sky. It is famous for its unique, colorful, and ornate appearance.



ST. BASIL'S CATHEDRAL,  
MOSCOW, RUSSIA

◀ **1406**

## TEMPLE OF HEAVEN

This temple complex is intended to symbolize Heaven and Earth. Its most important building is the Hall of Prayer for Good Harvests, where sacred ceremonies were conducted by the Chinese emperors.



THE HALL OF PRAYER FOR GOOD  
HARVESTS, BEIJING, CHINA

◀ **1333**

## HIMEJI CASTLE

Also known as White Heron Castle, Himeji is Japan's largest and best preserved castle. It was built as a fortress, and its multiple moats, fortified gates, and winding passages were designed to confuse and exhaust intruders.



HIMEJI CASTLE,  
JAPAN

◀ **1238**

## ALHAMBRA PALACE

A palace and fortress built by Moorish (North African Muslim) kings of southern Spain, the Alhambra was designed to represent Paradise on Earth. There are enclosed landscaped gardens, and the palace is lavishly decorated.

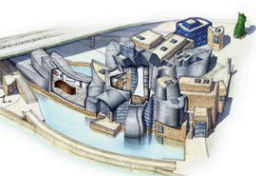


THE ALHAMBRA PALACE,  
GRANADA, SPAIN

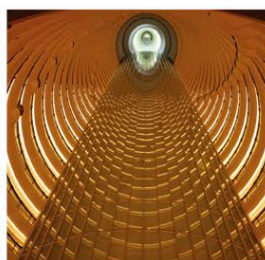
▶ **1994**

## JIN MAO TOWER

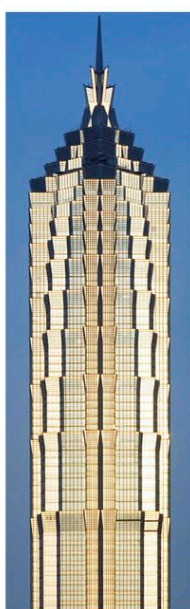
Traditional Chinese and modern Western architectural styles are combined in this Shanghai skyscraper. Each tier flares outward at its top like a pagoda-style roof. The tower is covered in glass and designed to be wind and earthquake resistant. There is a swimming pool on the 57th floor.



THE GUGGENHEIM  
AND SURROUNDING  
BUILDINGS



INSIDE THE JIN  
MAO TOWER



JIN MAO TOWER,  
SHANGHAI, CHINA

▶ **2004**

## BURJ KHALIFA

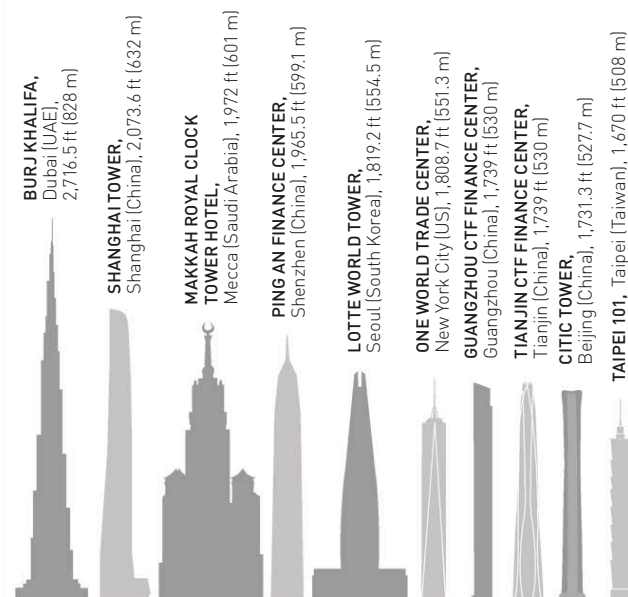
With 163 floors, Burj Khalifa is the world's tallest building. It is topped with a spiral minaret, like those on mosques. Its 24,348 windows are machine-cleaned, but the top of the spire is cleaned by hand, with the workers dangling from ropes.



BURJ KHALIFA, DUBAI,  
UNITED ARAB EMIRATES

## TOP 10 TALLEST SKYSCRAPERS

A skyscraper is a building used for offices, homes, or hotels that is higher than 450 ft (150 m).





# Great books

Thousands of years ago, stories were simply spoken aloud or told with pictures. As writing developed, tales were inscribed on clay and stone, then on parchment and paper. Great books transport us to different lives and are enjoyed by generations of readers all over the world.

► 2ND MILLENNIUM BCE

## THE EPIC OF GILGAMESH

This poem was inscribed on clay tablets and is among the first pieces of written literature. It describes the journey of Gilgamesh, king of Uruk, who is on a quest with a wild man to fight evil.

“Humbaba’s mouth is fire; his roar the floodwater; his breath is death.”

► C.16TH–1ST CENTURY BCE

## THE EGYPTIAN BOOK OF THE DEAD

This collection of drawings and magic spells was written over hundreds of years in ancient Egypt. The spells were buried with the dead to help them in their next life in the Underworld.



A PAGE FROM THE BOOK OF THE DEAD

► C.4TH–2ND CENTURY BCE

## INDIAN EPICS

*Mahabharata* by Vyasa and *Ramayana* by Valmiki are important Sanskrit poems that began as songs long before they were written down. They tell stories about Indian culture, Hinduism, great wars, and exciting adventures.



A WARRIOR FROM THE MAHABHARATA

◀ 1908

## ANNE OF GREEN GABLES

L. M. Montgomery tells a heart-warming tale about an orphan with a wonderful imagination. Anne is sent to a family who asked for a boy, but she thrives in her new home.

“Because when you are imagining, you might as well imagine something worthwhile.”

◀ 1894

## SEVEN LITTLE AUSTRALIANS

This delightful story by Ethel Turner is about the mischievous Woolcot children, running wild at their home in Sydney.



BABY WOOLCOT WASHES THE KITTENS

◀ 1876



TOM SAWYER

## THE ADVENTURES OF TOM SAWYER

Wily Tom Sawyer plays tricks on everyone, but after he witnesses a murder, the games get serious. Mark Twain’s adventures include grave robbers, children lost in caves, and a box of gold.

◀ 1861

## GREAT EXPECTATIONS

Charles Dickens’s story about Pip on his journey to becoming a gentleman includes bitter old Miss Havisham. She has been wearing her wedding gown ever since she was jilted at the altar.

“Ask no questions and you’ll be told no lies.”

◀ 1847

## JANE EYRE

In Charlotte Brontë’s novel, Jane Eyre has a harsh upbringing as an orphan. When she becomes a governess, she falls in love with her employer, Mr. Rochester, who has a terrible secret in his house.

“I am no bird; and no net ensnares me.”

► 1935

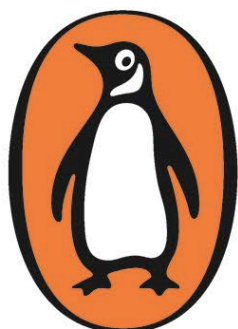
► 1937

► 1937

► 1943

► 1945

► 1947



THE PENGUIN LOGO

## PENGUIN PAPERBACKS

Most quality books were published with expensive hard covers until Allen Lane created Penguin paperbacks. He wanted people everywhere to be able to read good books in a format that they could afford.

## OF MICE AND MEN

John Steinbeck tells a sad, bleak story about two farmhands struggling to find work during the Great Depression. George tries to look out for his strong, slow-witted friend Lennie, who dreams of farming rabbits.



LENNIE’S MOUSE

## THE HOBBIT

For this story, J. R. R. Tolkien created a complete world called Middle Earth filled with hobbits, wizards, elves, dwarves, and trolls. On his quest to steal a dragon’s treasure, Bilbo Baggins meets many dangers and finds a powerful magic ring.



THE RING



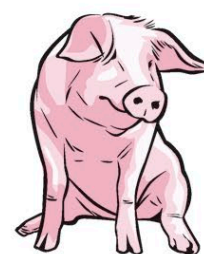
THE LITTLE PRINCE’S HOME PLANET

## THE LITTLE PRINCE

This magical little story from Antoine de Saint-Exupéry tells the tale of a pilot who is stranded in the desert. He comes across a little prince, who has fallen to Earth from another planet.

## ANIMAL FARM

George Orwell was making a political point with this story about animals taking over a farm to create an equal society. Things go very wrong after Napoleon the pig seizes power.



NAPOLEON THE PIG


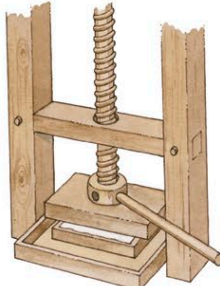

## THE DIARY OF A YOUNG GIRL

Anne Frank was 13 when she and her family went into hiding from the Nazis in World War II. The diary she wrote in their secret rooms has been translated into 70 languages.




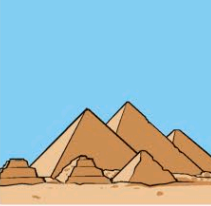




ANNE FRANK’S DIARY



<p>▶ <b>c.2ND CENTURY BCE</b></p> <p><b>INVENTION OF PAPER</b></p> <p>Before the invention of paper by a resourceful Chinese civil servant named Cai Lun, writers used parchment, papyrus, or palm leaves.</p>  <p>PAPER AND BRUSH</p>	<p>▶ <b>c.700–1500 CE</b></p> <p><b>ARABIAN NIGHTS</b></p> <p><i>Arabian Nights</i> (also called <i>One Thousand and One Nights</i>) is a collection of captivating stories compiled over many centuries. Two of the best known are <i>Ali Baba and the Forty Thieves</i> and <i>Sinbad the Sailor</i>.</p> <p>“Open Sesame!” <i>(Ali Baba and the Forty Thieves)</i></p>	<p>▶ <b>c.750–1000</b></p> <p><b>BEOWULF</b></p> <p><i>Beowulf</i> is an Old English poem about good and evil. The hero, Beowulf, destroys a terrible monster and then a dragon, but is killed during his last battle.</p> <p>“When a chance came, he caught the hero in a rush of flame and clamped sharp fangs into his neck.”</p>	<p>▶ <b>c.1440</b></p> <p><b>THE PRINTING PRESS</b></p> <p>The invention of the printing press by Johannes Gutenberg changed everything. Many more books were available, and ordinary people could own them for the first time.</p>  <p>THE PRINTING PRESS</p>	<p>▶ <b>c.1595</b></p> <p><b>ROMEO AND JULIET</b></p> <p>William Shakespeare wrote 37 brilliant plays and many sonnets. One of his most famous plays, <i>Romeo and Juliet</i>, tells the tragic story of two young lovers whose families are fierce rivals.</p>  <p>ROMEO'S POISON AND DAGGER</p> <p>“O Romeo, Romeo, wherefore art thou Romeo?”</p>
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<p>◀ <b>1831</b></p> <p><b>THE HUNCHBACK OF NOTRE DAME</b></p> <p>Up in the towers of the Notre Dame Cathedral in Paris lives the hunchback Quasimodo. In Victor Hugo's story, this tragic hero tries to save a kind gypsy dancer from death.</p>  <p>NOTRE DAME CATHEDRAL</p>	<p>◀ <b>1813</b></p> <p>“Angry people are not always wise.”</p> <p><b>PRIDE AND PREJUDICE</b></p> <p>Finding husbands for five daughters is a major challenge in the Bennet family. Jane Austen's complicated romance between Elizabeth Bennet and Mr. Darcy is now a classic of English literature.</p>	<p>◀ <b>1812</b></p> <p><b>GRIMMS' FAIRY TALES</b></p> <p>The Brothers Grimm wrote many gruesome fairy tales with wicked characters that still frighten and thrill children today. <i>Little Snow White</i> and <i>Little Red Riding Hood</i> are two of the most famous.</p> <p>“Mirror, mirror, on the wall, who in this land is the fairest of all?” <i>(Little Snow White)</i></p>	<p>◀ <b>18TH CENTURY</b></p>  <p>A TRADITIONAL CHINESE FAN</p> <p><b>DREAM OF THE RED CHAMBER</b></p> <p>This classic Chinese novel by Cao Xueqin is about the rise and fall of the aristocratic Jia family. It has a huge number of characters and paints a vivid picture of life in 18th-century China.</p>	<p>◀ <b>1605</b></p> <p><b>DON QUIXOTE</b></p> <p>Don Quixote sets out on his lanky horse Rocinante with his sidekick Sancho Panza on a donkey. Miguel de Cervantes' hero is in search of a knightly quest and a maiden to woo, but most of his adventures happen inside his head.</p> <p>“Can we ever have too much of a good thing?”</p>
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<p>▶ <b>1950</b></p>  <p>THE WARDROBE</p> <p><b>THE LION, THE WITCH AND THE WARDROBE</b></p> <p>C. S. Lewis set his adventures in Narnia—the mysterious world of ice and snow that four children discover by walking through a door at the back of a wardrobe.</p>	<p>▶ <b>1952</b></p> <p><b>CHARLOTTE'S WEB</b></p> <p>In E. B. White's heart-warming story, Wilbur the pig is saved from slaughter by a supportive spider named Charlotte, who weaves flattering messages about him in her web.</p>  <p>CHARLOTTE IN HER WEB</p>	<p>▶ <b>1960</b></p>  <p>THE MOCKINGBIRD IS A SYMBOL OF INNOCENCE</p> <p><b>TO KILL A MOCKINGBIRD</b></p> <p>Two children learn harsh lessons about equality in Harper Lee's explosive novel set in Alabama. Their lawyer father defends a black man who is accused of a crime he did not commit.</p>	<p>▶ <b>1988</b></p> <p><b>THE ALCHEMIST</b></p> <p>Paulo Coelho's young shepherd, Santiago, tries to fulfill his “Personal Legend” by hunting for treasure. He learns valuable lessons on his journey.</p>  <p>SANTIAGO SEEKS TREASURE AT THE PYRAMIDS</p>	<p>▶ <b>1997</b></p> <p><b>HARRY POTTER AND THE SORCERER'S STONE</b></p> <p>The <i>Harry Potter</i> series by J. K. Rowling is about the adventures of a special young wizard named Harry and his school friends. In this first story, an evil wizard hunts for the Sorcerer's Stone so he can live forever.</p>  <p>THE SORTING HAT TELLS STUDENTS WHICH SCHOOL HOUSE THEY WILL BE IN</p>	<p>▶ <b>2005</b></p>  <p>BURNING BOOKS</p> <p><b>THE BOOK THIEF</b></p> <p>Markus Zusak's novel is narrated by Death. He tells the touching story of a young girl who steals books in Germany during World War II.</p>
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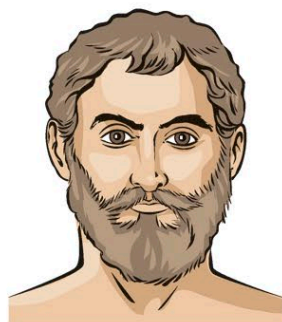
# Great thinkers

Throughout history, people have asked questions about the world and our place in it. Some great philosophers have come up with answers that have transformed our thinking—and others challenge us by posing new problems for us to think about.

◀ **c.624–546 BCE**

## THALES “THE WISE”

Thales lived in Asia Minor (modern Turkey). He had the idea that water was the basic ingredient of everything and that our world floated like a log in a Universe of water.



▶ **c.570–495 BCE**

## PYTHAGORAS

A Greek scientist, Pythagoras believed that everything in the Universe could be explained by mathematics. He led a group of followers who obeyed his strict code about how to live, work, and honor the gods.

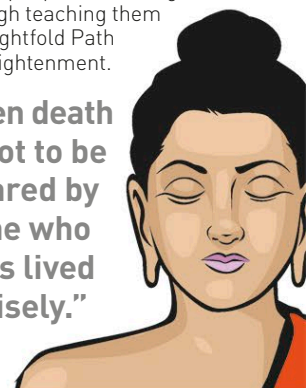


▶ **c.563–483 BCE**

## SIDDHARTHA GAUTAMA

Known as the Buddha, or “enlightened one,” he taught that nothing in the world is permanent. His goal was to end people’s suffering through teaching them the Eightfold Path to enlightenment.

“Even death is not to be feared by one who has lived wisely.”

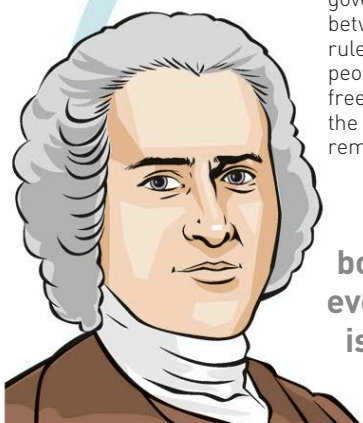


◀ **1712–1778**

## JEAN-JACQUES ROUSSEAU

Swiss-born key thinker in the Enlightenment. Rousseau held that government is a contract between people and their rulers. If rulers ignore people’s rights and freedoms, they break the contract and can be removed from power.

“Man was born free, but everywhere he is in chains.”



◀ **1711–1776**



## DAVID HUME

A Scottish founder of “skeptical” philosophy, Hume said that there is nothing we can know for certain. He believed knowledge came only from direct experience, not from a person’s ideas or religious beliefs.

◀ **1694–1778**

## VOLTAIRE

A French poet, playwright, and historian, Voltaire argued for free speech—that in a civilized society, everybody should have the right to say and think whatever they like.



◀ **1632–1704**

## JOHN LOCKE

Englishman John Locke believed that people have the right to control their own body, and no one can tell them what to do with it. His ideas about power and freedom influenced lawmakers in the newly formed US, who based the US Constitution of 1787 in part on Locke’s ideas.

“Where there is no law, there is no freedom.”

◀ **1596–1650**

## RENÉ DESCARTES

A French philosopher, scientist, and mathematician, Descartes started a revolution in philosophy by doubting everything—including whether he really existed. He decided that as he had thoughts, someone must be thinking them—so he must really exist.

“I think, therefore I am.”

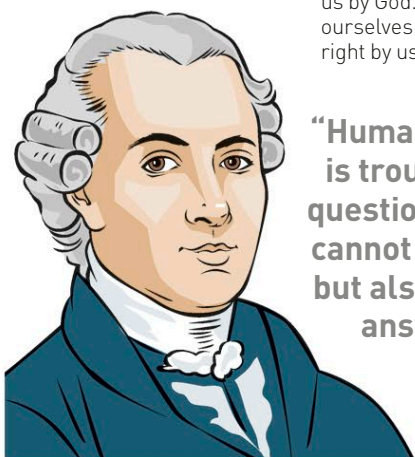


▶ **1724–1804**

## IMMANUEL KANT

Unlike many philosophers of his time, Kant believed that knowledge of what is right and wrong is not born in us or given to us by God. We decide for ourselves what is morally right by using reason.

“Human reason is troubled by questions that it cannot dismiss, but also cannot answer.”



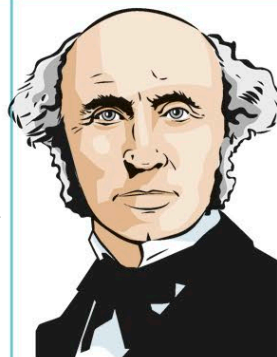
▶ **1759–1797**

## MARY WOLLSTONECRAFT

A British writer and teacher, she campaigned for women to have the same opportunities and rights as men. Her book, *A Vindication of the Rights of Women*, argued that girls should be educated as well as boys.



▶ **1806–1873**



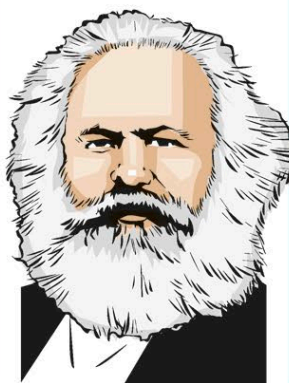
## JOHN STUART MILL

British economist and political thinker who believed that all people should be free to do whatever they choose, so long as it does not harm other people or prevent them from doing what they want.

▶ **1818–1883**

## KARL MARX

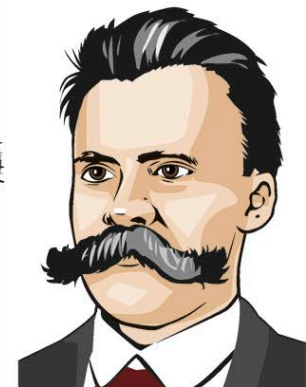
A revolutionary economist and thinker from Germany, Marx founded the theory of socialism, in which all the property, resources, and wealth of a country is owned by the public and not by individuals.



▶ **1844–1900**

## FRIEDRICH NIETZSCHE

A German writer whose main philosophy was that people should aim to achieve their full potential and be a “Superman” rather than an ordinary person.





► 551–479 BCE

## CONFUCIUS

One of the most important early Chinese philosophers, Confucius taught that in order to live good and happy lives, people should respect their neighbors, honor their families, and obey their rulers.

“To study and not think is a waste. To think and not study is dangerous.”

► 469–399 BCE

## SOCRATES

One of the greatest Greek thinkers, Socrates devised a way of testing theories that involved asking lots of questions until he arrived at the truth. To him, the most important question of all was: “What makes a good life?”

“I am not an Athenian or a Greek, but a citizen of the world.”

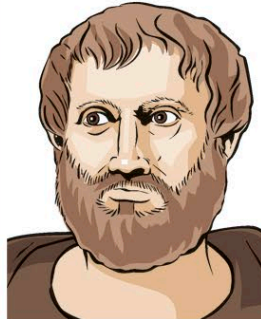
► 427–347 BCE

## PLATO

Plato thought that our world is a faulty reflection of a perfect world that exists somewhere else. He founded the world’s first university, the Academy, near Athens in Greece.



► 384–322 BCE



## ARISTOTLE

Plato’s pupil, Aristotle, is often called the first scientist. He believed that we should base our theories on on what we have seen and experienced for ourselves, rather than what we feel or hear is true.

► c.355–415 CE

## HYPATIA

An eminent Greek scholar and philosopher living in Egypt, Hypatia was a gifted teacher at the Neoplatonic school in Alexandria. She was also a well-known mathematician and astronomer.

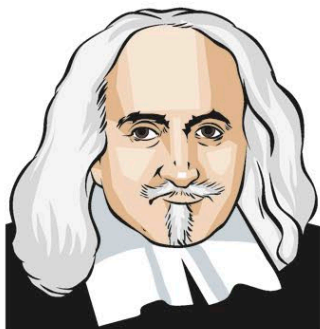
“... the lady who truly presides over the mysteries of philosophy.”

*Synesius of Cyrene, on Hypatia*

◀ 1588–1679

## THOMAS HOBBS

An English philosopher who believed that people are basically selfish. A civilized society needs to agree on a set of laws, then appoint a strong leader to make sure everyone obeys those laws.



◀ 1469–1527

## NICCOLÒ MACHIAVELLI

An Italian writer and diplomat. He wrote *The Prince*, a book of advice for politicians. In it, he argues that sometimes it is right for a leader to do terrible things, such as lying or even killing, if they are done for the good of his kingdom.

“The first method for estimating the intelligence of a ruler is to look at the men he has around him.”

◀ 1225–1274



## THOMAS AQUINAS

A noble-born Italian monk, he wanted to prove God’s existence through reason. He believed that it is obvious from observing the world that a supremely intelligent being must have created it, and this being must be God.

◀ 1126–1198

## IBN RUSHD (AVERROËS)

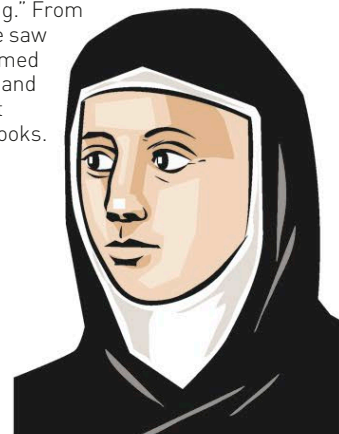
A Muslim philosopher from Córdoba in Spain. He studied Aristotle and Plato and tried to combine their scientific approach with Muslim religious views to create a unified idea of how the world works.



◀ 1098–1179

## HILDEGARD OF BINGEN

A German writer, composer, and nun, Hildegard wrote about how to treat physical diseases by “spiritual healing.” From the age of 6, she saw visions that seemed to be from God, and she wrote about them in many books.



► 1868–1963

## W. E. B. DU BOIS

An African-American historian, author, and campaigner, Du Bois fiercely opposed the widely held view of the time that white people were a superior race. He believed that all people were equal and deserved equal rights, whatever their ethnicity or gender.



► 1905–1980



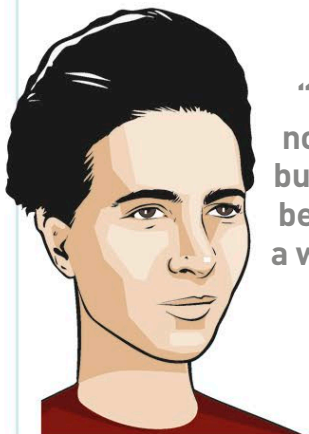
## JEAN-PAUL SARTRE

French writer and existentialist thinker. He believed that there is no God, and people have not been invented for any particular purpose: we must choose for ourselves what to do with our lives.

► 1908–1986

## SIMONE DE BEAUVOIR

French writer who argued that girls are not very different from boys when they are born. But because people treat women differently, they are forced to become submissive and obedient.



“One is not born, but rather becomes, a woman.”

► 1924–2019

## MARY WARNOCK

British philosopher of morality, Mary Warnock made significant contributions to science and education. She established guidelines for embryo research, which led to the Human Fertility and Embryology Act of 1990 in the UK. She also argued for children with special needs to be educated in mainstream schools.



► 1930–2004

## JACQUES DERRIDA

French philosopher who devised a way of thinking called “deconstruction.” Language must be pulled apart, or deconstructed, to show how there are no fixed meanings to words. In fact, words get in the way of the search for truth.

“To pretend, I actually do the thing: I have therefore only pretended to pretend.”



# Food around the world

Every country has traditional food, based on local ingredients and handed-down recipes. Once upon a time, you could get pizza only in Italy and sushi only in Japan. But today, the world is like one huge café—with tastes from every continent available in big supermarkets and on city streets.



## SOUTH AMERICA

Meat is a feast in South American countries, especially fine beef from cattle ranches on pampas grasslands. The continent's historic links with Spain and Portugal can be seen in stuffed empanadas; cheese-filled pastels; and colorful, spicy rice dishes.



TAMALES, BELIZE



TOSTONES, VENEZUELA



ARROZ CON POLLO, COLOMBIA



AREPAS, VENEZUELA



PASTELS, BRAZIL



ACARAJE, BRAZIL



BLACK BEAN AND PUMPKIN SOUP, BRAZIL



EMPANADAS, ARGENTINA



PUDIM DE ABÓBORA, BRAZIL



ROAST GUINEA PIG, PERU



PICADINHO, BRAZIL



LONGANIZA, URUGUAY



ICE CREAM WITH DULCE DE LECHE SAUCE, PARAGUAY



CEVICHE, PERU



QUIPE, ARGENTINA



DRY-RUB STEAK WITH CHIMICHURRI SAUCE, ARGENTINA



## NORTH AMERICA

People from many cultures have migrated to North America, introducing a wide range of food and recipes. The Thanksgiving roast turkey and pumpkin pie date back to the Puritan settlers, who cooked a feast of home-grown food to celebrate survival in their new land.



FRIED CHICKEN, US



HAMBURGER, US



HOT DOG, US



SWEETCORN CHOWDER, US



FAJITAS, MEXICO



ROAST TURKEY, US



## AFRICA

Food on this huge continent is full of flavors and scents—some from the Middle East and Asia. There are slow-cooked tagines and African curries, creamy dips with flatbread, and couscous with pomegranate seeds.



BRIK, TUNISIA



MECHOUIA, TUNISIA



SLADA BATATA HALWA, MOROCCO



TAGINE, MOROCCO



HARIRA, ALGERIA



COUSCOUS, TUNISIA



FERAKH MAAMER, MOROCCO



ZAHLOUK, MOROCCO



PASTILLA, MOROCCO



BABA GANOUSH, EGYPT



BOEREWORS, SOUTH AFRICA



GALINHA AFRICAN, MOZAMBIQUE



BOBOTIE, SOUTH AFRICA



BILTONG, SOUTH AFRICA



FUL MEDAMES, EGYPT





BLUEBERRY PIE,  
US



WALDORF SALAD, US



GUMBO, US



BURRITOS, MEXICO



## EUROPE

Traditional European dishes like Italian pizza and French coq au vin are served all over the world. A Mediterranean diet, rich in vegetables and olive oil, is the healthiest choice of all. But that doesn't stop people from enjoying English fish and chips or spicy German sausage.



FISH AND CHIPS,  
UNITED KINGDOM



ROAST BEEF,  
UNITED KINGDOM



LIMBURGSE VLAAI,  
THE NETHERLANDS



STOLLEN,  
GERMANY



ECLAIRS, FRANCE



QUICHE, FRANCE



COQ AU VIN, FRANCE



MOULES FRITES,  
BELGIUM



SAUERKRAUT,  
GERMANY



PICKLED HERRINGS,  
GERMANY



PAELLA,  
SPAIN



GAZPACHO, SPAIN



STRUDEL, AUSTRIA



GOULASH,  
HUNGARY



BAKLAVA,  
GREECE



FONDUE,  
SWITZERLAND



WIENER SCHNITZEL,  
AUSTRIA



SPAGHETTI  
BOLOGNESE, ITALY



TIRAMISU,  
ITALY



PIZZA,  
ITALY



## ASIA

Asian food has become popular everywhere. As well as spicy curries, there are delicately flavored dim sum dumplings, juicy kebabs, and hand-rolled sushi.



PASKHA, RUSSIA



BORSCHT, RUSSIA



TONKATSU, JAPAN



KEBABS,  
TURKEY



TABBOULEH,  
LEBANON



SUSHI, JAPAN



TEMPURA, JAPAN



KULFI, INDIA



THAI GREEN CURRY,  
THAILAND



DIM SUM, CHINA



TANDOORI CHICKEN, INDIA



SAMOSA, INDIA



KERALA FISH STEW,  
INDIA



BANH MI, VIETNAM



PHO GA, VIETNAM



PALAK PANEER, INDIA



MURG MAKHANI, INDIA



ICE KACHANG,  
SINGAPORE



SATAY,  
INDONESIA



NASI GORENG, INDONESIA



## AUSTRALIA AND OCEANIA

Barbecues are ideal for the outdoor life in sunny Australia. Ice-cream puddings such as Peach Melba are popular, too. In the Pacific Islands, cooks use Asian flavors and lots of fruit and fish.



COCONUT CHICKEN  
CURRY, MICRONESIA



BARBECUED CHICKEN,  
AUSTRALIA



ROUROU, FIJI



ANZAC BISCUITS,  
AUSTRALIA



PEACH MELBA, AUSTRALIA



KIWI FRUIT SALAD,  
NEW ZEALAND



PAVLOVA, NEW ZEALAND

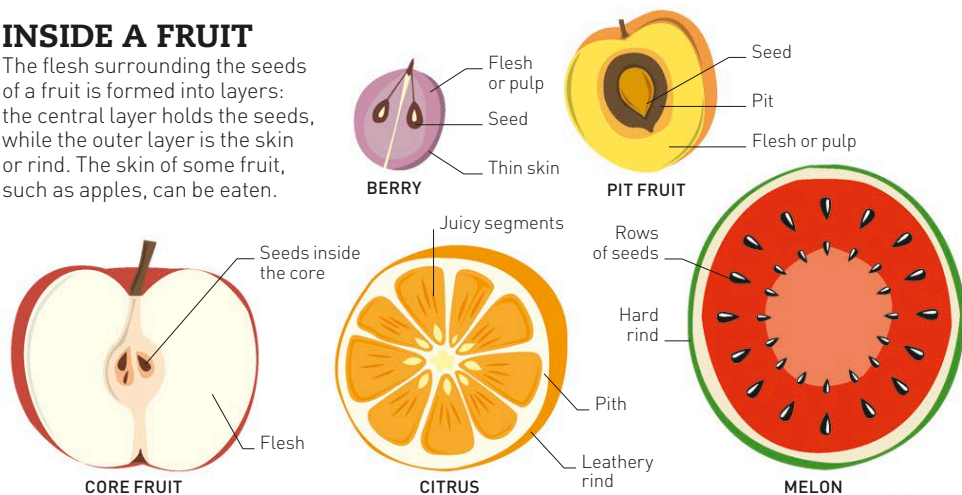


# Fruit

A fruit is the part of a plant that develops from its flowers. Each fruit contains a seed (or seeds) that is often surrounded by flesh and enclosed in a skin or rind. Many fruits are edible and full of sweet-tasting natural sugar.

## INSIDE A FRUIT

The flesh surrounding the seeds of a fruit is formed into layers: the central layer holds the seeds, while the outer layer is the skin or rind. The skin of some fruit, such as apples, can be eaten.



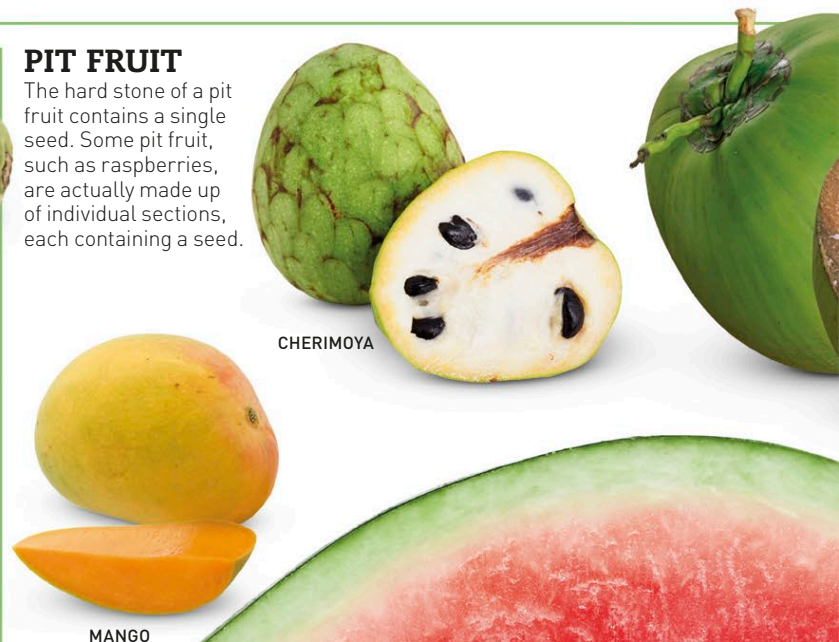
## BERRIES

A berry is a fruit with a seed, or seeds, that is produced from a single flower. The seeds are hidden in soft, often juicy flesh. Many smaller berries have edible skins.



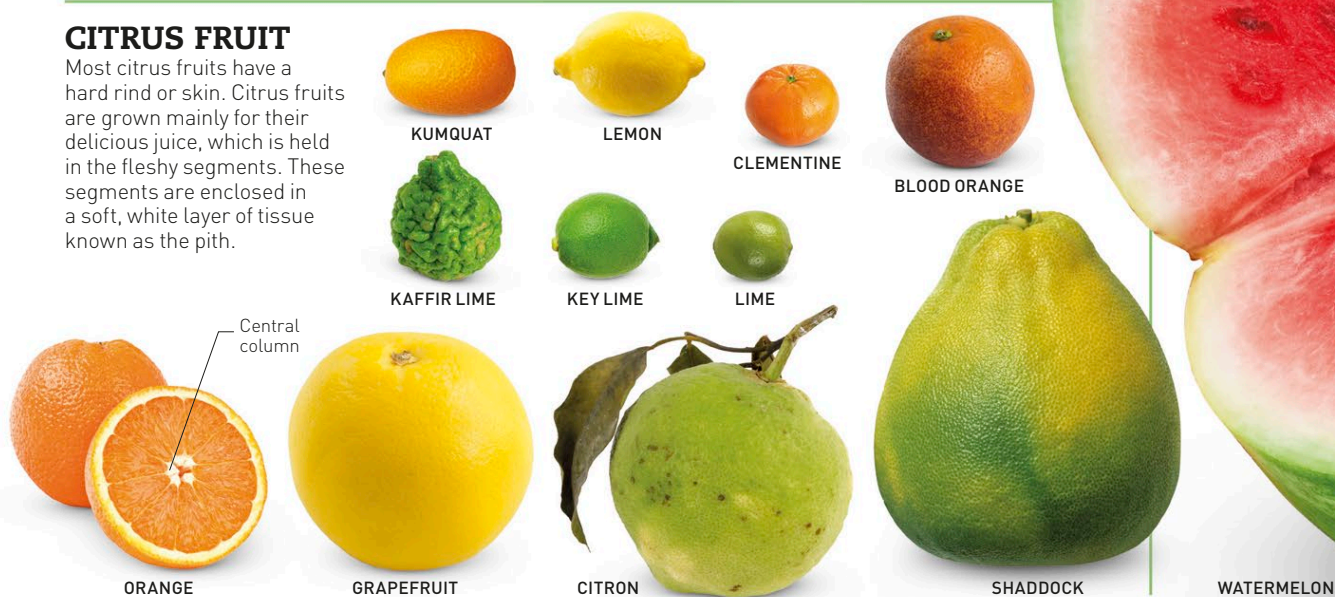
## PIT FRUIT

The hard stone of a pit fruit contains a single seed. Some pit fruit, such as raspberries, are actually made up of individual sections, each containing a seed.



## CITRUS FRUIT

Most citrus fruits have a hard rind or skin. Citrus fruits are grown mainly for their delicious juice, which is held in the fleshy segments. These segments are enclosed in a soft, white layer of tissue known as the pith.





## SPREADING SEEDS

Fruit seeds are spread in a number of ways. They can be blown by the wind, carried by water, or dropped when a fruit falls from a plant or tree. Often, seeds are spread by birds.

### 1 BIRD EATS FRUIT

Birds love to eat the bright fruits that hold the seeds.

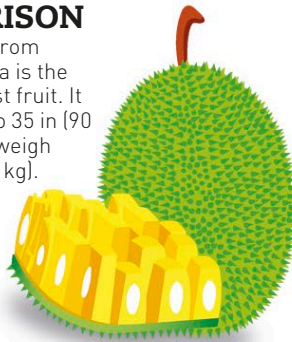
### 2 BIRD PASSES SEED OUT

Once the bird has digested the fruit, it excretes the seed that was inside the fruit.

**3 NEW TREE GROWS**  
The seed germinates in the ground and begins to form a new plant or tree.

## SIZE COMPARISON

The jackfruit from Southeast Asia is the world's largest fruit. It can grow up to 35 in (90 cm) long and weigh up to 79 lb (36 kg).



## STINKIEST FRUIT

Many people consider the world's stinkiest fruit to be the durian. It can smell like rotten onions but has a sweet, custardlike flesh.



DURIAN

## ACCESSORY FRUIT

Some kinds of fruit grow differently from others. They are known as accessory fruit. The core fruit group is sometimes included within this category.



STRAWBERRY

**STRAWBERRIES ARE PART OF THE ROSE FAMILY OF FLOWERING PLANTS.**



COCONUT



NECTARINE



LYCHEE



RAMBUTAN



PEACH



BLACKBERRY



RASPBERRY



DAMSON



PLUM



APRICOT

## CORE FRUIT

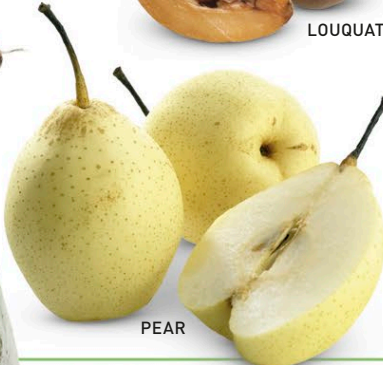
These fleshy fruits have thin, often edible skins. Their seeds are contained in the core at the center of the fruit.



LOQUAT



APPLE



PEAR



QUINCE



PINEAPPLE



BREADFRUIT



FIG

**MELONS BELONG TO THE SAME PLANT FAMILY AS THE CUCUMBER AND HAVE BEEN GROWN SINCE ROMAN TIMES.**

## MELONS

The melon originated in Africa. Each melon contains many seeds in the center, which are surrounded by soft, sweet, juicy flesh. The hard skin is inedible.



CANARY MELON



CANTALOUPE



CRENSHAW MELON



HONEYDEW MELON



KIWANO



# Vegetables

The word “vegetable” is not a scientific term. It is a word that people began to use hundreds of years ago to refer to plants that were grown to eat rather than foraged from the wild. There are many different types, and they are rich in vitamins and minerals.

## TYPES OF VEGETABLE

Vegetables are divided into groups according to the part of the plant that is eaten—for example, roots, stems, leaves, pods, or flowers. Some are strictly “fruits,” but because they are used in savory cooking, are commonly called vegetables.



FRUIT



POD  
VEGETABLES



LEAFY  
VEGETABLES



FLOWERS  
AND BUDS



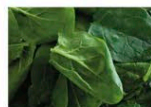
ROOT  
VEGETABLES



BULBS  
AND STEMS

## COLORS

You can often tell the health benefits of a vegetable from its color. The colors of vegetables come from their natural pigments.



**CHLOROPHYLL**  
Helps replenish red blood cells in the body.



**CAROTENOIDS**  
Convert to vitamin A, which is good for eye health.



**ANTHOCYANINS**  
Help protect the body's cells from damage.



**LYCOPENE**  
Protects body cells and may reduce the risk of cancer.

## POD VEGETABLES

Pod vegetables come from plants that produce fruits in the form of seeds or beans, nestled inside a pod. Many pod vegetables belong to a family of vegetables known as legumes. These vegetables are very high in protein.



OKRA



GREEN BEANS

## LEAFY VEGETABLES

All vegetables have leaves, but “leafy vegetables” are the ones where we eat the leaves rather than trim them off. The darker the leaves, the stronger the taste, and the richer they are in vitamins A and C and bone-strengthening calcium.



CABBAGE



AMARANTH



BRUSSELS  
SPROUTS



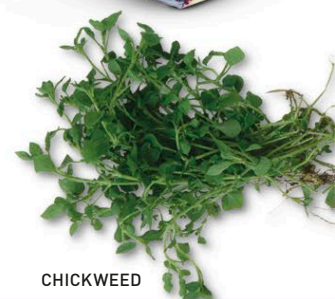
RED CABBAGE



ARUGULA



BOK CHOY



CHICKWEED

## FRUIT

These vegetables are all the fruit of a plant, and contain the seeds it would use to reproduce. In this sense, they are very like apples and oranges, but these fruits contain less sugar and taste more savory than sweet.



PEPPER



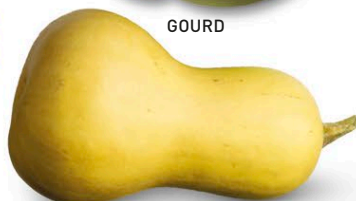
RED CHILI



SQUASH



GOURD



BUTTERNUT SQUASH



MARROW



EGGPLANT



ZUCCHINI



PUMPKIN

## FLOWERS AND BUDS

These vegetables are taken from plants that are grown for their edible flower heads or buds, such as broccoli and cauliflower. They are sturdy and high in fiber, which is good for the digestive system.



CAULIFLOWER



ARTICHOKE



BROCCOLI



DI SICILIA VIOLETTA  
CAULIFLOWER



ROMANESCO  
CAULIFLOWER

**“BROCCOLI” IS AN ITALIAN  
WORD THAT MEANS  
“LITTLE SPROUTS”  
OR “LITTLE SHOOTS.”**



WATER  
CHESTNUT



HAMBURG  
PARSLEY



SWEDE



PARSNIP



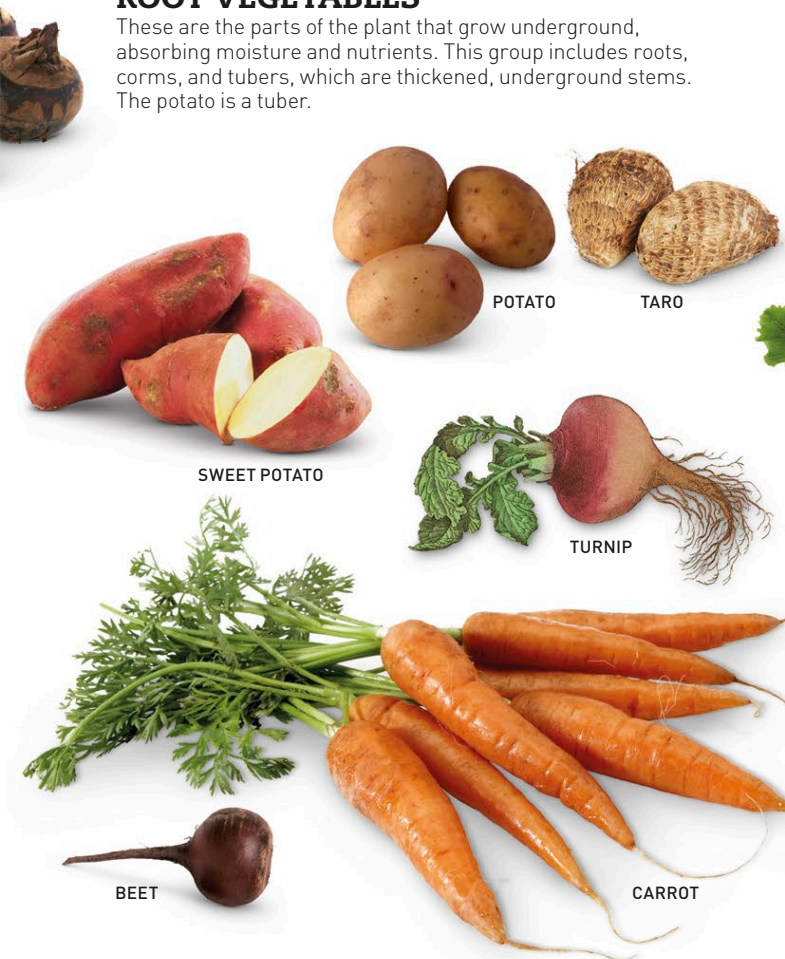
RADISH





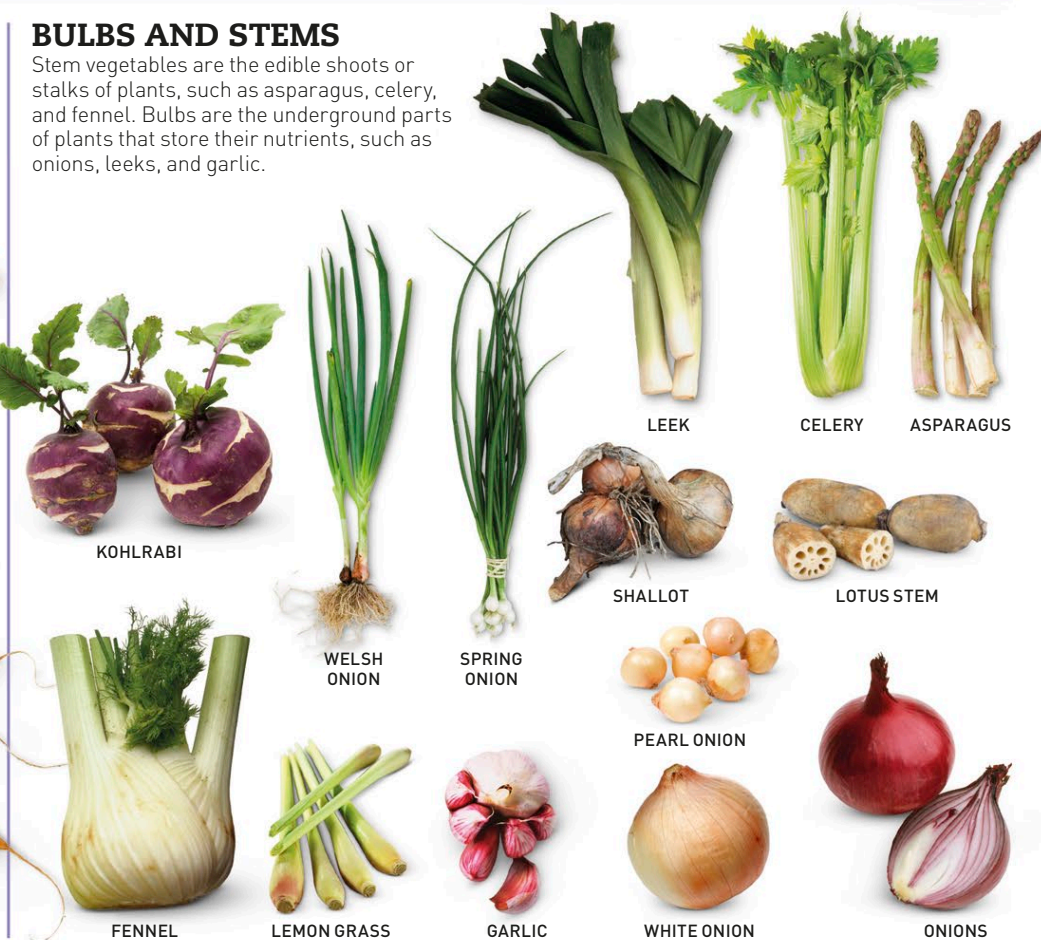
## ROOT VEGETABLES

These are the parts of the plant that grow underground, absorbing moisture and nutrients. This group includes roots, corms, and tubers, which are thickened, underground stems. The potato is a tuber.



## BULBS AND STEMS

Stem vegetables are the edible shoots or stalks of plants, such as asparagus, celery, and fennel. Bulbs are the underground parts of plants that store their nutrients, such as onions, leeks, and garlic.





## MAKING CHEESE

The first stage in the making of any type of cheese is to curdle the milk. This means getting the milk to separate into solid lumps (curds) and a liquid called whey. The photographs below show the steps for producing a hard cheese such as Cheddar.

**CASU MARZU,  
A SARDINIAN  
CHEESE, IS EATEN  
FULL OF LIVE MAGGOTS.**



**1 CURDLING THE MILK**  
A machine stirs an enzyme called rennet into the milk to speed curdling.



**2 DRAINING AND HEATING**  
The milk curds are cut into cubes and the whey is allowed to drain off.



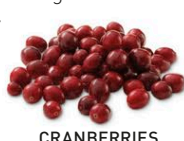
**3 "CHEDDARING"**  
The curds are "cheddared" (piled up) to press out more moisture.



**4 RIPENING**  
To shape the cheese, the curds are put into molds, then left to ripen.

## ADDED FLAVORS

Many people like to eat cheese just as it is. But cheeses are also made with added spices, fruit, and herbs to give them an interesting new taste.



CRANBERRIES



PAPRIKA



CHIVES



THYME



GARLIC



ASH

## WHO EATS THE MOST CHEESE?

In 2017, people in these eight countries ate the most cheese per person per year (in lb/kg).

- DENMARK**  
62 lb (28.1 kg) Favorite: Havarti, a hard cheese made from pasteurized cow's milk.
- ICELAND**  
61 lb (27.7 kg) Favorite: Skyr, soft cheese with a yogurtlike texture.
- FINLAND**  
60.1 lb (27.3 kg) Favorites: Oltermanni, semisoft and buttery; and Aura, blue and creamy.
- FRANCE**  
59.9 lb (27.2 kg) Favorites: Camembert and Brie, both soft and creamy cheeses.
- CYPRUS**  
58.8 lb (26.7 kg) Favorite: Halloumi, made from mixing milk from a goat and a sheep.
- GERMANY**  
54.4 lb (24.7 kg) Favorites: Gouda, semihard and rich-tasting; and Bruder Basil, a semisoft smoked cheese.
- SWITZERLAND**  
50 lb (22.2 kg) Favorites: Emmental, classic "holey" cheese; and Gruyère, firm and nutty.
- THE NETHERLANDS**  
47.6 lb (21.6 kg) Favorites: Gouda Holland, a naturally matured, semihard cheese; and Leerdammer, made from cow's milk.



# Cheese

Filling a sandwich, used in a sauce, or just nibbled, cheese is one of the world's favorite foods. It is delicious, nutritious, and made in so many varieties that there is a cheese to suit almost everyone. Most people have eaten only a few different cheeses, but there are thousands to try.

## HARD CHEESE

This type of cheese is made from cooked curds pressed firmly into shape and left to age. The method removes as much moisture as possible from the curds and produces a solid cheese that keeps well. Semihard cheese has a higher moisture content.



BEAUFORT  
France



CANESTRATO DI MOLITERNO  
Italy



COMTÉ  
France



CANESTRATO PUGLIESE  
Italy



PAVE DU NORD  
France



GOUDA  
Netherlands



GRUYÈRE  
Switzerland



CHEDDAR  
UK



CHESHIRE  
UK



EDAM  
Netherlands



JARLSBERG  
Norway



CANTAL  
France



MONTEREY JACK  
US/Mexico

## SOFT CHEESE

The curds of soft cheeses are not cooked or pressed, but shaped and left to drain. Some types are eaten soon after making. Others are ripened until a wrinkly rind forms. Depending on the type of cheese, the center may have a creamy or chalky texture.



RICOTTA AFFUMICATA  
Italy



FETA  
Greece



SUSSEX SLIPCOTE  
UK



CAMEMBERT  
France



HOLY GOAT PANDORA  
Australia



OLIVET CENDRÉ  
France



MOZZARELLA  
Italy



CHABICHOU DU POITOU  
France



KETEM  
Israel



BRIE DE MELUN  
France



WABASH CANNONBALL  
US



WINNIMERE  
US

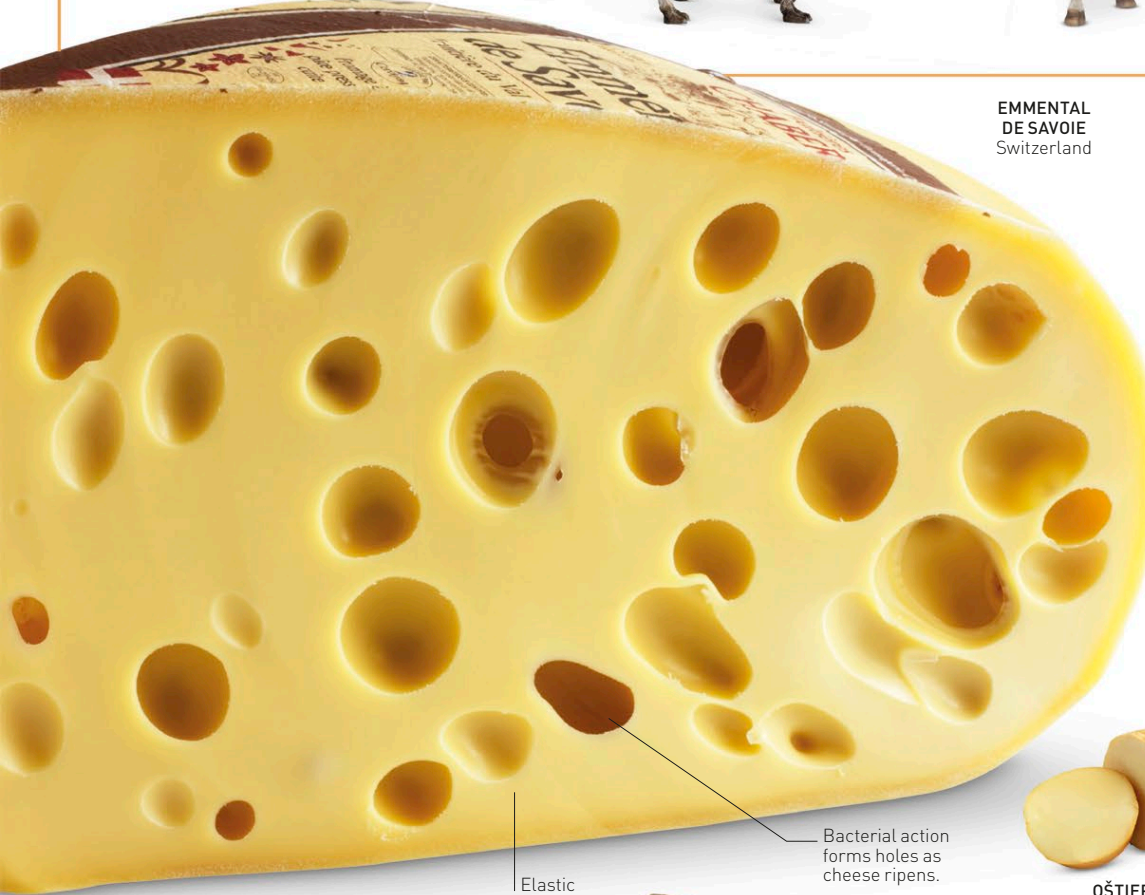


SAKURA  
Japan



## WHICH MILK MAKES CHEESE?

Most of the world's cheeses are made with milk from cows, goats, sheep, and buffalo. In dry regions with poor grazing, camels are an important source of milk. More rarely, cheese is made from the milk of horses, donkeys, yaks, and reindeer.



EMMENTAL  
DE SAVOIE  
Switzerland

Bacterial action  
forms holes as  
cheese ripens.

Elastic  
texture



GRAVIERA  
Greece



TIROLER  
GRAUKÄSE  
Austria



PECORINO  
SARDO  
Italy



BITTO  
Italy



OŠTIEPOK  
Slovakia



SARDO  
Argentina



ALLGÄUER  
BERGKÄSE  
Germany



VÄSTERTOTTENSOST  
Sweden



POSTEL  
Belgium



CRESCENT DAIRY  
FARMHOUSE  
New Zealand



KASHKAVAL  
Hungary



MANCHEGO  
Spain



PECORINO  
ROMANO  
Italy



GAMALOST  
Norway



GORGONZOLA  
Italy



STILTON  
UK



ROQUEFORT  
France



BAVARIA BLU  
Germany



BLEU BÉNÉDICTIN  
Canada



BLEU DE CHÈVRE  
France



GAMONEDO  
Spain



VALDEÓN  
Spain



BARKHAM BLUE  
UK

## BLUE CHEESE

The moldy-looking streaks running through blue cheeses really are mold—but a type that is safe to eat. To produce blue cheese, the makers add mold spores to the curdled milk. After shaping the cheese, they pierce, or "needle," it to let in air, which kickstarts the mold's growth. Blue cheese, which can be hard or soft, usually has a strong flavor.

## CHEESE HISTORY

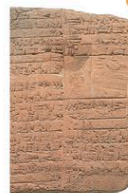
Cheesemaking began long ago when people discovered, probably by chance, that curdled milk was good food. The cheese we eat today has a history of approximately 8,000 years.

### 8000 BCE



**8000 BCE**  
People start keeping sheep and learn to milk them.

**5500 BCE**  
Pots dating from this time in Europe may be the earliest cheese strainers.



**3500 BCE**  
Sumerian clay writing tablets mention curd making.  
**Ancient Sumerian script**

**300 CE**  
Cheese is sold and eaten throughout Europe.



**1697**  
First reference to Gouda, named after the Dutch town.  
**City Hall, Gouda**



**Statue of Marie Harel in Normandy, France**

**1815**  
First-ever cheese factory opens in Switzerland.

**2011**  
A 2,070-lb (939-kg) goat cheese takes the world title for the biggest cheese ever.

### 2025

**1860s**  
Mass-produced rennet makes cheesemaking more consistent.

**2019**  
The European Union (EU) is the largest producer of cheese, at over 11 million tons.



# Bread

First eaten around 30,000 years ago, bread is a favorite food all around the world. Usually made with wheat or rye flour, it is easy to make and a great source of carbohydrates for energy. There are thousands of delicious varieties of bread, from flat and crisp to braided and fluffy.

## MAKING BREAD

Making bread is not difficult, although you need some strength to knead the dough and patience while it proofs (rises). These steps show how to make a simple white loaf.



**1 FLOUR**  
Sift plain flour and salt into a bowl.



**2** Add a mixture of water, milk, and yeast. Combine everything together until they form a dough.



**3** Place the dough on a floured board. Let it rest for a few minutes. Then knead it for 5–10 minutes.



## ROLLS

Rolls, and other forms of bread, come in all shapes and sizes. Many, such as bagels, have become popular all over the world.



**WHOLE-WHEAT ROLL**  
UK



**PICOS ROLLS**  
Spain



**SKILLET BREAD**  
US



**PIRAGI**  
Latvia

## WHO EATS THE MOST BREAD?

In 2013, these 10 countries ate more bread per person per year than anywhere else in the world.

- 1 TURKEY**  
230 lb (104 kg) Favorites: bazlama, gözleme, and pide.
- 2 BULGARIA**  
210 lb (95 kg) Favorites: pitka, kozunak, and mesenitza.
- 3 UKRAINE**  
196 lb (89 kg) Favorites: paska, bublik, pampushka, and korovai.
- 4 GREECE**  
150 lb (68 kg) Favorites: daktyla, lagana, and pita.
- 5 THE NETHERLANDS**  
137 lb (62 kg) Favorites: whole-grain, rye, and suikerbrood.
- 6 FRANCE**  
126 lb (57 kg) Favorites: baguette, ficelle, brioche, and fougasse.
- 7 GERMANY**  
123 lb (56 kg) Favorites: rye, wheat-rye, and whole-grain.
- 8 BELGIUM**  
122 lb (55 kg) Favorites: ververs, molasses, and raisin breads.
- 9 RUSSIA**  
121 lb (55 kg) Favorites: darnitskiy, stolichniy, karavai, and kalach.
- 10 ITALY**  
114 lb (52 kg) Favorites: piadina Romagnola, panettone, and ciabatta.



## LEAVENED BREAD

In leavened breads (where the dough rises), yeast or baking powder is added to the flour combined with a liquid like buttermilk to create carbon dioxide gas. This makes the bread light and airy. Thousands of different types of leavened bread are baked around the world.



**PUMPERNICKEL**  
Germany



**SEVEN-GRAIN BREAD**  
US



**WHOLE-WHEAT COTTAGE LOAF**  
UK



**BAGUETTE**  
France



**ZOPF**  
Switzerland



**CIABATTA**  
Italy



**WHITE LOAF**  
UK



**SOURDOUGH LOAF**  
Middle East



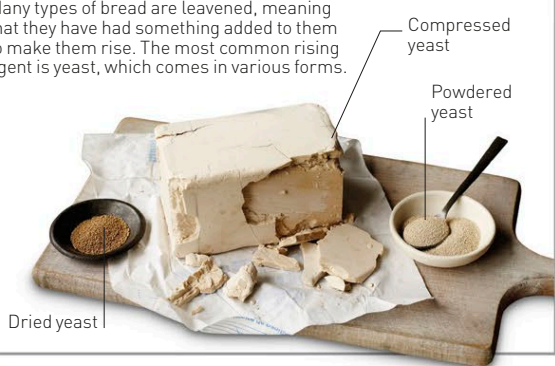
**PANE DI PATATE**  
Italy



**PARTYBROT**  
Germany

## RIISING AGENT

Many types of bread are leavened, meaning that they have had something added to them to make them rise. The most common rising agent is yeast, which comes in various forms.



**MANTOU STEAMED BREAD**  
China



**HEFEZOPF**  
Germany



**PAIN À L'ANCIENNE**  
France



**FOCACCIA**  
Italy



**PIZZA**  
Italy

## FLATBREADS

Most flatbreads do not contain yeast, although some, such as pita bread and naan, are slightly leavened. Pita bread opens up to form a pocket that can be filled with different ingredients. Other flatbreads can be used like a plate and then eaten.



**PITA BREAD**  
Middle East



**PIDE**  
Turkey



**NAAN**  
India



**FLATBREAD**  
Italy



**CRISPBREAD**  
Sweden



**TORTILLA**  
Spain

## FLAVORS FOR BREAD

Bread can be mixed with lots of different ingredients to make it taste savory or sweet. Savory breads can be flavored with strong tastes, such as onion and cheese. Sweet-flavored breads often have fruit, nuts, and spices added to them.

**GERMANY HAS MORE THAN 3,200 VARIETIES OF BREAD, ROLLS, AND PASTRIES.**





**4** Put the dough into a clean bowl, cover with plastic wrap, and let it proof (rise) for about three hours.



**5** Punch the dough down while it is still in the bowl to take some of the air out.



**6** Turn the dough out on to a floured board and knead it again for about two minutes.



**7** Form the dough into the desired shape, or put it in a pan and cover with plastic wrap and let it rise for 90 minutes.



**8** Bake the bread for about 30 minutes in a preheated oven at 350°F (180°C) until it is golden brown and sounds hollow.



**9** Turn the loaf out on to a wire rack and let it cool. Store the bread in a bread bin or pan so that it stays fresh.



**PARKER HOUSE ROLLS**  
US



**BRIOCHE**  
France



**BAGELS**  
Poland



**GRISSINI**  
Italy



**FAN TAN (BUTTERMILK ROLL)**  
France



**PRETZELS**  
Germany



**BRIOCHE  
NANTERRE LOAF**  
France



**SEEDED RYE BREAD**  
Russia



**PUGLIESE BREAD**  
Italy



**BARMBRACK**  
Ireland



**ANADAMA BREAD**  
US



**GLUTEN-FREE BROWN BREAD**  
US



**PANE DI PRATO**  
Italy



**SODA BREAD**  
Ireland



**GÖZLEME**  
Turkey



**FOUGASSE**  
France



**HOT CROSS BUNS**  
UK—Easter



**CIAMBELLA  
MANDORLATA**  
Italy—Easter



**PANDORO BREAD**  
Italy—Christmas



**PANETTONE**  
Italy—Christmas



**STOLLEN**  
Germany—Christmas



**TSOUREKI**  
Greece—Christmas



**CHERRIES**



**CHOCOLATE**



**RAISINS**



**CURRENTS**



**SULTANAS**



**CARDAMOM**



**WALNUTS**



**PISTACHIOS**



**ONION**



**OLIVES**



**CHEESES**



**CHALLAH**  
Middle East—  
Jewish Sabbath



**MATZO**  
Middle East—  
Jewish Passover

## SPECIAL- OCCASION BREADS

In many countries and within some religious groups, there is a tradition of baking special types of bread for certain occasions. Some recipes are everyday breads but with added ingredients such as fruit or nuts. Other varieties are only baked once a year.



# Pasta

Made from flour and eggs, plus a little water or olive oil, pasta has always been a very important food in Italy. Now it is popular throughout the world because it can be cooked in so many different ways. Pasta is also a great source of energy for our bodies.

## MAKING PASTA

Pasta is not complicated to make, but it can take a little while. You can make it by hand, or you can use a food mixer. A pasta machine can be used to roll the pasta dough out and cut it into strips, depending on the shape that you want. You can use different types of flour, such as plain, semolina, buckwheat, or whole-wheat.



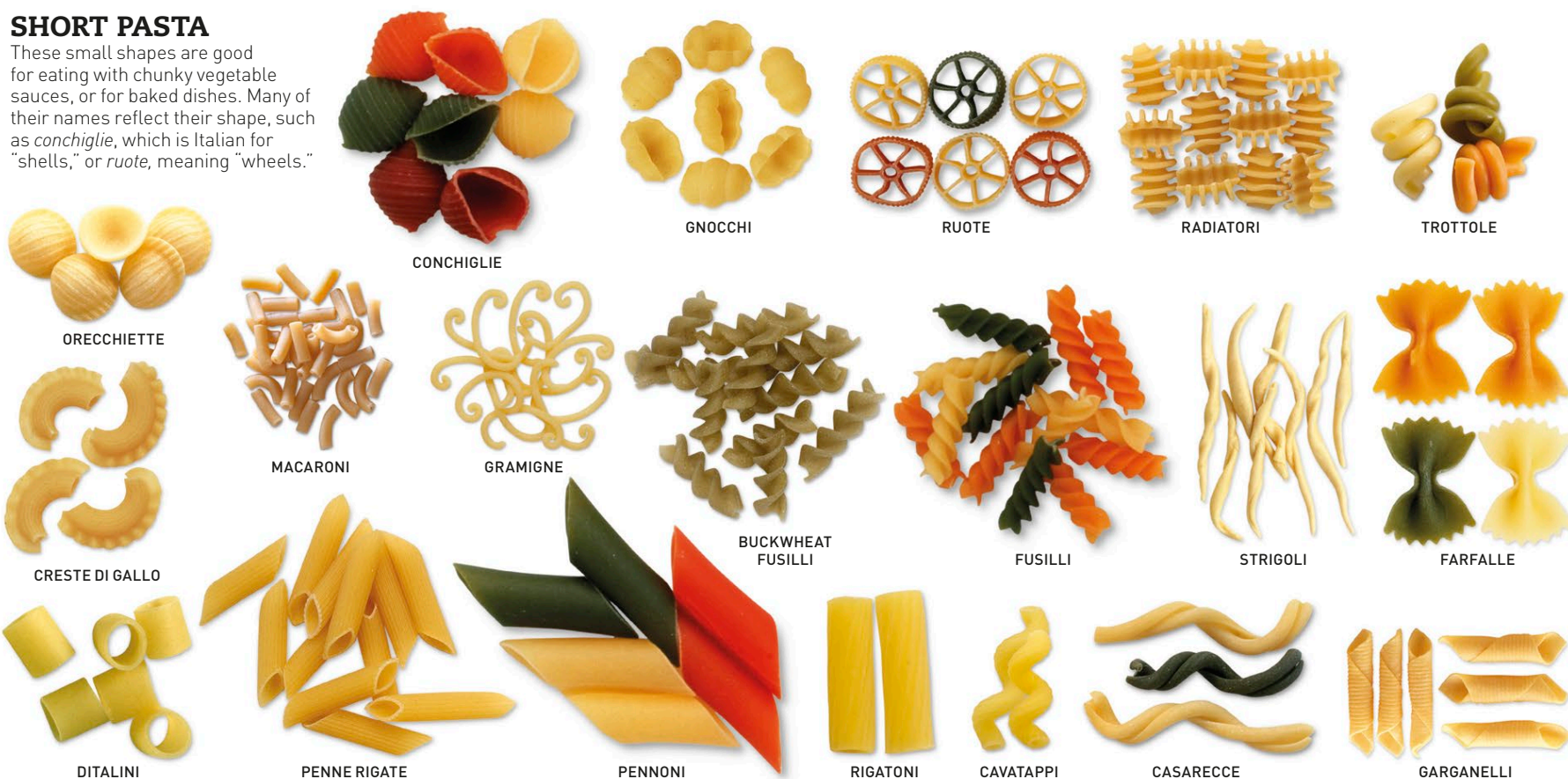
**1 ADD THE EGGS TO THE FLOUR**  
Make a well in the center of the flour and then add the eggs.



**2 MIX THE EGGS AND FLOUR TOGETHER**  
Combine the eggs and flour to form a dough, using a little olive oil or water to keep it moist.

## SHORT PASTA

These small shapes are good for eating with chunky vegetable sauces, or for baked dishes. Many of their names reflect their shape, such as *conchiglie*, which is Italian for "shells," or *ruote*, meaning "wheels."



## LONG PASTA

Long strands of pasta come in various thicknesses and can be round or flat. They are usually served with creamy sauces or tomato sauces that coat each strand of the pasta and add flavor.



## TINY PASTA

Very small pasta shapes are often used in soups or added to stews because they are a quick and easy way to make the dishes more filling and serve more people.







**3 KNEAD THE DOUGH**  
Use your hands to knead the pasta dough for about 5–7 minutes until it is smooth.



**4 REST THE DOUGH**  
Cover the dough in plastic wrap and let it rest for 30 minutes. Unwrap it and place it on a floured board.



**5 FLATTEN THE DOUGH**  
Flatten the dough, using your hands and a rolling pin. Don't let the dough get too warm or floury.



**6 ROLL THE DOUGH**  
Roll the dough out with a rolling pin or feed it through a pasta machine until it becomes thin.



**7 CUT THE PASTA**  
Once the dough is thin enough, it can be cut into strips, or you can cut it by hand into different shapes.

## STUFFED PASTA

Some pasta shapes are stuffed with a filling and sealed before they are cooked. Fillings can include creamy cheeses and vegetables such as spinach.



DISCHI VOLANTI



CAVATELLI



CAMPANELLE



STROZZAPRETI



PANSOTTI



CAPPELLETTI



CANNELLONI



LUNETTE



TORTELLINI



RAVIOLI



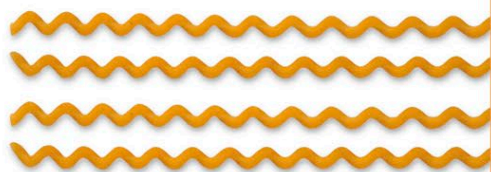
CARAMELLE



FETTUCCINE



PERCIATELLI



FUSILLI LUNGI



STORTINI



DITALINI RIGATI



FARFALLINE



SORPRESE

## COLORED PASTA

The basic ingredients of pasta don't change, but you can add different foods to pasta that will affect its color and taste. Added flavors include garlic, herbs, and wine, as well as vegetables such as mushrooms.



CURRY



HERBS



WILD MUSHROOM



TOMATO



RED WINE



SPINACH



ONION



EGG

## WHO MAKES THE MOST PASTA?

In 2018, nearly 17 million tons of pasta was produced worldwide. These were the five countries that produced the most pasta per year.

- 1 ITALY**  
3.6 million tons
- 2 US**  
2.2 million tons
- 3 TURKEY**  
1.4 million tons
- 4 BRAZIL**  
1.3 million tons
- 5 RUSSIA**  
1.2 million tons



## WHO EATS THE MOST PASTA?

Pasta consumption across the world has grown by more than 60 percent in the last two decades. In 2018, people in these five countries ate the most pasta per person.

- 1 ITALY**  
**53 lb (24 kg)** Favorites: penne, spaghetti, fusilli.
- 2 TUNISIA**  
**35 lb (16 kg)** Favorites: nwassar (flat pasta) and mhammas (small pellets made of durum wheat).
- 3 VENEZUELA**  
**26.4 lb (12 kg)** Favorites: lasagna and spaghetti.
- 4 GREECE**  
**24.6 lb (11.2 kg)** Favorite: matsata—a flat, ribbonlike home-made pasta.
- 5 SWITZERLAND**  
**20 lb (9.2 kg)** Favorites: macaroni varieties.



**THERE ARE MORE THAN 600 DIFFERENT SHAPES OF PASTA PRODUCED THROUGHOUT THE WORLD.**



CURRY



HERBS



WILD MUSHROOM



TOMATO



RED WINE



SPINACH



ONION



EGG









# Fish for food

All over the world, fish is an important part of people's diets. It contains protein, vitamins, and minerals. Fish can be cooked in many different ways or even eaten raw.

## WHO EATS THE MOST FISH?

In 2017, these 10 countries ate more fish per person per year than anywhere else in the world.

- ICELAND**  
200 lb (90.71 kg) Favorites: haddock, halibut, herring, and plaice. 
- MALDIVES**  
199.3 lb (90.41 kg) Favorites: skipjack tuna, yellowfin tuna, and mahi-mahi. 
- KIRIBATI**  
169 lb (76.69 kg) Favorites: lobster, yellowfin tuna, and skipjack tuna. 
- MALAYSIA**  
127 lb (57.62 kg) Favorites: prawns, crab, squid, cuttlefish, octopus, and sea cucumbers. 
- PORTUGAL**  
125 lb (56.84 kg) Favorites: cod, sardine, octopus, squid, crab, lobster, clams, mussels, and oysters. 
- SOUTH KOREA**  
121 lb (54.97 kg) Favorites: salmon, tuna, sea bass, halibut, mackerel, pacific herring, and shellfish. 
- ANTIGUA AND BARBUDA**  
116 lb (52.54 kg) Favorites: white marlin, mahi-mahi, yellowfin tuna, blackfin tuna, and barracuda. 
- NORWAY**  
113 lb (51.35 kg) Favorites: smoked salmon, prawns, trout, crab, cod, and herring. 
- MYANMAR**  
104 lb (47.32 kg) Favorites: catfish, carp, tilapia, herring, shrimp, prawns, and crabs. 
- JAPAN**  
100 lb (45.49 kg) Favorites: tuna, eel, octopus, squids, and scallops. 

## SUSHI AND SASHIMI

Raw fish is often used in Japanese dishes. Nigiri sushi uses rice formed into a rectangle with fish placed on top. Sashimi is very fresh, sliced raw fish. Maki sushi rolls are wrapped in seaweed called nori.



NIGIRI SUSHI



SASHIMI



MAKI SUSHI ROLLS

## SALTED FISH, DRIED FISH

Fish does not stay fresh for long, particularly if it cannot be refrigerated. So fish is often preserved in salt or brine (very salty water) or dried to use later.



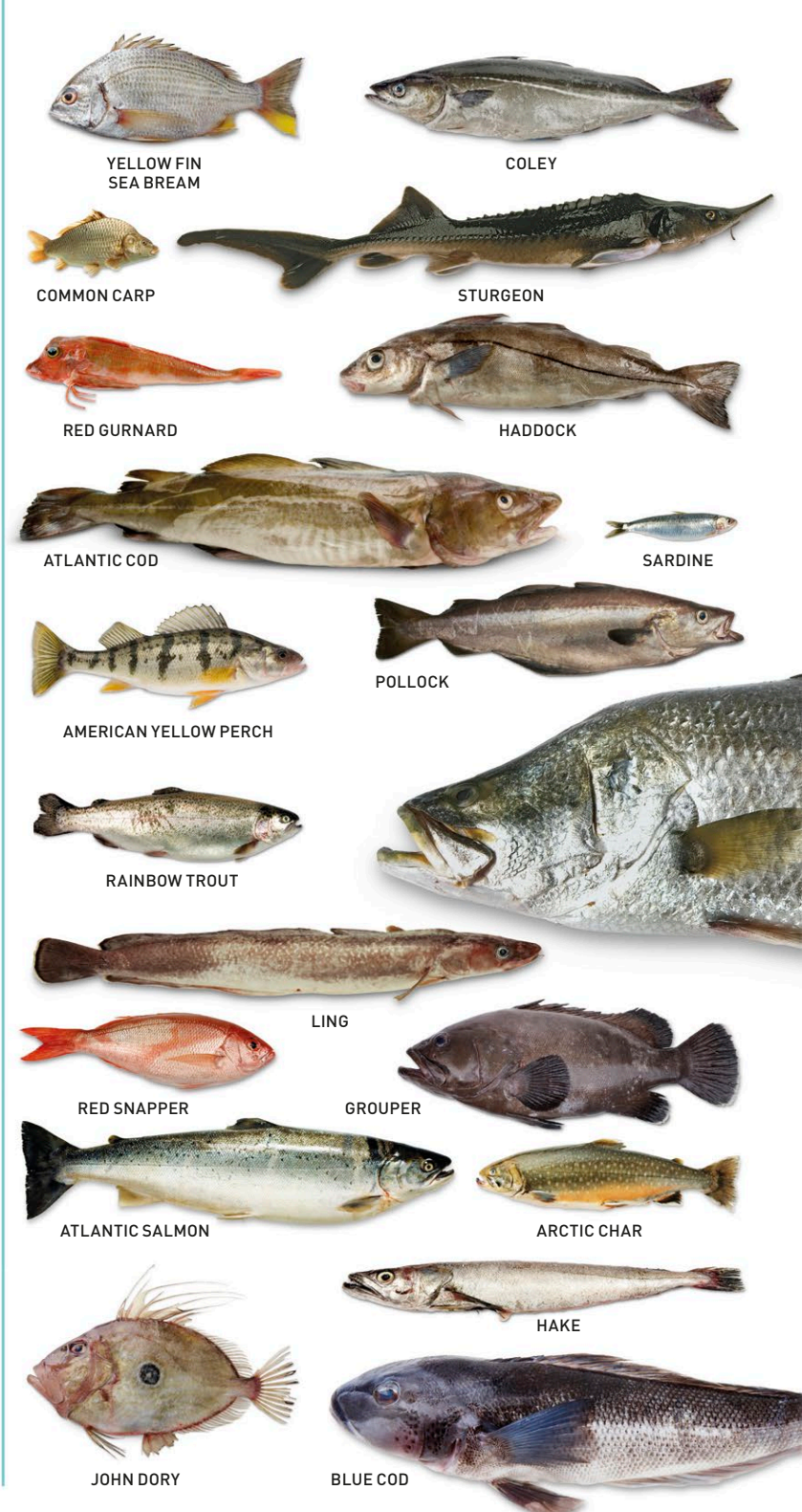
## SMOKED FISH

Fish can also be preserved by smoking in one of two ways. Hot-smoked fish are brined, dried, and then smoked quickly. Cold-smoked fish are brined and then smoked for 1–5 days.

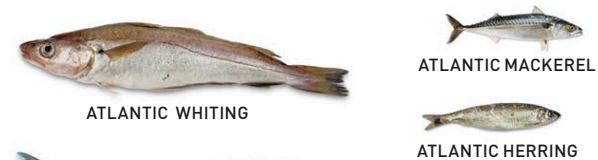
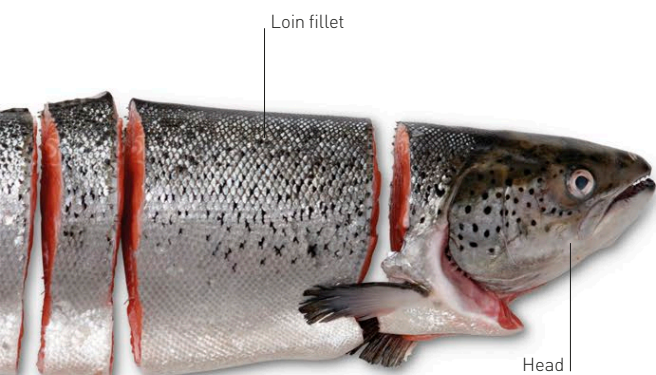


## ROUND FISH

Round fish have cylindrical bodies, making it possible to fillet (cut) pieces from both sides of their bodies. Depending on their texture, they are known as either white fish or oily fish.

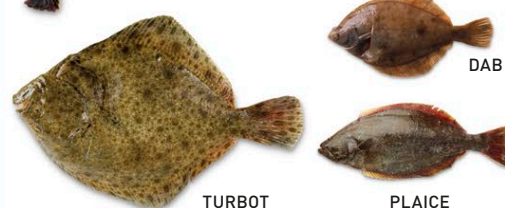
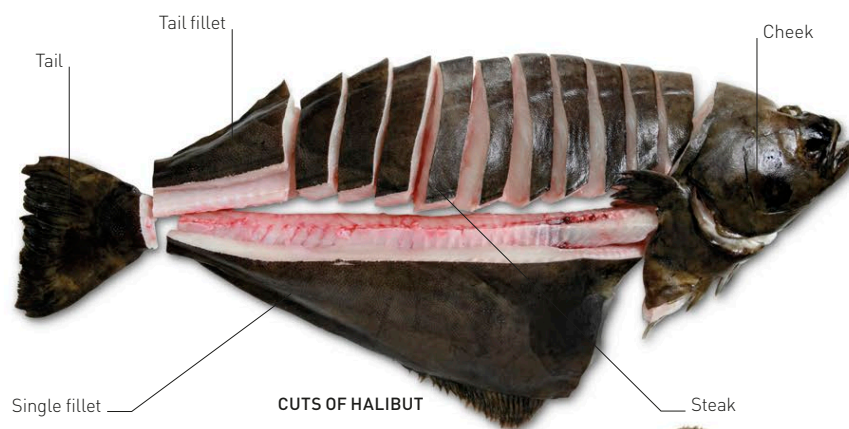






## FLATFISH

Flatfish start life as small round fish but turn on to their side as they grow. Flatfish are usually cut into long slices along their backbone. If they are large and thick enough, it is possible to cut steaks from them.



## FISH ROE

Roe is the name for the ripe eggs that are either found inside a fish's body or released outside it. Roe can be eaten raw or cooked. Sturgeon roe is highly prized and very expensive. It is made into caviar by curing it in salt.



LUMP FISH ROE



FRESH COD ROE



SMOKED COD ROE



HERRING ROE (SOFT)



HERRING ROE (HARD)



BELUGA CAVIAR



SEVRUGA CAVIAR

## SHELLFISH

Shellfish include marine animals such as oysters and mussels that live in shells, as well as creatures like lobsters, crabs, and prawns. They can be used in many recipes.



SEA CUCUMBER



SEA URCHIN



SQUID

CRAB



LOBSTER



ABALONE



CUTTLEFISH



WHELKS



COCKLES



CLAMS



WINKLES



MUSSELS



OYSTERS



PRAWNS



CRAYFISH



QUEEN SCALLOP



# Meat

Humans have eaten meat for thousands of years. Animals such as cows, pigs, sheep, and chickens are reared on farms especially to provide us with meat. Other animals live in the wild and are hunted for their meat. A good source of protein, meat can be prepared and cooked in many ways.

**MEAT CONTAINS MANY OF THE VITAMINS AND MINERALS THAT ARE IMPORTANT IN A HEALTHY DIET.**

## WHO EATS THE MOST MEAT?

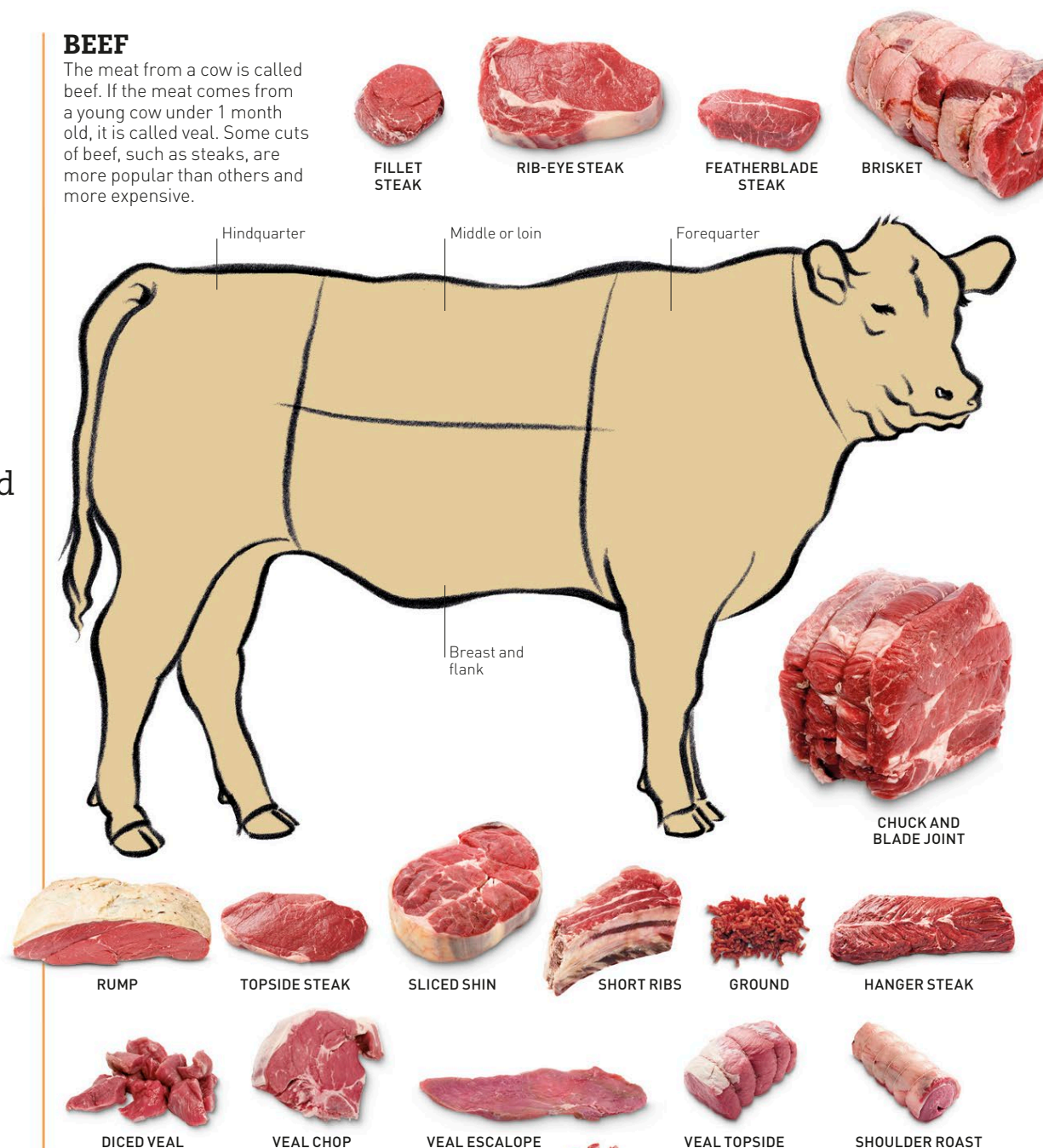
In 2017, people in these 10 countries ate more meat per person per year than anywhere else in the world.

- US**  
274 lb (124 kg) Favorites: beef (especially steak), chicken, and pork (especially bacon).
- AUSTRALIA**  
268 lb (121.6 kg) Favorites: lamb and beef.
- ARGENTINA**  
241 lb (109.38 kg) Favorites: beef, chicken, and pork.
- NEW ZEALAND**  
222 lb (100.89 kg) Favorites: lamb and chicken.
- SPAIN**  
221 lb (100.25 kg) Favorites: beef, pork (especially cured hams), and lamb.
- ISRAEL**  
213.8 lb (97.01 kg) Favorites: chicken, beef, and lamb.
- ICELAND**  
200.6 lb (91.01 kg) Favorites: mutton, pork, and chicken.
- POLAND**  
195.5 lb (88.7 kg) Favorites: pork, chicken, and beef.
- MONGOLIA**  
195 lb (88.37 kg) Favorites: mutton, beef, and chicken.
- GERMANY**  
193.5 lb (87.78 kg) Favorites: pork, chicken, and beef.



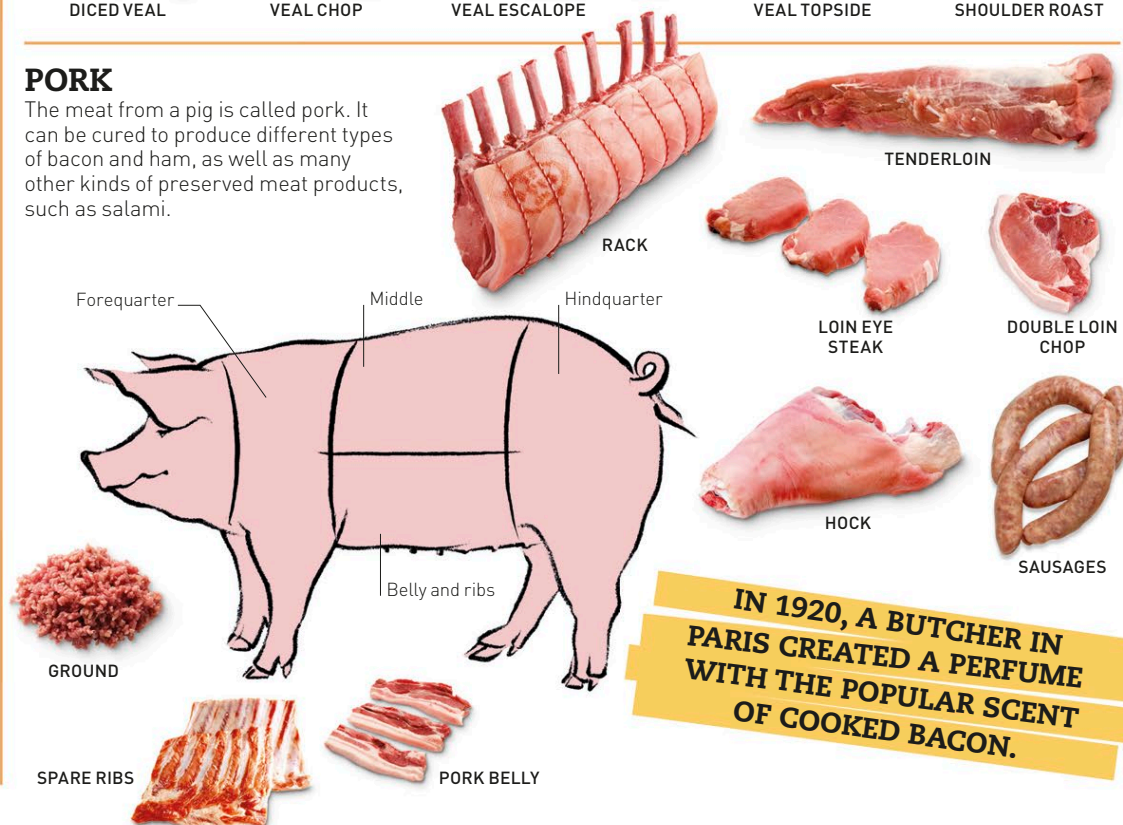
## BEEF

The meat from a cow is called beef. If the meat comes from a young cow under 1 month old, it is called veal. Some cuts of beef, such as steaks, are more popular than others and more expensive.



## PORK

The meat from a pig is called pork. It can be cured to produce different types of bacon and ham, as well as many other kinds of preserved meat products, such as salami.

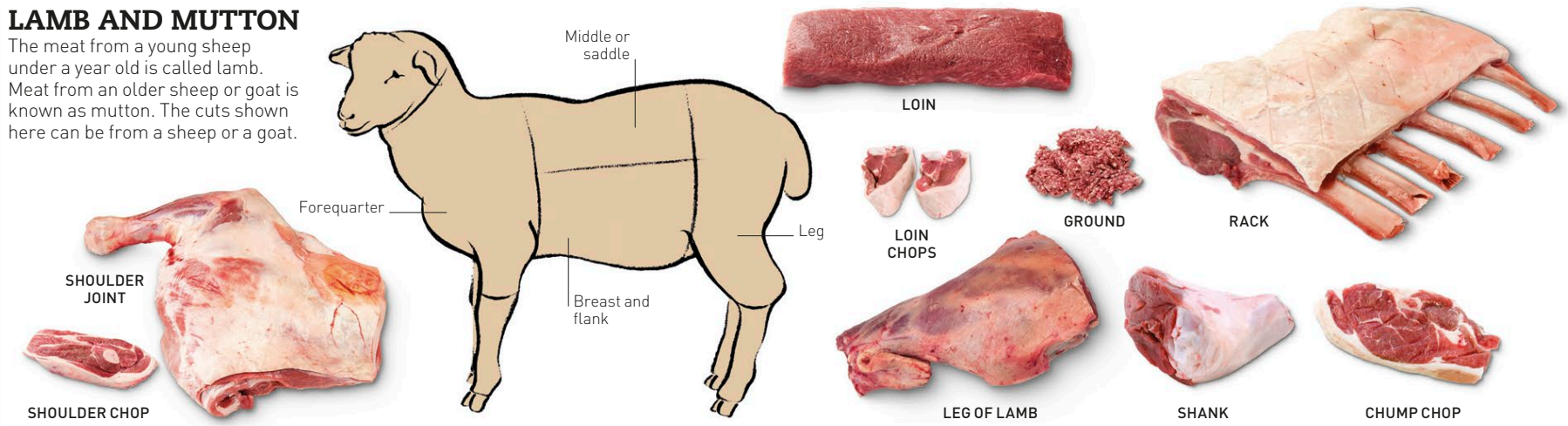


**IN 1920, A BUTCHER IN PARIS CREATED A PERFUME WITH THE POPULAR SCENT OF COOKED BACON.**



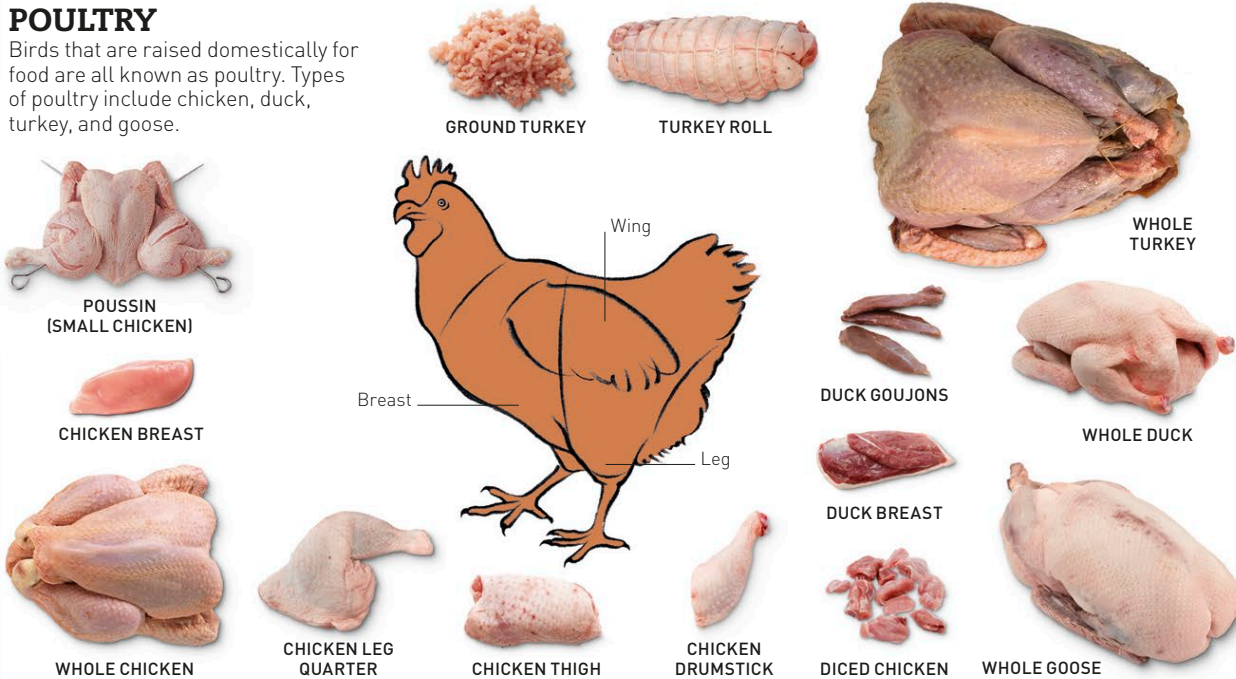
## LAMB AND MUTTON

The meat from a young sheep under a year old is called lamb. Meat from an older sheep or goat is known as mutton. The cuts shown here can be from a sheep or a goat.



## POULTRY

Birds that are raised domestically for food are all known as poultry. Types of poultry include chicken, duck, turkey, and goose.



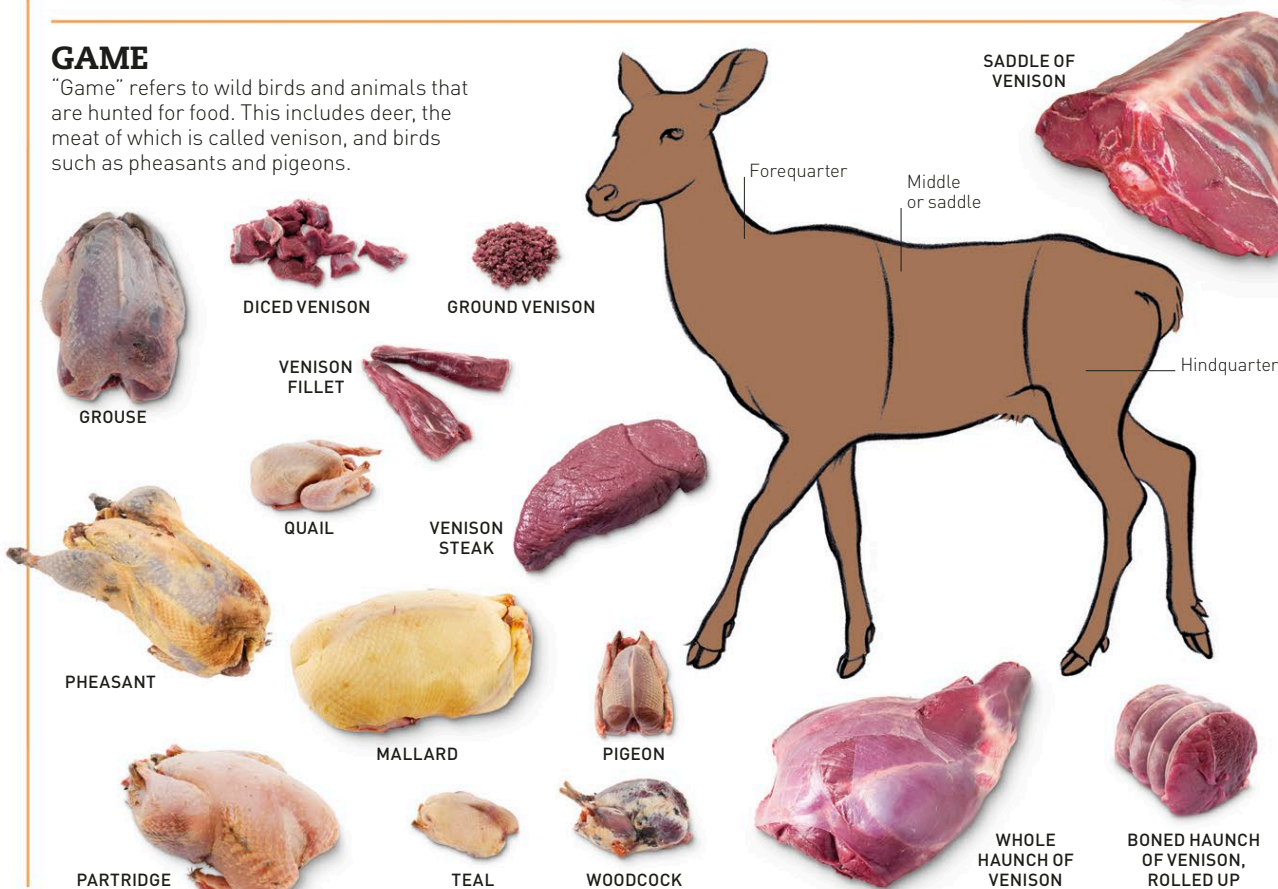
## PRESERVED MEATS

Most meat can be preserved in different ways. It can be dried, smoked, or cured by soaking it in very salty water, or made into sausages such as salami that can be eaten raw. Pork is the meat that is preserved most often.



## GAME

"Game" refers to wild birds and animals that are hunted for food. This includes deer, the meat of which is called venison, and birds such as pheasants and pigeons.





# Men's fashion

The style of Western men's clothing, hair, and accessories changes as fast as women's fashion. Even centuries ago, men were obsessed with fashion and loved to wear stylish clothes. They often spent more on clothes than women did.

## 2ND CENTURY BCE

### THE ROMANS

Ancient Rome had strict clothing rules. Roman senators, part of the government, were at the highest level of society—their tunics, called togas, had a special purple stripe.



ROMAN TOGA

BROOCH TO HOLD ROBE IN PLACE



STUDED SANDALS

## 12TH CENTURY CE

### MEDIEVAL

Rich young men could become knights. They wore metal armor over their legs, while on top they wore a shirt made from metal mesh, called chain mail. This made it easier for the knight to move and protected him from stab wounds.



LACE-UP CHAIN MAIL

## 1550s

### COURT STYLE

The kings of Europe set the trends, wearing new fabrics such as silk from China and Iraq and cotton from India and Egypt. Clothes came in new colors, too, such as scarlet-red, as exotic dyes were imported from around the world.



PLUS FOURS AND KNITTED VEST

## 1930s

### ELEGANCE

Men dressed to show off their upper body, wearing jackets with padded shoulders and wide lapels to give the illusion of a strong chest. The athletic look was in fashion, so men took up sports to get in shape.



SWIMMING COSTUME



FEDORA HAT



PLUS FOURS AND POLO SHIRT



BAGGY SUIT

## 1920s

### THE ROARING TWENTIES

Sports was the new trend, so many men dressed in a more casual style, ready for cycling, golf, tennis, athletics, and dancing. Short pants called plus fours were a popular new fashion.



KNICKERBOCKERS WITH ARGYLE SOCKS



STRIPED ENAMEL CUFFLINKS



OPEN SUMMER SHOES



STRAW BOATER



BROGUES



TWEED CAP



ATHLETIC WEAR

## 1940s

### THE FORTIES

There were not many clothes for sale during World War II, as producing food and weaponry was more important. Men made do with fewer suits and dressed simply, although shoes and hats were still key accessories.



FORMAL SUIT



BAGGY PANT SUIT



TRILBY HAT



AVIATOR SUNGLASSES



SPECTATOR SHOES

## 1950s

### SMART CASUAL

After years of wearing military uniforms, men wanted to relax and wear more casual clothes. Pinstripe, double-breasted suits were popular, and so were shorter Italian-style jackets. Young men developed their own style, and jeans were especially fashionable.



HOMBURG HAT



SUEDE SHOES WITH CREPE SOLES



LEATHER JACKET



COWBOY JEANS



FORMAL SUIT

## 1960s

### THE NEW DANDIES

Young men wanted to show off and stand out. They wore slim, ankle-length pants or jeans with tight-fitting shirts or sweaters. Pop music was a big influence on fashion and hairstyles.



LEATHER COAT, SLIM PANTS



BEATLES-STYLE SUNGLASSES



POINTED SHOES





FURS WITH FEATHERED HAT



SHORT TUNIC WITH COLORED STOCKINGS

## LATE 1500s

### ELIZABETHAN

Men's clothes became even fancier. Gentlemen with money wore fitted velvet jackets with wide, frilly lace collars, and knee-length pants called breeches with long silk or wool socks.



SUIT WITH RUFF



BREECHES WITH PADDED JACKET

## 1700s

### ROCOCO

In Europe, a new style came into fashion, Rococo, which was more glamorous than anything before. Men's clothes were richly decorated. They wore huge wigs and make-up to complete the look.



LINEN UNDERSHIRT



TIGHT WAISTCOAT



FRILLY BOW AND SLEEVES



SUIT WITH WHITE WIG

## 1900-1910s

### THE NEW CENTURY

Male fashion became plainer and more serious. More men worked in offices and dressed to fit in, not to stand out. They wore suits in dark colors with white shirts and ties.



SWIMMING CAP



BOWLER HAT



PANAMA HAT



WORK SUIT

FORMAL OUTFIT WITH TOP HAT

## 1850s

### THE GENTLEMAN

Clothes became cheaper because they could be made by machine rather than by hand, so more men could afford to dress well. There were outfits for every occasion, and accessories such as hats, pointy shoes, and walking sticks were important.



EVENING OUTFIT



JACKET AND SLIM PANTS



SWIMMING COSTUME

WAISTCOAT AND POCKET WATCH

## 1800s

### THE DANDY

Wealthy men of the 19th century wore top hats and curled their hair and mustaches. Their clothes were tight to show off their figure, and they changed outfits many times a day.



TIGHT JACKETS AND HIGH COLLARS



FITTED COAT WITH HIP POCKETS

## 1970s

### BELL BOTTOMS AND PLATFORMS

Men experimented with fashion and enjoyed dressing up for fun in colorful patterned clothes. Extra-long bell bottom pants were worn with high platform shoes, and hairstyles were long and shaggy.



BIG SUNGLASSES



PLATFORM SHOES



PLAID JACKET AND BELL BOTTOMS



FANCY PLATFORMS

## 1980s and 1990s

### INDIVIDUAL STYLE

There were many looks to choose from in the 1980s and '90s. Suits had padded shoulders in the 1980s and became very slim in the 1990s. Many clothing styles were influenced by music such as punk and hip-hop.



PLAIN SUIT WITH PINK STRIPED SHIRT



COWBOY BOOTS



PUNK STYLE

## 2000s

### ANYTHING GOES

Since the start of the new millennium, fashion for men has become very relaxed. Jeans and athletic shoes are the most popular look. Other casual styles include chinos or khaki pants worn with polo shirts, graphic T-shirts, or sweatshirts.



SUNGLASSES



CLASSIC SHOES



JEANS AND POLO SHIRT



# Women's fashion

Fashion is the style of what we wear and how we wear it. The most important thing about Western fashion is that it changes. Hundreds of years ago, styles altered slowly, but now they move on very fast.

## 1300s

### FASHION STARTS HERE

Fashionable clothes had always been popular, but by the 1300s, fashion started changing more quickly and new dress styles were invented. There were strict laws on what to wear, but women found ways to break the rules.



WOOL



MEDIEVAL DRESS

## 1400–1600s

### RICH RENAISSANCE

Beautiful soft new materials, such as silk and velvet, became available to the rich. Skirts became wider, and mix-and-match clothes were popular. Sleeves could be untied and taken off for washing.



VELVET DAY DRESS



ORNATE HANDBAG



OUTDOOR SHOES

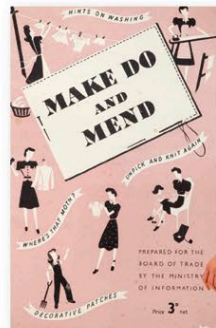


COURT DRESS

## 1940s

### THRIFTY FORTIES

During World War II, material was scarce. Women dressed sensibly and learned how to make and recycle their own clothes. They still wanted to look stylish, using colorful accessories to add personality to plain outfits.



**WAR ADVERT**  
To encourage women to make clothes last longer.



EMERALD-GREEN HEELS



HAIR TIED UP, KNEE-LENGTH DRESS

## 1930s

### GLAMOROUS GOWNS

In this decade, fashion was inspired by Hollywood film stars. Long, sleek dresses were designed to create a slender look. Jackets had padded shoulders, which made the waist and hips look narrower.



WHITE SATIN EVENING DRESS



FLORAL DRESS



WIDE-BRIMMED STRAW HAT



ELEGANT LEATHER GLOVES



DRESS PATTERN



FITTED JACKET AND SKIRT

## 1950s

### THE "NEW LOOK"

French Designer Christian Dior created a new way of dressing in the 1950s. The look was very feminine, with a tight waist, swirling skirt, pearl necklaces, and earrings. Gloves and hats were almost always worn when leaving the house.



DAY HANDBAG



PEEP-TOE HEELS



LONG SUIT DRESS

## 1960s

### THE SWINGING SIXTIES

London designer Mary Quant invented the mini skirt. Hems were the shortest they had ever been in the history of fashion. Shiny fabrics, space-age silver, knee-high boots, and lots of eye make-up were popular.



SILVER BOOTS WITH POINTED TOES



POLKA-DOT MINI DRESS



PLASTIC ZIP-UP JACKET



STRIPED SEQUINED MINI



MATCHING HAT, GLOVES, AND SHOES



## 1700s

### THE FLAMBOYANT 1700s

French Queen Marie Antoinette became one of the first fashion celebrities. She loved clothing and often changed her outfits. Bright colors and ornate dresses were in fashion.



FORMAL DRESS, FRONT AND BACK



RED FOOTWEAR



HIGH-HEELED SHOES



DELICATE SILK BOOTS



DAINTY DANCING SLIPPERS

## 1850–1900s

### THE VICTORIANS

Victorian women tried all sorts of tricks to change their body shape. They wore huge petticoats called crinolines under their skirts to make their hips look wide, or pads over their bottoms, called bustles. This made their waists look smaller.



**1 CAGE CRINOLINE**  
Step into the crinoline and pull it up to the waist.

**2 DOME SHAPE**  
Tie it at the waist. A skirt worn on top forms a dome shape.



TARTAN DRESS



BONNET WITH RIBBONS



FAN



CORSET WORN UNDER DRESS



BLACK GOWN WITH BUSTLE

## 1920s

### THE JAZZ AGE

In the 1920s, more women worked, played sports, went to parties, and lived on their own. They wore loose, knee-length dresses, or pants, so they could move freely, especially when dancing to jazz music.



UNEVEN HEMLINE

NO SLEEVES, PRETTY DECORATION

SIMPLE STYLE WITH STRIPES



SMALL, NEAT HAT



PATTERNED SILK SHOES



LACE-UPS FOR WALKING



PURSE WITH EGYPTIAN SYMBOLS



SPARKLY EVENING PURSE



SHORT HAIR, LONG BEADS, STRAIGHT DRESS

## 1900–1920s

### BELLE EPOQUE

During the Belle Epoque—French for “the beautiful era”—women wore pretty dresses with puffed sleeves, lace, frills, and feathered hats. Using special underwear, they created an S-shape body, with a big bust, tiny waist, and a big bottom.



LONG CORSET WORN UNDER DRESS



LACE-UP BOOTS



HIGH HEELS



SILK PURSE



LACE-COVERED DRESS

## 1970s

### HIPPIE STYLE

Bright colors, big patterns, big hair, and even bigger shoes were in fashion in the 1970s. Long skirts and dresses and wide bell bottom pants were worn with high platform boots or sandals. Indian-style accessories and decoration were also popular.



PATCHWORK MAXI DRESS



FLOPPY FLOWERY HAT



PLATFORM SANDALS

## 1980s and 1990s

### THE STYLISH '80s AND '90s

Punk music and punk style ruled the streets in the 1980s. The look included ripped jeans, tight T-shirts, heavy black boots, and tartan skirts. By the 1990s, stretchy “body-con” dresses and all-black outfits were fashionable.



TARTAN SKIRT WITH BLACK LEGGINGS



METALLIC STILETTOS



HEAVY BOOTS



TIGHT BODY-CON DRESS



HEAD-TO-TOE BLACK

## 2000s

### ANYTHING GOES

In the new century, fashion is casual but creative. Jeans and athletic shoes are the most popular outfit for young people—accessories add an individual touch. Styles from the past few decades are mixed to make new looks.



TAN LEATHER SATCHEL



BLUE BOWLING BAG



HIGH-TOP SHOES

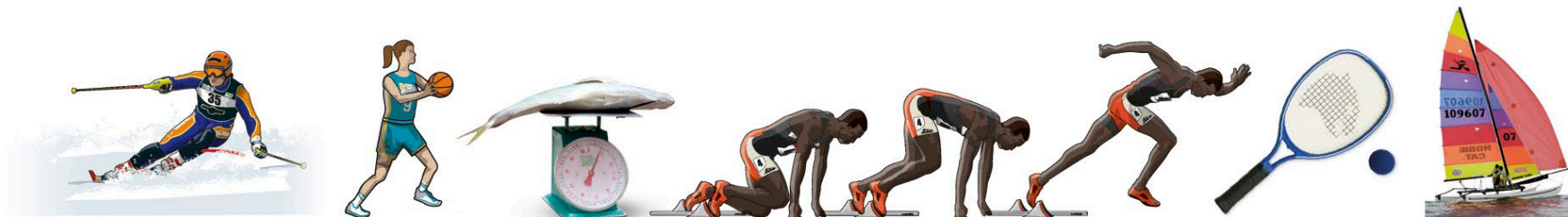


CHUNKY-HEELLED SANDALS



JEANS WITH CASUAL TOP









# Sports and hobbies





# Ball sports

Ball games have been played for at least 3,500 years, and today there are hundreds of different kinds. Some can be played by a single person, while others involve as many as 30 players and need a huge field to play on.



## MARBLES

Two players take turns to knock an X-shaped group of marbles from a large chalked circle by throwing one marble.



## SQUASH

A game played by two people on a walled, indoor court. Players use rackets to bounce the ball off the walls and floor.



## TABLE TENNIS

This fast game is also known as ping pong. Two players hit a very light ball back and forth over a small net on a special table.



## GOLF

Golf is played on a huge grass course with 18 holes. Golfers use various clubs to hit the small, dimpled ball into the holes.



## REAL TENNIS

The oldest racket sport, real tennis is played on an unusual indoor court. Players hit a felt-covered cork ball back and forth across a net using wooden rackets.



## TENNIS

Played on a variety of surfaces. Players hit a felt-covered bouncy ball to each other across a net using tightly strung graphite or fiberglass rackets.



## BOULES

In this outdoor game, two teams throw heavy metal *boules* (French for "balls") toward a small target ball known as a "jack." The team that gets the ball closest to the jack wins.



## HURLING

A traditional Irish game played on a grass field. Players use a flat-ended, curved stick to catch, bounce, and toss the ball to each other in order to score goals.



## CRICKET

Two teams of 11 players each take turns to bat and field. Batsmen score "runs" by running the length of a field, with wickets at either end, while the other team tries to get them "out."



## FIELD HOCKEY

Played on a large outdoor grass field by two teams of 11. Players pass the ball to each other using sticks with a hook-shaped end and try to score goals in their opponent's net.



## SEPAK TAKRAW

Also known as kick volleyball, two teams of three players face each other on either side of a high net. The teams kick the ball over the net, winning a point if their opponents let the ball touch the ground inside the court.



## HANDBALL

Two teams of seven players bounce and throw the ball to each other using only their hands and try to score goals. Handball is played indoors, and players can take a maximum of three steps while holding the ball.



## VOLLEYBALL

Two teams of six players stand on either side of a high net. One player serves the ball over the net using his or her hand and the other team must hit it back. The teams try to hit the ball back and forth, but if the ball hits the ground, the other team gets a point.



## BEACH VOLLEYBALL

This form of volleyball is played by two teams of two or more players on a beach or sandy court. The ball must be hit, not caught; if it touches the ground, the other team wins a point.



## DODGEBALL

Dodgeball is played indoors or outdoors on a small court divided into two equal sections. Two teams of six to 10 players start with three balls each and try to hit someone from the other team by throwing the ball at them. If they succeed, that player is out—the aim is to get all the opposing players out.



## NETBALL

Netball is played by two teams of seven players on a hard indoor or outdoor court. Players must not run with the ball; they are only allowed to move one foot in order to turn and pass the ball to a teammate. The aim is to throw the ball into a netted hoop and score a goal.



## BASKETBALL

Two teams of five players move the ball up and down a court by bouncing the ball with one hand as they run or by throwing it to another team member. The aim is to score goals by shooting the ball through one of the raised hoops that sit at either end of the court. A goal is known as a "basket."





#### HAND-PELOTA

One of many forms of pelota, hand-pelota is played on a court with two walls. The small, hard ball is hit with bare hands.



#### SNOOKER

This is played on a large, cloth-covered table with six pockets. Players take turns to knock 21 colored balls into the pockets using wooden cues (sticks) and a white cue ball.



#### 8-BALL POOL

Similar to snooker, this form of pool is played by two players on a smaller table with 15 colored balls and one white cue ball. Each player uses a cue to knock seven colored balls of a pattern and the black 8-ball into the pockets.



#### RACQUETBALL

A fast game played on an enclosed indoor or outdoor court. Two or four players use rackets to bounce the rubber ball off the four walls and the ceiling.



#### ROUNDERS

An outdoor bat-and-ball game for two teams of nine players each. The batting team try to score "rounders" by hitting the ball and running around four bases.



#### BANDY

Played on an ice rink similar in size to a soccer field. Players use sticks to shoot an orange ball through nets at either end of the rink.



#### LACROSSE

A fierce outdoor sport in which two teams try to shoot a rubber ball into each other's goals using long sticks with nets at the top. A men's team has 10 players, while a women's has 12.



#### BASEBALL

Two teams of nine take turns to bat and field. A batter hits a ball thrown by the "pitcher" and then runs around four bases. The fielding team tries to get the batting team "out."



#### POLO

Two teams of four players ride horses while trying to hit the plastic ball into a goal using long sticks called mallets. Games are divided into periods of time known as "chukkas."



#### CROQUET

In this outdoor game, players use a small mallet to hit balls through metal hoops placed in the ground. Players take turns and must play the hoops in order; the first to finish wins.



#### SHOT PUT

Competitors take turns to throw a heavy metal ball (known as the "shot") from a standing position. The person who throws the shot the farthest wins.



#### SOFTBALL

Softball is a variant of baseball, played using a larger ball on a smaller field. It can be played inside or outside by teams of nine or 10. The ball must be pitched with an underarm motion.



#### BOWLS

Bowls can be played on an indoor or outdoor area known as a bowling green. Players try to roll weighted bowls as close as possible to a small ball, or "jack," at the end of the bowling green.



#### SOCCER

Two teams of 11 players each try to score goals by kicking a soccer ball from one to another and then into netted goals at either end of a large grass field. Variants of the game can be played indoors or on the beach.



#### GAELIC SOCCER

In Gaelic soccer, two teams of 15 players can kick, "hand-pass" (hit), or run with the ball for up to four steps. A goal is scored by kicking or hand-passing the ball over the top of a high crossbar.



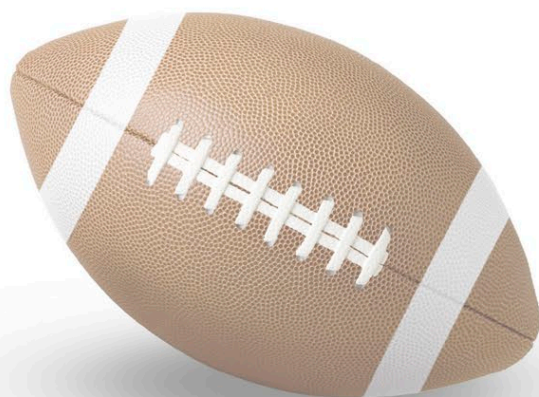
#### WATER POLO

This game is played in a swimming pool. Two teams of seven players throw the ball to one another while treading water. The aim is to throw the ball into a net guarded by a goalkeeper.



#### BOWLING

This is also called "10-pin bowling" because players try to knock down 10 long, bottle-shaped objects known as pins. Players score points for the number of pins knocked down in each set after having two attempts.



#### FOOTBALL

Played by two teams of 11 players on a large field, the aim is to get the ball into the other team's "end zone" and score a touchdown. The team with the ball has four chances to move the ball forward by throwing or running with it in 10-yd (9-m) chunks. If it succeeds, it has four more chances to move another 10 yd (9 m). If it fails, the other team wins possession of the ball.



#### RUGBY

Two teams of 13 (rugby league) or 15 (rugby union) players try to move the ball down the field by running with it, passing it to team members, or kicking it. The opposing team tries to tackle the player with the ball to gain possession. Points are scored by getting the ball to the opposite end or by kicking it through one of the tall, H-shaped goals.



#### AUSTRALIAN RULES FOOTBALL

This game is played by two teams of 18 players on an oval field. The aim is to get the ball to the opponent's end of the field and score points by kicking the ball through a set of goals. Players may use any part of their body to move the ball, but they cannot throw it. If they run with it, they must bounce it after every few steps.



# Soccer

Soccer is one of the most popular sports in the world. Its appeal is its simplicity: all you need to play is a ball, then you can play virtually anywhere—on grass, indoors, in the street, or even on the beach.

## THE GAME

During a soccer match, two teams of 11 players try to kick a ball into each other's goal. The aim is to score more goals than the other team. If no one scores any goals, or the scores are equal at the end of the game, it is called a draw.



LASTS  
90 MINUTES



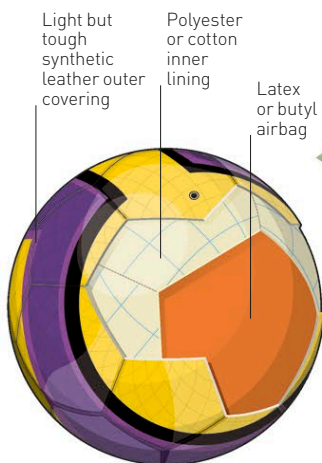
TWO HALVES OF  
45 MINUTES



HAS TWO TEAMS  
OF 11 PLAYERS

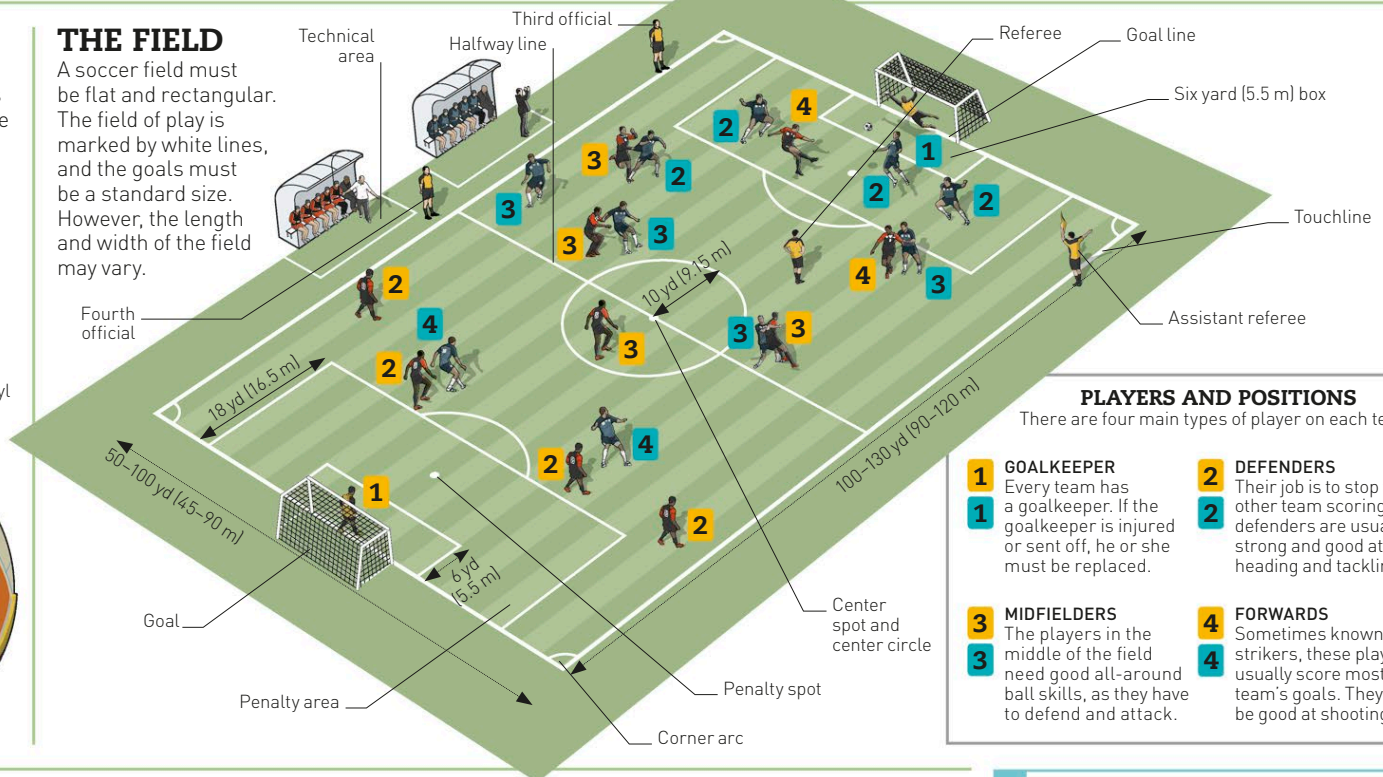
## THE BALL

The first soccer balls were made of inflated pigs' bladders covered with leather. They were heavy and not very bouncy, especially if they got wet. Modern soccer balls are made of high-tech materials and are much lighter and bouncier.



## THE FIELD

A soccer field must be flat and rectangular. The field of play is marked by white lines, and the goals must be a standard size. However, the length and width of the field may vary.



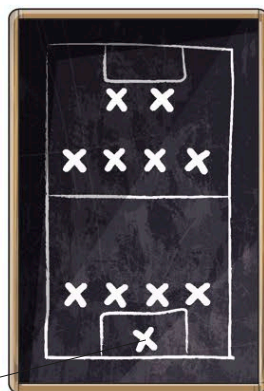
## PLAYERS AND POSITIONS

There are four main types of player on each team.

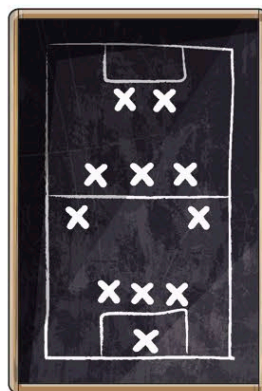
- |  |   |
|--|---|
| <b>1 GOALKEEPER</b><br><b>1</b> Every team has a goalkeeper. If the goalkeeper is injured or sent off, he or she must be replaced.           | <b>2 DEFENDERS</b><br><b>2</b> Their job is to stop the other team scoring, so defenders are usually strong and good at heading and tackling.   |
| <b>3 MIDFIELDERS</b><br><b>3</b> The players in the middle of the field need good all-around ball skills, as they have to defend and attack. | <b>4 FORWARDS</b><br><b>4</b> Sometimes known as strikers, these players usually score most of the team's goals. They must be good at shooting. |

## FORMATIONS

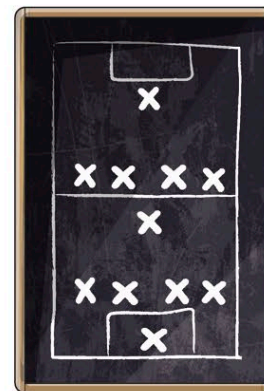
Before a match, the manager organizes the players in a way that he or she thinks will help them win. This is known as the formation. The formation is usually a set of three or four numbers, which show how many defenders, midfielders, and forwards there are. Often teams will start a match in one formation and then change during the game.



**4-4-2**  
In this basic formation, there are four defenders, four midfielders, and two forwards. The two central midfielders have different roles—one defensive and one attacking.



**3-5-2**  
This is an attacking formation. The two wide midfielders, often known as wing backs, have to help out in both defense and attack.



**4-5-1**  
This is a defensive formation. There is only one striker, who receives support from the wide midfield players.

**GOALKEEPER**  
Every team must have a goalkeeper, so he or she is not included in the formation.

## RULES OF SOCCER

During a match, a referee, assisted by officials on each touchline, makes sure the game is played fairly. Soccer has 17 official rules, or laws. Here are the three most fundamental rules, which apply whether you are playing in the park with friends or in the World Cup.

- **NO HANDS**  
A goalkeeper is allowed to touch the ball with his or her hands during a match, but only in the penalty area. If another player touches the ball with his or her hand, the opposition wins a free kick. If a defender touches the ball with his or her hand in the penalty area, it is a penalty.
- **FOUL PLAY**  
If a player commits a foul, such as a bad tackle or a handball, a free kick (or penalty if it is inside the penalty area) is awarded to the opposition. For a bad foul or a deliberate handball, a player is shown a yellow card. If that player then commits a second yellow-card offense, he or she will be shown a red card and "sent off" from the field. For serious foul play, a player can be shown a straight red card.
- **OFFSIDE**  
The purpose of the offside rule is to make it harder for a side to score goals. Attackers cannot just stand by the goal waiting to score—there must be at least two defenders between them and the goal line when the ball is passed to them. One of these defenders is usually the goalkeeper. If a player is ruled offside, the defending team is awarded a free kick.

## FIFA WORLD CUP

The Fédération Internationale de Football Association (FIFA) governs soccer around the world. Since 1932, FIFA has organized an international competition to find the best soccer team in the world. It is called the FIFA World Cup, and the finals tournament is held every four years. So far, only eight different countries have ever won it.



## AROUND THE WORLD

FIFA has 211 members, but each continent, apart from Antarctica, also has its own soccer federation. These govern the game in the region and organize international competitions at club and country level.

**THE LARGEST FEDERATIONS ARE UEFA (EUROPE), WITH 55 MEMBERS, AND CAF (AFRICA), WITH 56.**



## ATTACKING SKILLS

The attacking team is the one in possession of the ball and which moves toward the opponent's goal. The players aim to pass the ball to each other and create a goal-scoring opportunity. They have to work together and try to avoid the opposing team. Here are some of the key ball skills attacking players need.



### SHOOTING

If a player is in a position to score a goal, he or she will shoot. He or she can use the inside or outside of the foot, but the top (instep) will produce the hardest shot.

### CROSSING

A pass from the edge of the field to the center is called a cross. A cross into the penalty area is hard to defend and can often lead to a goal.

### HEADING

Heading the ball can be an attacking or defensive skill. Heading the ball with the middle of the forehead gives maximum power and control and avoids injury.

### DRIBBLING

Running with the ball at the feet is known as dribbling. It is a vital skill required to beat an opponent.

## OVERHEAD KICK

This is a really impressive way to score a goal. However, it is also a very difficult skill to master. A player has his or her back to the goal and must time the kick perfectly. It is best to practice this kick on soft ground to prevent injury.



### 1 LIFT OFF

Raise your nonkicking leg in the air and push off with the other foot.

### 2 SCISSOR MOTION

As you start to fall backward, bring your kicking leg up. Your other leg should fall back to the ground.

### 3 STRIKE THE BALL

When your back is parallel to the ground, strike the back of the ball with the top of your foot.

## DEFENDING SKILLS

The team without the ball must do everything it can to stop its opponent from scoring a goal. Here are some of the skills a team may use to regain possession of the ball or prevent the other team from scoring a goal. Once the defending team has won the ball, it becomes the attacking team.



### TACKLING

A defender can use his or her feet to take the ball away from the attacker. Known as a tackle, timing is very important. If the defender kicks the player instead of the ball, it is a foul.

### MARKING

By staying close to his or her opponent, a defender might be able to prevent the attacking team making a pass or even intercept the ball. This is known as marking.

### INTERCEPTION

By marking a player closely or guessing where an attacker is going to pass the ball, a defender may intercept it. He or she can then start an attack for their own team.

### GOALKEEPING

The goalkeeper is the last line of defense. He or she can use any part of the body to prevent a goal. Goalkeepers need to be strong, agile, and able to react quickly when the ball is struck at them.

## DEAD-BALL SKILLS

If the referee has stopped play for a foul or the ball has gone out of play, it is called a dead ball. Corners, throw-ins, free kicks, and penalties are all dead-ball situations known as "set pieces." Teams will spend a lot of time practicing set pieces, as they are good goal-scoring opportunities.



### CORNER

If a defender kicks the ball over the goal line, the attacking team is awarded a corner. It is taken from the nearest corner arc.

### THROW-IN

When the ball crosses the touchline, whichever team kicked the ball last loses possession. The other team can then throw the ball and begin an attack.

### FREE KICK

If a player commits a foul outside the penalty area, the other team will be awarded a free kick. The closer this kick is to the goal, the greater chance the attacking team has of scoring.

### PENALTY

If a player from the defending team commits a foul inside the penalty area, the attacking team is awarded a penalty—a one-on-one shot against the goalkeeper.

## PENALTIES

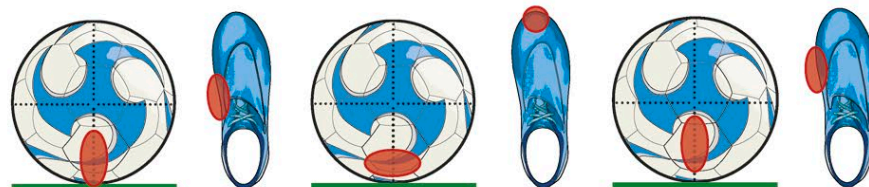
Here are the best places to aim for if you want to score a penalty and the different ways you could strike the ball. Even if the goalkeeper guesses where you will shoot, he or she is unlikely to be able to save it—unless the shot is weak.

### WHERE TO AIM YOUR PENALTY

- Goalkeeper is likely to save, unless he or she dives too early.
- Goalkeeper may be able to save if shot struck weakly.
- Goalkeeper is highly unlikely to save.



### HOW TO STRIKE THE BALL



### PASS THE BALL

This type of penalty is best for accuracy. However, striking the ball in this manner could produce a weak shot that the goalkeeper could easily save.

### CHIP THE BALL

Only a confident player should try this shot, which is aimed up and over the goalkeeper. This shot also requires great skill to get it on target.

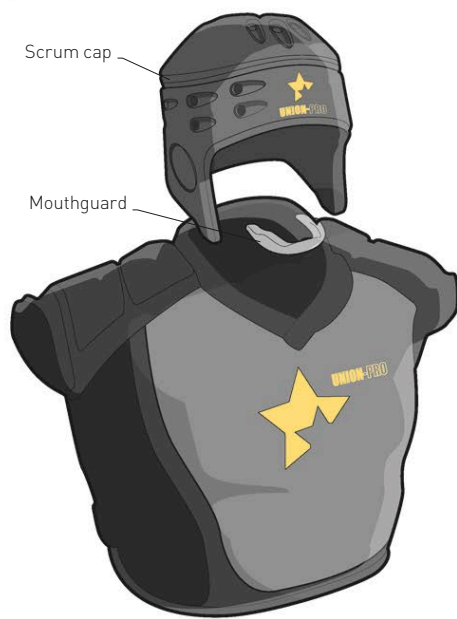
### POWER SHOT

A powerfully struck penalty will always beat the goalkeeper—if it is on target. However, increased power also means less accuracy.



# Rugby

Played in more than 100 countries around the world, rugby is one of the most physically demanding of all ball sports. There are several forms of rugby, but the most popular form is rugby union.



## EQUIPMENT

Players wear a jersey, shorts, socks, and boots and protect their teeth with a mouthguard. Some forwards also wear a scrum cap to protect them from hard knocks, while other players wear upper-body padding.



**THE BOOTS**  
Players wear either high-cut boots, which help support their ankles, or low-cut soccer shoes that are lighter and give them greater mobility.



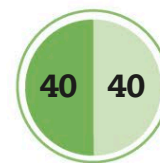
**THE BALL**  
The oval ball is 11–12 in (28–30 cm) long, 23–24 in (58–62 cm) at its widest point, and weighs 14–16 oz (410–460 g).

## THE GAME

Rugby union is played by two teams. Each team is made up of 15 players, and seven substitutions are allowed by each team. The aim is to score more points than the opposition. If both teams score the same points or do not score at all, the match is a draw.



LASTS  
80 MINUTES



TWO HALVES OF  
40 MINUTES



HAS TWO TEAMS  
OF 15 PLAYERS

## SCORING POINTS

There are four ways of scoring in rugby:

### ○ TRY

A team gets five points for scoring a try. A try is given when a team touches the ball down in the opponent's in-goal area.

### ○ CONVERSION

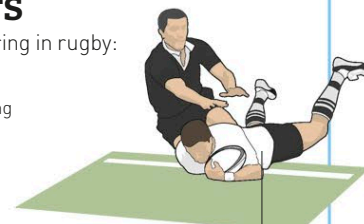
A try gives the team the chance of scoring an extra two points from a conversion. This is a place kick, where the player taking the conversion scores the extra points if he or she kicks the ball over the crossbar.

### ○ PENALTY GOAL

Worth three points, the penalty kick is like a conversion. It is taken from the place where the offense was committed. While the kick is being taken, the opponents have to stay back by at least 11 yd (10 m).

### ○ DROP GOAL

A drop goal is worth three points. It can be taken from anywhere on the field, but the player must drop the ball on the ground just before he or she kicks it through the posts. Defenders can charge down a conversion attempt as soon as the kicker starts to move toward the ball.



The player has to be in control of the ball when scoring a try.

## THE RUGBY FIELD

Rugby union is played on a rectangular grass field, or pitch. For professional matches, the length of the field is 103–109 yd (94–100 m) between the two try lines, but the width of the field and the distance from the try line to the dead ball line can vary. A series of solid and dotted white lines are also marked at regular intervals. These show where restart kicks can be taken from and help players position themselves during set pieces.

The 11-yd (10-m) line is used when the game starts or restarts with a kick—a player has to kick the ball past the 11-yd (10-m) line and the team receiving the ball have to stand behind this line.

The halfway line divides the field into two halves.

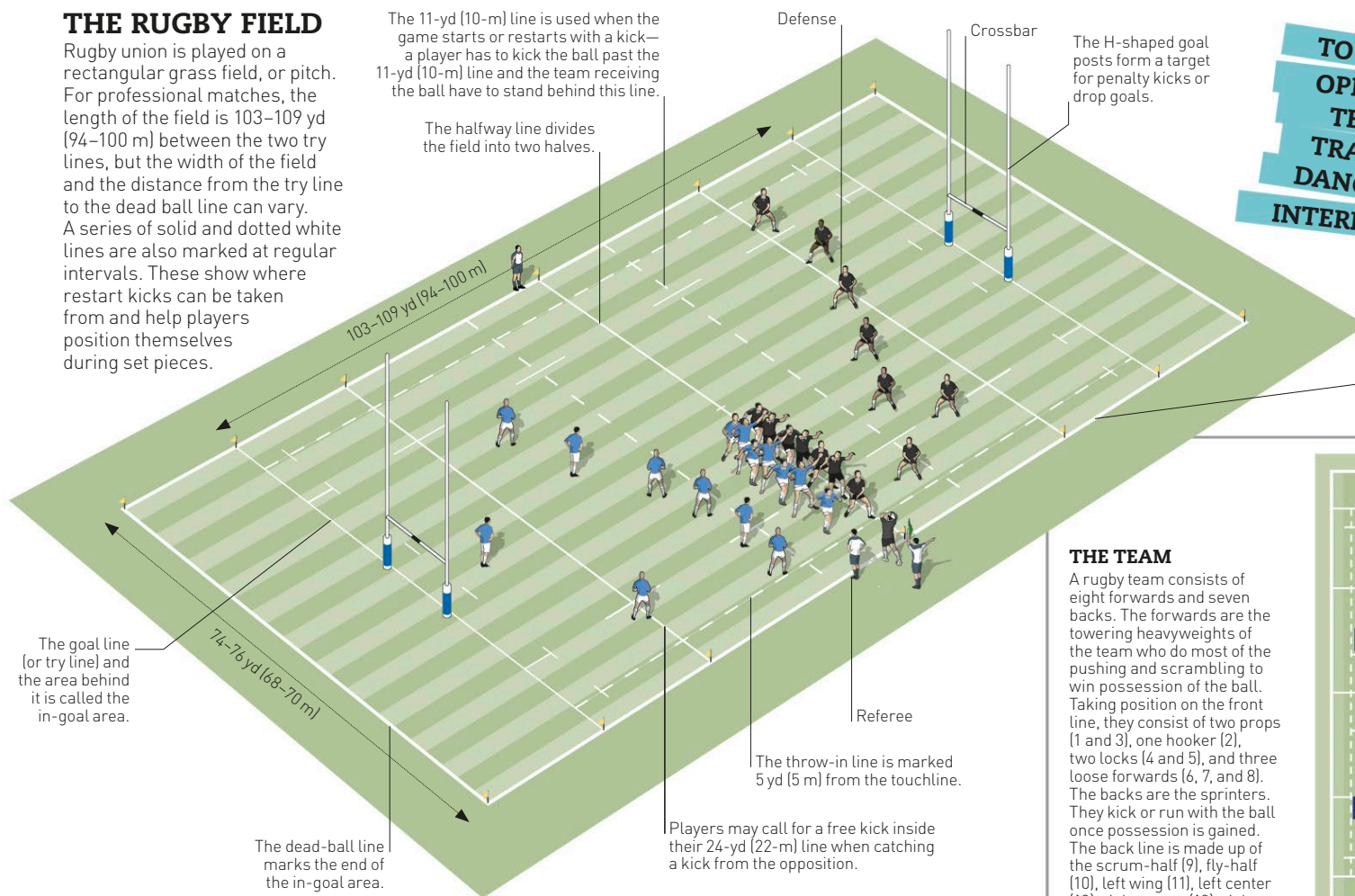
Defense

Crossbar

The H-shaped goal posts form a target for penalty kicks or drop goals.

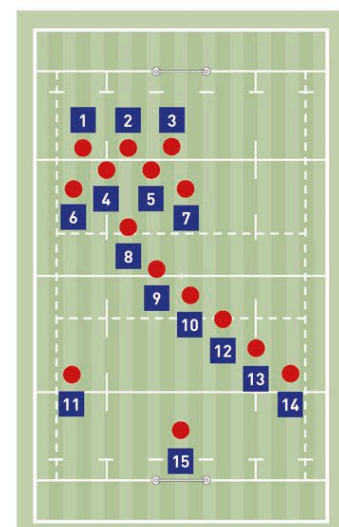
TO INTIMIDATE THEIR OPPONENTS, SOME TEAMS PERFORM A TRADITIONAL WAR DANCE BEFORE AN INTERNATIONAL MATCH.

The touch line marks the edge of the field—if the ball crosses the touch line, then it is out of play.



## THE TEAM

A rugby team consists of eight forwards and seven backs. The forwards are the towering heavyweights of the team who do most of the pushing and scrambling to win possession of the ball. Taking position on the front line, they consist of two props (1 and 3), one hooker (2), two locks (4 and 5), and three loose forwards (6, 7, and 8). The backs are the sprinters. They kick or run with the ball once possession is gained. The back line is made up of the scrum-half (9), fly-half (10), left wing (11), left center (12), right center (13), right wing (14), and full back (15).



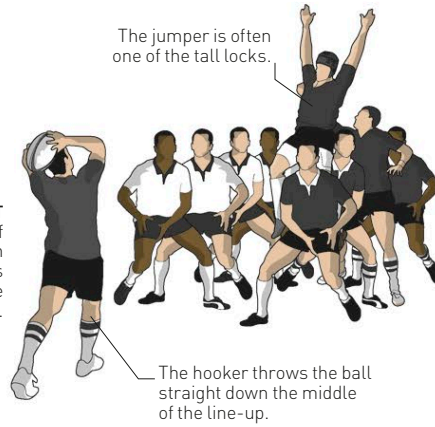


## PLAYING THE GAME

In rugby, a team gains territory by running with the ball and passing it between players. A player can also kick the ball forward to gain territory, but passing the ball forward to a teammate is not allowed. The opposition team can defend by tackling the player with the ball. In rugby, there are several important set pieces as follows:

### LINE-OUT

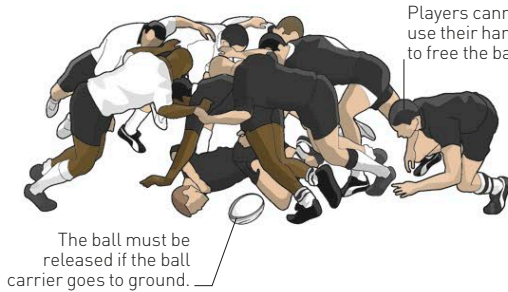
A line-out is given to restart the game if the ball goes out of play. It is awarded to the team who were not the last to touch the ball when it went out of play. Between two and seven players may be put in the line. The ball is thrown down the middle of the line-up, and players jump to get possession for their team.



Players cannot use their hands to free the ball.

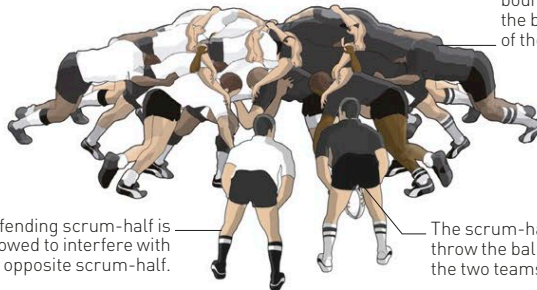
### RUCKING AND MAULING

A ruck forms when the player carrying the ball goes to the ground. The first players to arrive from each side can bind together over the ball, pushing their opponents back. Players are only allowed to use their feet to boot the ball back to their side. This is called rucking. A maul is similar to a ruck, but the ball carrier remains on their feet.



### SCRUM

In a scrum, eight players from each team bind together and push against the other team. The scrum-half rolls the ball into the channel between the two teams. Then the hooker attempts to secure the ball by heeling it toward the back of the scrum.



The back-row players remain bound until the ball is out of the scrum.

## KEY SKILLS

Rugby involves a range of individual skills and techniques. Players need to have good passing and catching skills, be able to kick with accuracy, and be able to make a strong tackle.

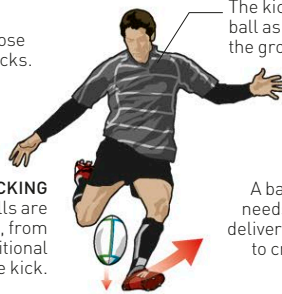


### CATCHING

A player needs to have good hand-eye coordination because catches need to be taken from close proximity, as well as from high kicks.

### KICKING

Various kicking skills are needed during a game, from drop-kicks, a quick positional punt upfield, to a place kick.



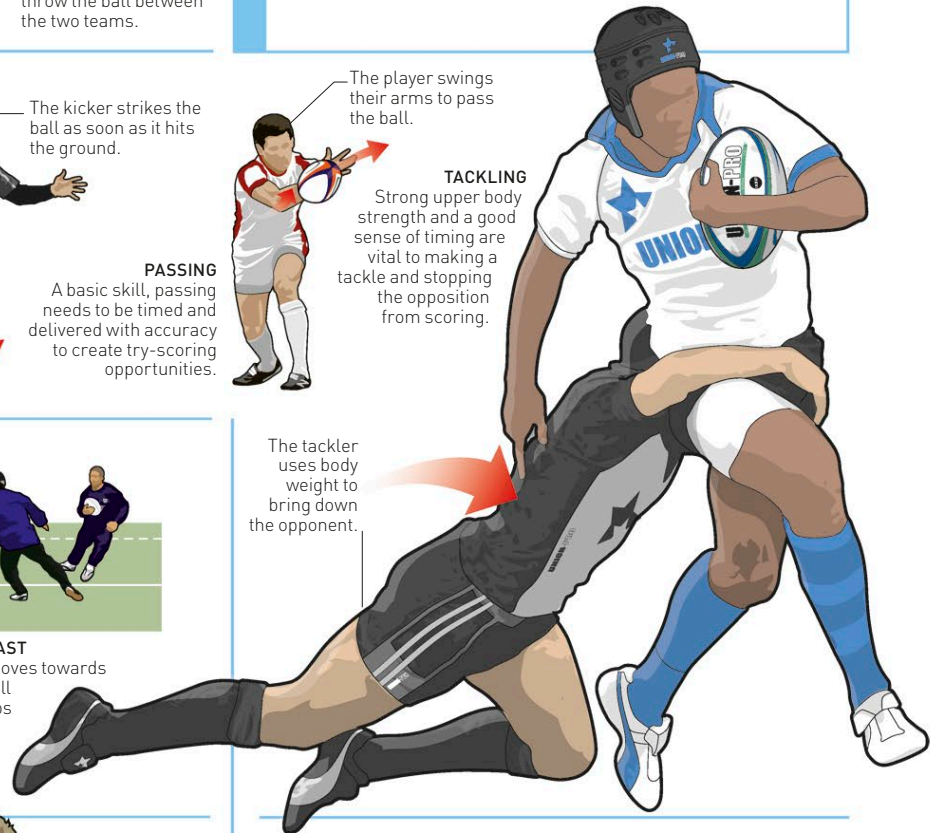
### PASSING

A basic skill, passing needs to be timed and delivered with accuracy to create try-scoring opportunities.



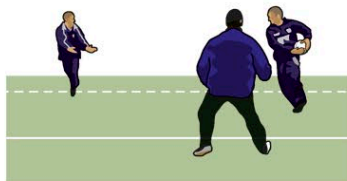
### TACKLING

Strong upper body strength and a good sense of timing are vital to making a tackle and stopping the opposition from scoring.



## TEAM TACTICS

To score more points than the opposition, teamwork is essential, as well as individual skills. Players use tactics such as throwing a dummy. Another tactic is to kick the ball into touch to gain territory. This is also used by a defending side to slow down the game and take the pressure off their team.



### 1 THROWING A DUMMY

When a player wants to mislead an opponent, he or she looks toward a teammate and positions the ball in their hands as if he or she is about to pass it to the teammate.

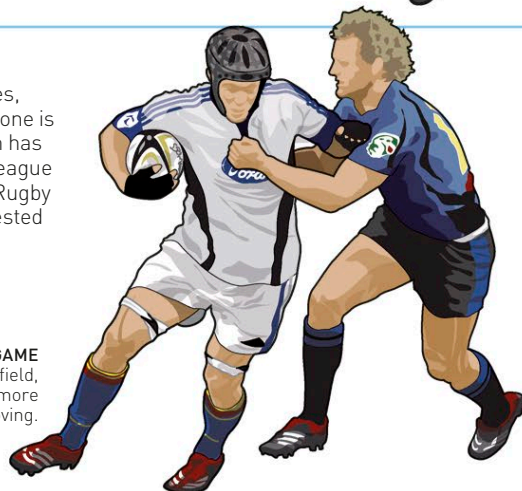


### 2 SIDE-STEPPING PAST

As the opponent moves towards the other player, the ball carrier easily side-steps past the opponent.

## RUGBY LEAGUE

Rugby union and rugby league are very similar games, but there are some major differences, too. The main one is in the number of players. In rugby league, each team has 13 players and 10 substitutions are allowed. Rugby league is played in more than 70 countries worldwide. The Rugby League World Cup is held every four years and contested by about 16 countries.



### A FAST-MOVING GAME

With fewer men on the field, rugby league is considered to be more physically demanding and faster moving.

## RULES OF RUGBY

The most important rule in rugby is that the ball cannot be passed forward. If this rule is broken, the result is a scrum to the opposition. Free kicks are awarded for lesser offenses, while penalties are awarded against players who are in an offside position or commit foul play. The referee uses various hand signals to convey what has been awarded.



PENALTY KICK

### OFFSIDE RULE

If a player gets in front of a teammate who is carrying the ball, then this is an offside offense. A scrum is awarded against the players involved. The offside rule also comes into play during set pieces.



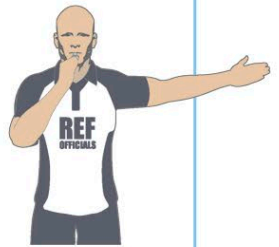
FREE KICK

### PENALTIES AND FOUL PLAY

Penalties are awarded for fouls such as in a ruck or a maul. Examples of foul play fall into four categories: obstruction, unfair play, repeated offenses, and misconduct.

### CARD CAUTIONS

As in other sports such as soccer, rugby referees use a card to caution a player. After a verbal warning, the referee uses a yellow card to send the player off the field for 10 minutes. If the same player commits another offense, a red card is shown and the player is sent off for the rest of the match.



SCRUM AWARDED

## CHAMPIONSHIPS

Staged every four years, the Rugby World Cup is the sport's major competition. The other international championships—the Rugby Championship and the Six Nations—take place annually. The Rugby Championship is played by the southern hemisphere countries (Argentina, Australia, New Zealand, and South Africa), while the Six Nations is played by the northern hemisphere countries (England, France, Ireland, Italy, Scotland, and Wales).



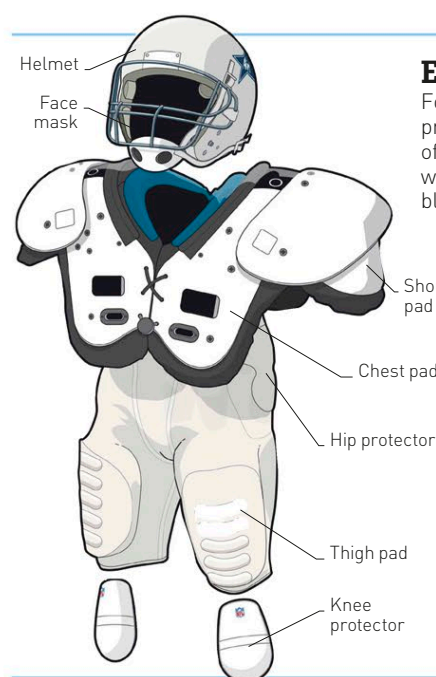
### WORLD CUP WINNERS

In 2019, South Africa beat England to become the Rugby World Cup champions.



# Football

Also known as gridiron in some countries, football is one of the most popular sports in the United States. Professional football (the NFL) and college football are the most popular forms of the game.



## EQUIPMENT

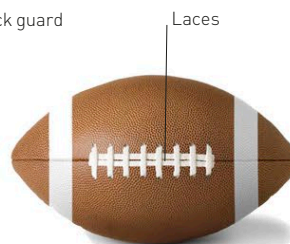
Football is a full-contact sport. Every part of the body needs to be protected against charging players. A helmet is the most vital piece of equipment, as head clashes in a game are common. Players also wear body armor worn over soft shock-pads, which absorb any hard blows; this gives them a top-heavy appearance.



Arm guard



Neck guard



Laces

## PADDING

A range of pads can be worn to protect specific parts of the body. The sort of protection a player wears often depends on the position in which he or she plays.

## THE BALL

The ball is oval in shape. It is 11 in (28 cm) long, has a circumference of 28 in (71 cm) at its widest point, and weighs 15 oz (425 g).

## THE GAME

Two teams of 11 players compete during four periods of play (known as "quarters"). The aim is to score points by advancing an oval ball into an opponent's end zone (to score a touchdown) or by kicking it through the goal posts (to score a field goal).



LASTS  
60 MINUTES



4 QUARTERS OF  
15 MINUTES



HAS 2 TEAMS OF  
11 PLAYERS

## SCORING POINTS

The objective in football is to score more points than the opposition. Points can be scored in five ways.

### TOUCHDOWN

A touchdown is scored if a team advances the ball into the opponent's end zone. The ball can either be run over the line or passed to a teammate in the end zone. A touchdown is the game's most valuable scoring play, worth six points.

### POINT AFTER TOUCHDOWN

After a touchdown, a team can score an extra point by kicking the ball through the goal posts.

### TWO-POINT CONVERSION

Teams do not have to opt for a kick after scoring a touchdown. Instead, they could opt to score a try. In this instance, the team has a single play to score a touchdown. If successful, the team is awarded an extra two points.

### FIELD GOAL

A field goal is scored when the ball is kicked through the goal posts. It is worth three points.

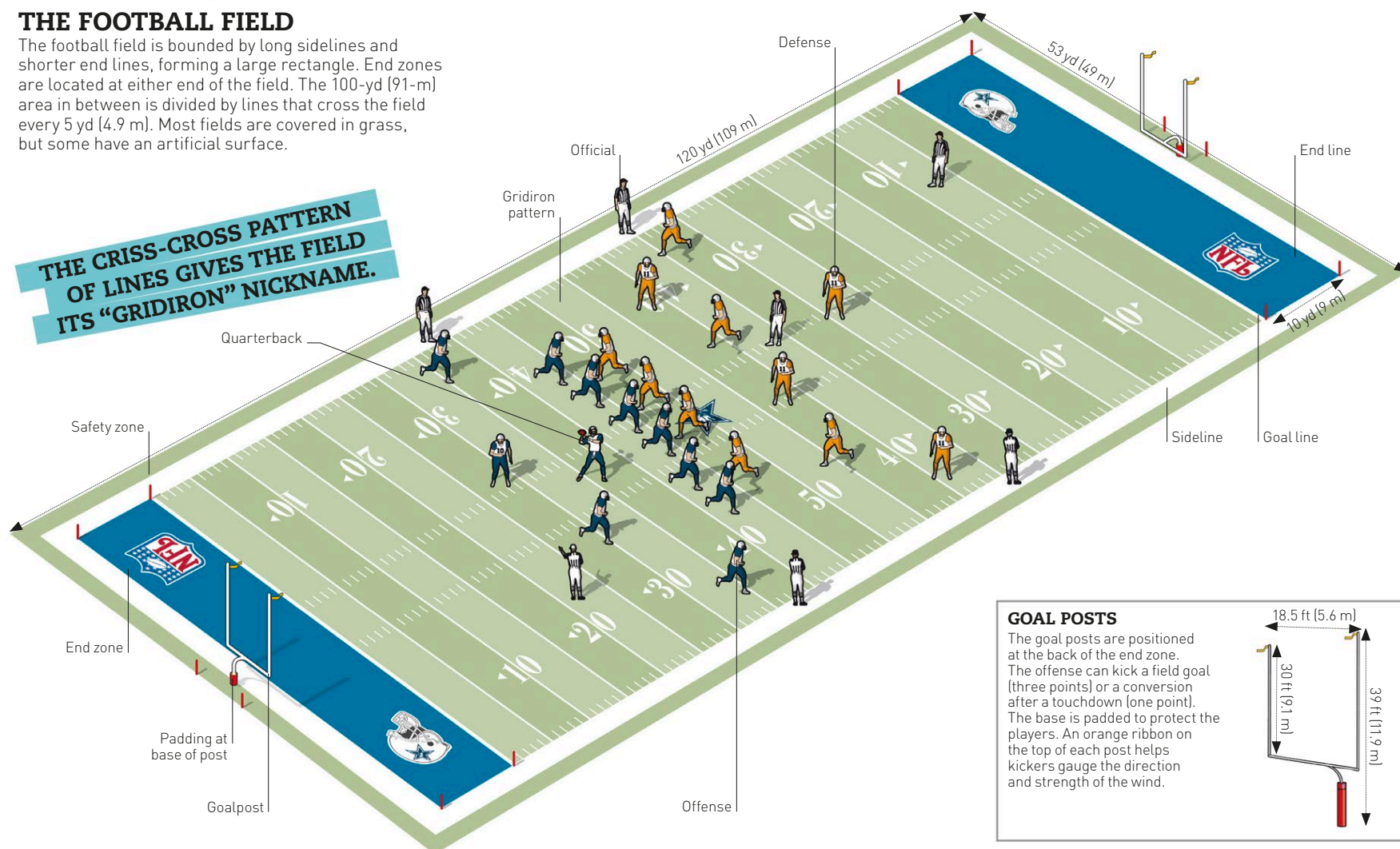
### SAFETY

A safety, worth two points, is awarded if an opponent is tackled or drops the ball in his or her own end zone and it goes out of play.

## THE FOOTBALL FIELD

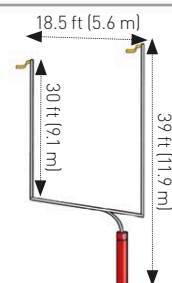
The football field is bounded by long sidelines and shorter end lines, forming a large rectangle. End zones are located at either end of the field. The 100-yd (91-m) area in between is divided by lines that cross the field every 5 yd (4.9 m). Most fields are covered in grass, but some have an artificial surface.

THE CRISS-CROSS PATTERN  
OF LINES GIVES THE FIELD  
ITS "GRIDIRON" NICKNAME.



## GOAL POSTS

The goal posts are positioned at the back of the end zone. The offense can kick a field goal (three points) or a conversion after a touchdown (one point). The base is padded to protect the players. An orange ribbon on the top of each post helps kickers gauge the direction and strength of the wind.





## 10 YARDS AT A TIME

Territory and possession of the ball are the keys to success in football. The team in possession of the ball is called the offense. It has four chances, called "downs," to advance the ball 10 yd (9 m) toward the opponent's end zone, either by running with the ball or by throwing it. If successful, the offensive team is awarded another four downs. If it fails to advance 10 yd (9 m), or if it loses possession of the ball during a play, possession of the ball passes to the defensive team.

### BASIC DEFENSE

The aim of the defense is to stop the offense from gaining the 10 yd (9 m) they need four new downs. Many teams use a formation called the 4-3 defense, in which four defensive linemen line up in front of the three linebackers. Two safeties play behind to stop longer passes and runs, while two cornerbacks are positioned to cover any passes made to the wide receivers.

There are five positions in defense:

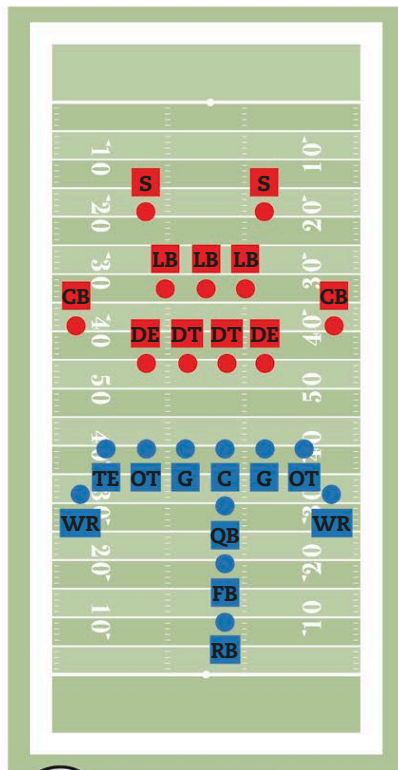
<b>DE</b>	Defensive end
<b>DT</b>	Defensive tackle
<b>LB</b>	Linebacker
<b>CB</b>	Cornerback
<b>S</b>	Safety

### BASIC OFFENSE

The "Standard I Formation" is a common attacking play using five offensive linemen. The "I" refers to the line formed by the quarterback, fullback, and running back (or tailback). A tight end lines up on one side, with a wide receiver at each end.

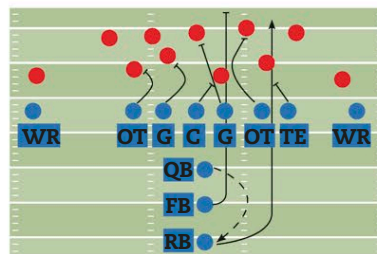
There are eight positions in offense:

<b>WR</b>	Wide receiver
<b>TE</b>	Tight end
<b>OT</b>	Offensive tackle
<b>G</b>	Guard
<b>C</b>	Center
<b>QB</b>	Quarterback
<b>FB</b>	Fullback
<b>RB</b>	Running back, or tailback



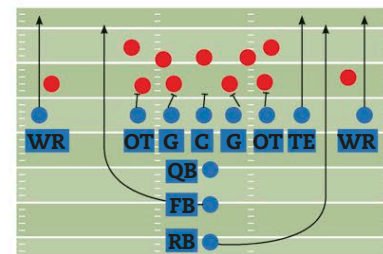
## PLAYS

Football is punctuated by a series of plays, or downs. Offensive plays aim to advance the ball toward the opponents' end zone. Defensive plays aim to stop the offense moving forward. Some of the most well-known plays are described below.



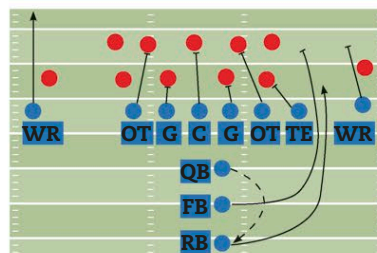
### RUNNING BACK OFF-TACKLE

The running back off-tackle is the most common running play in offense. The quarterback hands the ball to the running back, who runs through a hole created by the offensive tackle and the tight end.



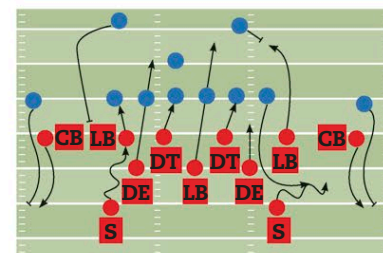
### HAIL MARY

The Hail Mary is a passing play in which the quarterback throws a long ball toward one of a number of receivers. The play is often used as a last resort by a trailing team toward the end of the game.



### SWEEP

The sweep is an organized offensive running play in which a running back receives the ball from the quarterback and then runs parallel to the line of scrimmage. This gives the fullback and offensive lineman time to create a gap for the running back.



### THE BLITZ

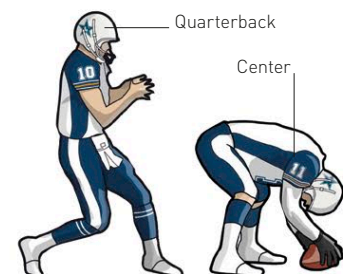
The blitz is a defensive tactic used to combat passing plays. The aim is to put the opposition quarterback under pressure by swamping the offense with defenders.

## KEY SKILLS

Different positions require different skills. For example, quarterbacks need to be good at throwing; wide receivers must have lightning acceleration and be able to catch the ball; and defenders must be excellent tacklers and blockers.

### PASSING THE BALL

One of the most important duties of a quarterback is to pass the ball to a receiver. A strong, accurate pass is vital, as the quarterback may have to throw the ball over a long distance.



### 1 THE SNAP

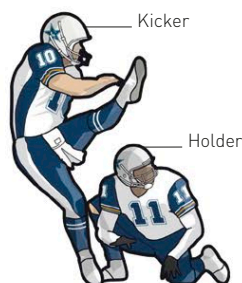
Each down begins with a snap. The center snaps the ball through the legs to the quarterback.

### 2 THE PASS

After collecting the ball, the quarterback grips the ball by the laces and passes it point first. The ball is spun as it is thrown, making it fly straight.

### KICKING

All football teams have a specialist kicker. His or her role is to kick for field goals or for the extra point following a touchdown. For a field goal attempt, the holder stands 7 yd (6 m) behind the center, who snaps the ball to the kicker. The holder catches the ball and sets it up for the kicker. The kicker steps forward and swings his or her foot through the ball, aiming to send it between the goal posts.



**ON AVERAGE, THE NFL HAS MORE SPECTATORS PER GAME THAN ANY OTHER SPORTS LEAGUE IN THE WORLD—66,151 IN 2019.**

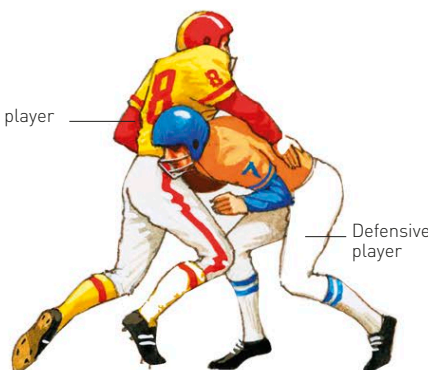


### CATCHING

All wide receivers must be able to catch the ball thrown by the quarterback. They sometimes do this running at full speed, often while having to fight off a defender.

### DEFENSE

The main task of a defender is to prevent the offensive side from advancing with the ball. He or she can do this by tackling the offensive player who is carrying the ball.



## REFEREE'S SIGNALS

If a rule is broken during the course of a game, an official will bring play to a halt by waving a yellow flag. The referee then conveys the decision by using a hand signal and making an announcement.



### INTERFERENCE

A penalty in which a player has interfered with another player during a play.



### FIRST DOWN

The offense advances 10 yd (9 m) within four downs, so a new series of downs is called.



### FALSE START

This is called when a member of the offense moves illegally before the ball is snapped.



### OFFSIDE

A defensive player is on the wrong side of the line of scrimmage at the start of play.



### HOLDING

A penalty in which a player of either side has illegally held an opponent.



### ILLEGAL BALL TOUCH

A penalty in which the ball is illegally touched, kicked, or batted.



# Baseball

Baseball is played in more than 100 countries around the world, including China, Japan, Venezuela, and Cuba. However, the game is often most closely associated with the US, where it is one of the most popular sports.

## THE GAME

Two teams take turns batting and fielding. The batting team tries to score "runs" by hitting the ball and then running around four bases. The fielding team tries to get the batting team "out" (stop it scoring runs). Three "outs" ends the inning, and the team with the most runs after nine innings wins.



NO TIME RESTRICTION



9 TURNS (INNINGS) EACH, PLUS EXTRA IF SCORE IS TIED



2 TEAMS OF 9 PLAYERS

## EQUIPMENT

The most essential equipment for a game of baseball is, of course, the bat and the ball. As the ball can travel at speeds of up to 100 mph (160 kph), some safety gear is also required.

### BALL

A baseball has a tough rubber and cork core, surrounded by red cotton wool and covered with two strips of leather.

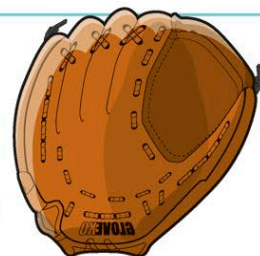


Red stitching

3 in (7.5 cm)

### CATCHER'S MASK

Face and head protection is essential for catchers. Batters also wear helmets to protect their heads.



### GLOVES

Fielders wear a large, padded leather glove to make it easier and safer to catch the ball. The catcher also has a special mitt.

### BAT

Professional bats are made from wood and usually weigh no more than 4 lb (1.8 kg).



The barrel—where the batter strikes the ball

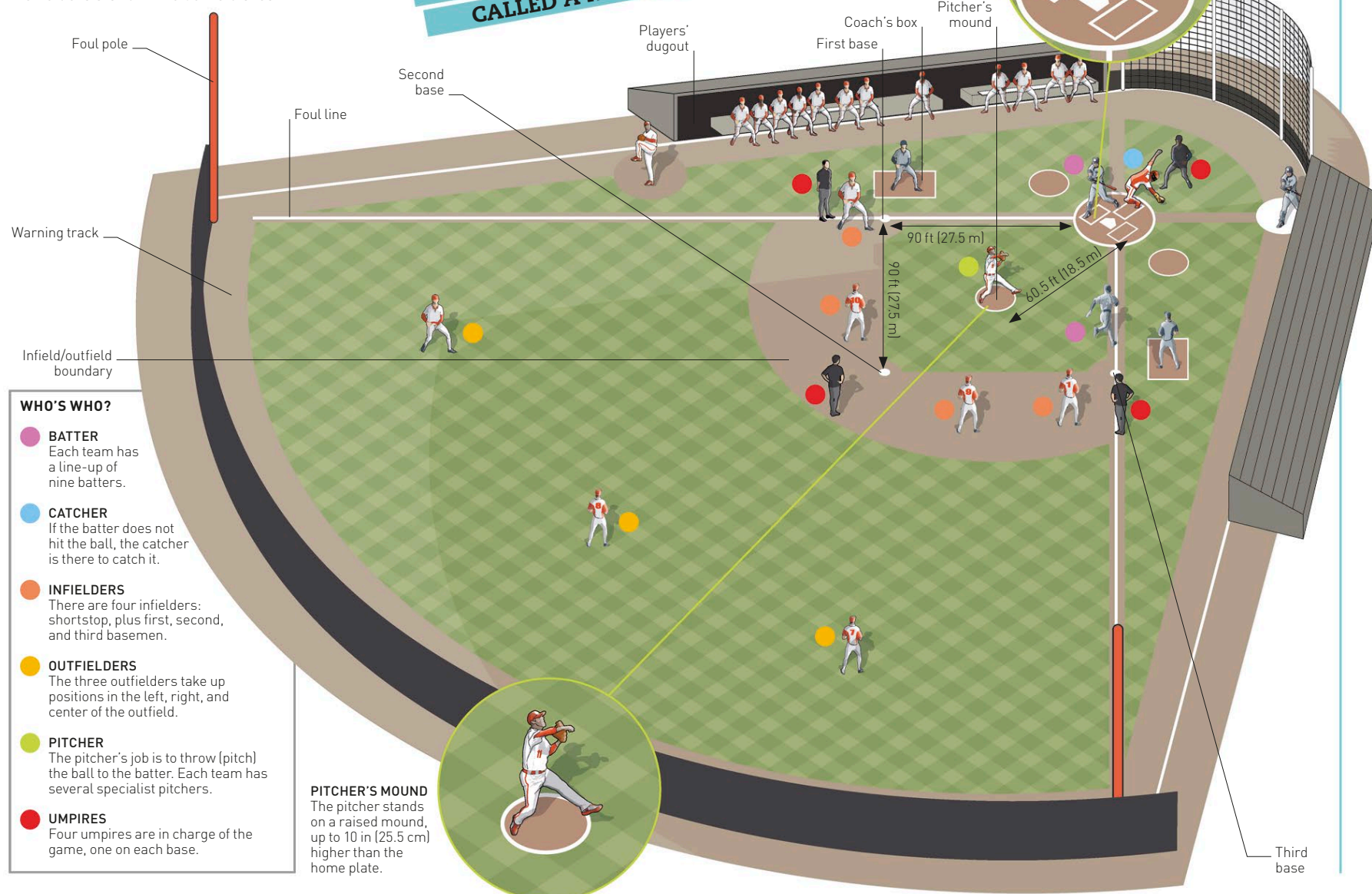
Tapered handle

Up to 40 in (101.6 cm)

## THE FIELD

The playing area is divided into the infield and the outfield. The infield is also known as the "diamond" and is where the batter, pitcher, and catcher all stand. It also contains the four bases and some fielders. The rest of the fielders stand in the outfield area.

IF A BATTER HITS THE BALL SO FAR THAT HE OR SHE CAN RUN AROUND ALL THE BASES IN ONE GO, IT IS CALLED A HOME RUN.



### WHO'S WHO?

- BATTER**  
Each team has a line-up of nine batters.
- CATCHER**  
If the batter does not hit the ball, the catcher is there to catch it.
- INFIELDER**  
There are four infielders: shortstop, plus first, second, and third basemen.
- OUTFIELDERS**  
The three outfielders take up positions in the left, right, and center of the outfield.
- PITCHER**  
The pitcher's job is to throw (pitch) the ball to the batter. Each team has several specialist pitchers.
- UMPIRES**  
Four umpires are in charge of the game, one on each base.

**PITCHER'S MOUND**  
The pitcher stands on a raised mound, up to 10 in (25.5 cm) higher than the home plate.



## PITCHING

A pitcher's job is to get the batter out. He or she needs to make it difficult for the batter to hit the ball—known as a strike—or place the ball so that the batter will hit it where it will be caught easily.

### 1 WIND UP

The pitcher starts with the back foot on the pitching rubber and then raises the front leg to waist height.

### 2 STRIDE

The pitcher then plants the front foot firmly on the ground and swings the pitching arm back.

### 3 PITCH

Finally, the pitcher throws the arm forward, releasing the ball when the arm is fully extended.

## PITCH STYLES

The way that the pitcher grips or releases the ball can affect the speed, force, and angle of the pitch. Here are some common pitches.

### FASTBALL

This is a popular pitch. Two fingers over the top of the ball allow it to be released at great speed.



### STRAIGHT PITCH

A fastball usually goes straight toward the home plate.

### CURVEBALL

A twist of the wrist gives this pitch topspin, which causes it to curve downward at the last moment.



### TAKING A TURN

The best curveballs cause the batter to swing at the wrong spot.

### SLIDER

Gripped slightly off-center, the slider is not quite as fast as a fastball or as curved as a curved ball.



### SPIN

A slider pitch swerves at the last moment, confusing the batter.

### KNUCKLEBALL

The most difficult to learn, the knuckleball is gripped with two fingers on the top of the ball and pitched straight.



### SLOW PITCH

A knuckleball moves so unpredictably that it is hard for the batter to time his or her swing.

**A CATCHER WILL SUGGEST OR "CALL" A PITCH STYLE TO THE PITCHER BASED ON THE BATTER'S STANCE.**

## STRIKE!

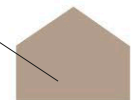
The pitcher must pitch the ball into the area known as the "strike zone." If the batter does not swing at all, misses the ball, or hits it into foul territory, the umpire at the home plate will call "strike." If a batter has three strikes, he or she is out, and it is the next batter's turn.

### STRIKE ZONE

The strike zone is the area above the home plate between the batter's knees and the midpoint of his or her torso.



Home plate



## BATTING

Batting requires strength, skill, timing, and the ability to out-think the pitcher. Most professional players are considered to be good hitters if they can safely hit three out of 10 pitches.

### 1 STANCE

The batter stands side-on. The legs are wide, the elbows bent, and the bat is raised above the head.

### 2 SWING

As the ball is pitched, the batter takes a big step forward and swings the bat toward the ball.

### 3 FOLLOW-THROUGH

The batter completes the swing and then prepares to run to first base, if the ball is hit.

Bat completes a full swing.

Head up to check where the ball has gone

Hips rotate to generate power.

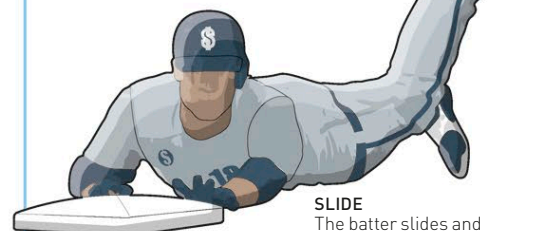
## BASE RUNNING

As soon as the batter hits the ball, they need to start running to first base. However, they must reach the base before a fielder can throw the ball to a teammate standing on the base.



### TAG OUT

The fielder touches the batter with the ball before he or she reaches a base. Out!



### SLIDE

The batter slides and touches the base before the base fielder can receive the ball. Safe!

**NICKNAMES FOR A HOME RUN INCLUDE: DINGER, TATER, LONG BALL, MOON SHOT, BOMB, OR GOPHER BALL.**

## WORLD SERIES

Every year, the winners of the American League and the winners of the National League compete in a set of games, known as the World Series. These teams have won the most World Series, including some, such as the Giants, who have played in more than one city.

- 1 **NEW YORK YANKEES** 27
- 2 **ST. LOUIS CARDINALS** 11
- 3 **OAKLAND ATHLETICS** 9
- 3 **BOSTON RED SOX** 9
- 4 **SAN FRANCISCO GIANTS** 8
- 5 **LOS ANGELES DODGERS** 6
- 6 **CINCINNATI REDS** 5
- 6 **PITTSBURGH PIRATES** 5
- 7 **DETROIT TIGERS** 4

## INTERNATIONAL BASEBALL

Baseball was dropped as an Olympic sport in 2008, then reinstated at the Tokyo Olympics in 2021. The last Baseball World Cup was held in 2011, so the most prestigious national competition at present is the World Baseball Classic, launched in 2006 and held every four years. Japan won the first two competitions, but the Dominican Republic were victorious in 2013, and the US in 2017.



# Basketball

Basketball is a fast-paced ball sport invented in 1891 in Massachusetts as an indoor game to keep students fit during the winter. It was originally played by shooting the ball into fruit-pickers' baskets, which is how the sport got its name.

## EQUIPMENT

One of the attractions of basketball is that you need very little equipment to play—just a ball and two baskets. Players do not even need special clothing, just suitable shoes for running on court.



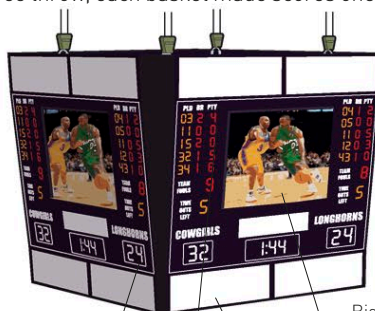
**BALL**  
A modern ball is made of rubber or a synthetic composite covered in leather. It is 30 in (76 cm) in circumference and weighs 21–23 oz (600–650 g).



**BASKET AND BACKBOARD**  
The basket, a hoop with netting hanging from it, is 18 in (45 cm) across. It is mounted on a vertical backboard.

## KEEPING SCORE

Spectators keep track of the score on a scoreboard. A basket made inside the three-point line scores two points. Baskets made from beyond the three-point arc score three points. When shooting a free throw, each basket made scores one point.



Time and score — Big screen  
Team and player stats — Space for advertising

## THE GAME

Two teams of five players each try to score points by shooting a ball through a hoop, which is 10 ft (3.05 m) above the ground. The winning team is the one that has scored the most points by the end of the game.



LASTS  
48 MINUTES



4 QUARTERS OF  
12 MINUTES (NBA)



HAS 2 TEAMS OF  
5 PLAYERS

## LAWS OF THE COURT

The NBA (National Basketball Association) governs the professional game in the US. The NBA sets out 14 rules, although each rule is divided into many clauses and subsections. Differing governing bodies worldwide have slightly different rules.

### PERSONAL AND TECHNICAL FOULS

If a team commits a foul, the opposing team is given possession of the ball. If a team is fouled while shooting, they are awarded one or more shots at the basket. Fouls can be either personal—for example, for pushing, blocking, or holding an opponent—or technical, for offenses such as deliberate time-wasting or arguing with the referee. In the NBA, once a player has recorded six fouls, they may take no further part in the game.

### VIOLATIONS

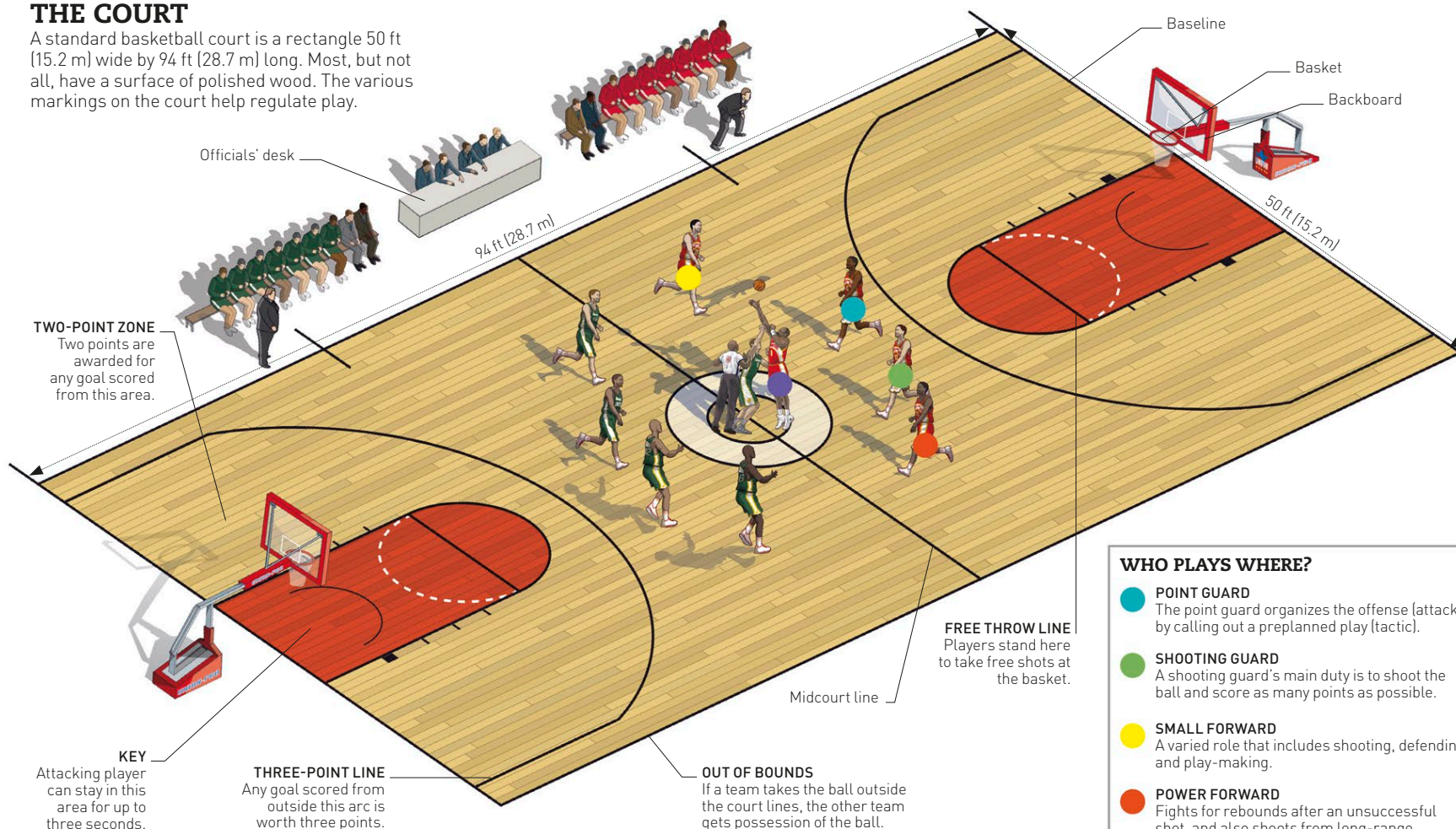
When a player breaks the rules, they commit a foul. For instance, players must dribble (bounce the ball in front of them) as they run. If they do not, they commit a foul known as “traveling.”

### TIME LIMITS

Basketball is designed to be a fast-moving, attacking sport. In the NBA, once in possession of the ball, a team must attempt a shot within 24 seconds; if it does not, possession passes to the other team.

## THE COURT

A standard basketball court is a rectangle 50 ft (15.2 m) wide by 94 ft (28.7 m) long. Most, but not all, have a surface of polished wood. The various markings on the court help regulate play.



**TWO-POINT ZONE**  
Two points are awarded for any goal scored from this area.

Officials' desk

94 ft (28.7 m)

KEY

Attacking player can stay in this area for up to three seconds.

**THREE-POINT LINE**

Any goal scored from outside this arc is worth three points.

Midcourt line

**FREE THROW LINE**  
Players stand here to take free shots at the basket.

**OUT OF BOUNDS**

If a team takes the ball outside the court lines, the other team gets possession of the ball.

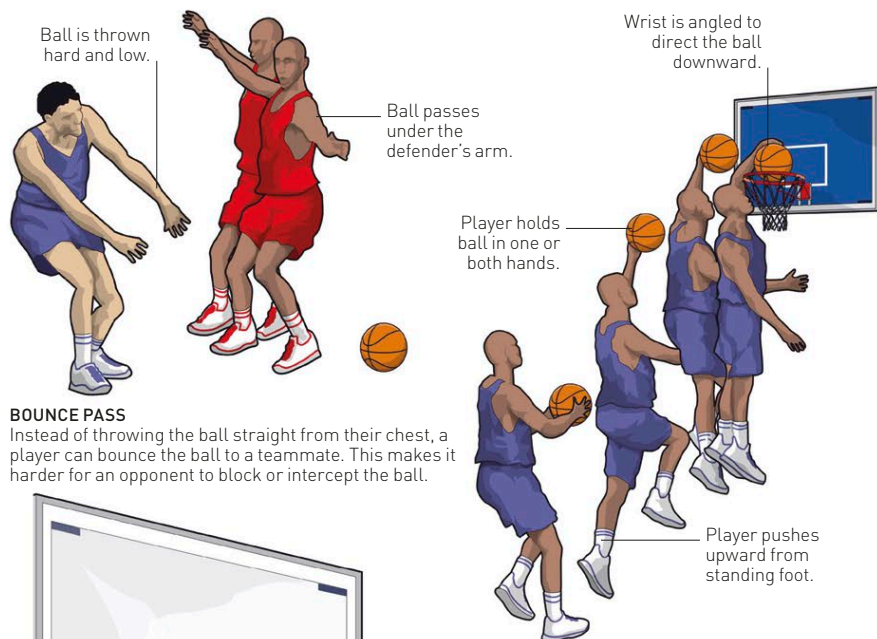
### WHO PLAYS WHERE?

- POINT GUARD**  
The point guard organizes the offense (attack) by calling out a preplanned play (tactic).
- SHOOTING GUARD**  
A shooting guard's main duty is to shoot the ball and score as many points as possible.
- SMALL FORWARD**  
A varied role that includes shooting, defending, and play-making.
- POWER FORWARD**  
Fights for rebounds after an unsuccessful shot, and also shoots from long-range.
- CENTER**  
The center is usually the tallest player and is the team's main shot-blocker.



## SKILLS AND TECHNIQUES

All basketball players need good ball-handling skills. To be successful, a team needs to be able to pass to each other, dribble, shield the ball from opponents, and most importantly shoot baskets.

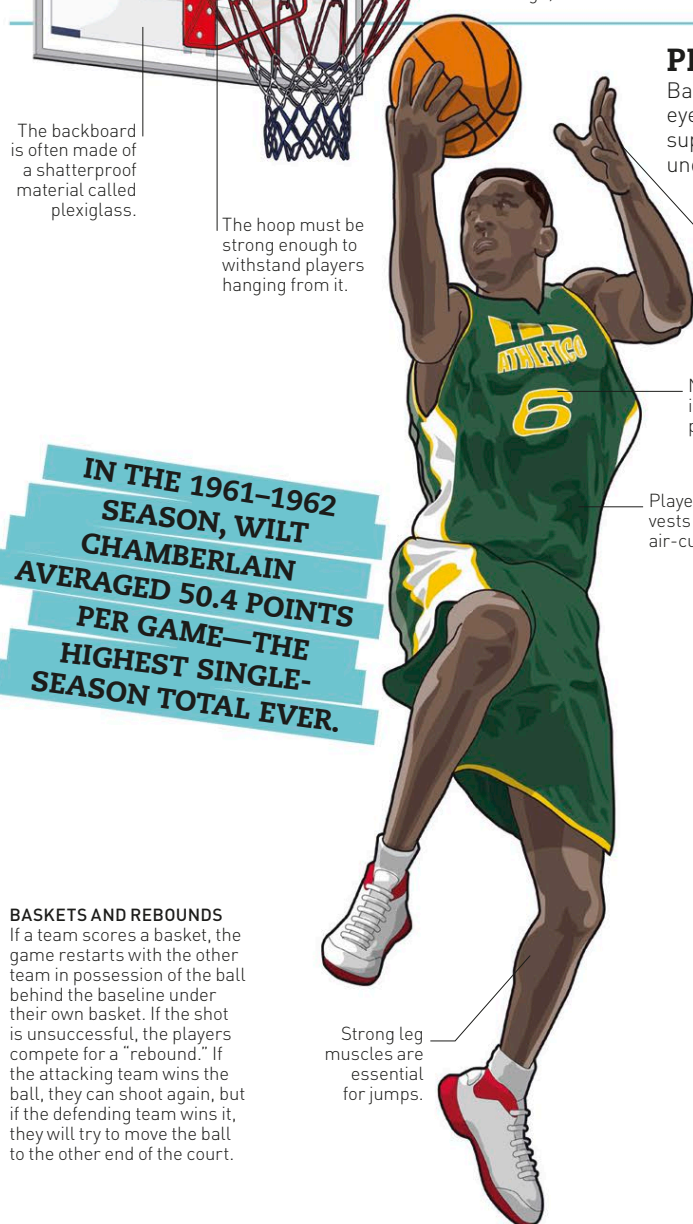


### BOUNCE PASS

Instead of throwing the ball straight from their chest, a player can bounce the ball to a teammate. This makes it harder for an opponent to block or intercept the ball.

### SLAM DUNK

The player runs up; jumps very high; and, with one or two hands, aims the ball downward into the basket. The slam dunk is a popular shot because, as long as the player can jump high enough, its success rate is high.

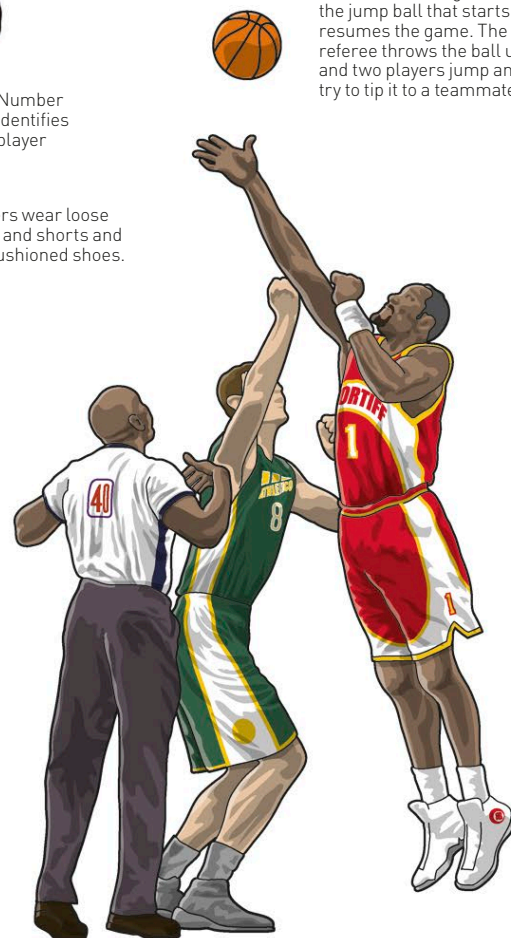


## PLAYING THE GAME

Basketball players require great athleticism; excellent hand-eye coordination; and, because it is such a fast-paced game, superb stamina. They also need to be tall. Players are rarely under 6 ft (1.8 m) and are often as tall as 7 ft (2.1 m).

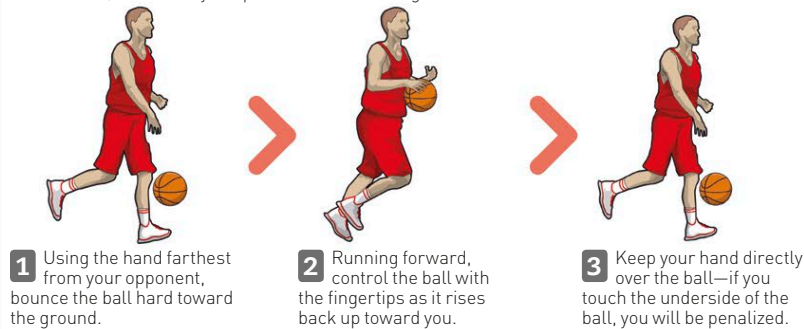
### TIP-OFF

This is the name given to the jump ball that starts or resumes the game. The referee throws the ball up, and two players jump and try to tip it to a teammate.



## DRIBBLING

Dribbling is the name given to bouncing the ball continuously. A player must dribble while moving with the ball, or else they are penalized for traveling.



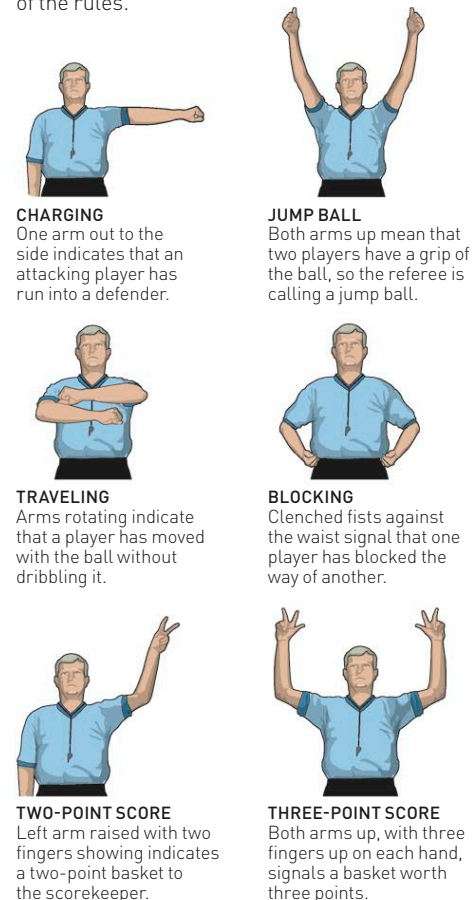
## MOVING

Once a player has stopped dribbling, he or she is not allowed to dribble for a second time. Instead, the player must keep one foot on the ground and pivot (swivel) on it before shooting or passing.



## OFFICIALS' SIGNALS

A team of officials oversees a game. The timekeeper starts the clock when the ball is in play and pauses it whenever play is stopped. The shot-clock operator makes sure that the team in possession shoots within a certain time. There are two referees who make gestures and signals to indicate aspects of play and breaches of the rules.



### BASKETS AND REBOUNDS

If a team scores a basket, the game restarts with the other team in possession of the ball behind the baseline under their own basket. If the shot is unsuccessful, the players compete for a "rebound." If the attacking team wins the ball, they can shoot again, but if the defending team wins it, they will try to move the ball to the other end of the court.

**IN THE 1961-1962 SEASON, WILT CHAMBERLAIN AVERAGED 50.4 POINTS PER GAME—THE HIGHEST SINGLE-SEASON TOTAL EVER.**



# Racket sports

There are many different racket sports, but they all need similar skills: good hand-eye coordination, quick reactions, speed, fitness, and agility. Most racket sports can be played by two people (1 vs. 1, known as singles) or four people (2 vs. 2, known as doubles).

## TENNIS

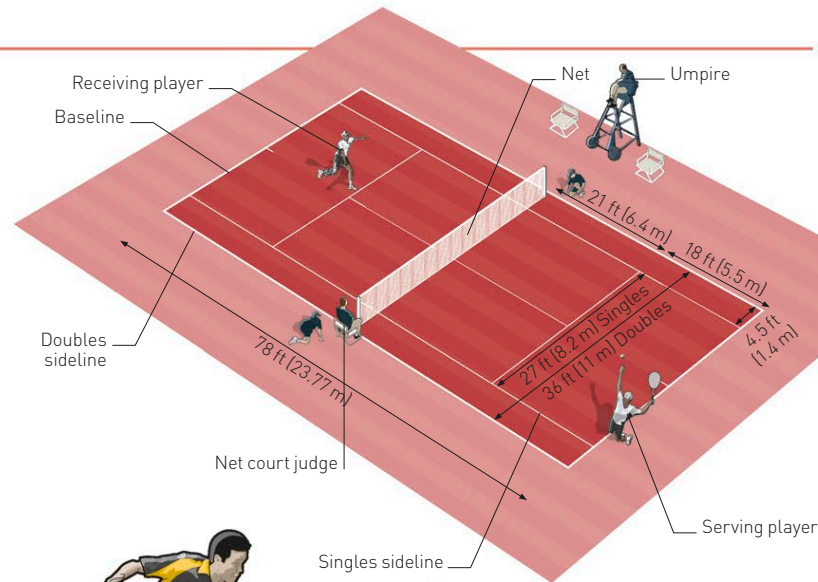
Players take turns serving and can score points whenever their opponent fails to return a ball over the net or hits the ball out of play. Tennis (also known as lawn tennis) matches are made up of games and sets, with players needing to win six games to win a set. Matches can last for hours, as a player must always win the final set by two games.



BEST OF THREE OR FIVE SETS



SINGLES OR DOUBLES



TENNIS RACKET



TENNIS BALL

Tennis balls are made of rubber, covered in felt, and weigh 1.9–2 oz (56–59 g). During a match, balls may be hit so hard that they lose their bounce and need to be replaced.

## TABLE TENNIS

A player wins a point if his or her opponent cannot return the ball or if the return does not land on the table. The first player to score 11 points wins the game. However, if both players score 10 points, the first player to gain a two-point advantage wins the game. Table tennis is also known as ping pong.



BEST OF FIVE OR SEVEN GAMES



SINGLES OR DOUBLES

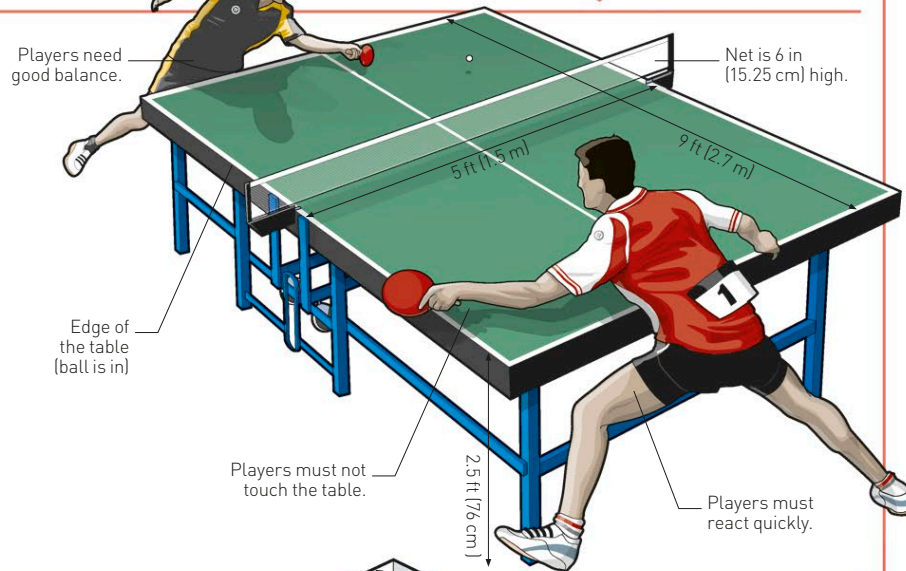


TABLE TENNIS BAT



TABLE TENNIS BALL

Made of plastic and filled with gas, a table tennis ball weighs a mere 0.1 oz (2.7 g).

## SQUASH

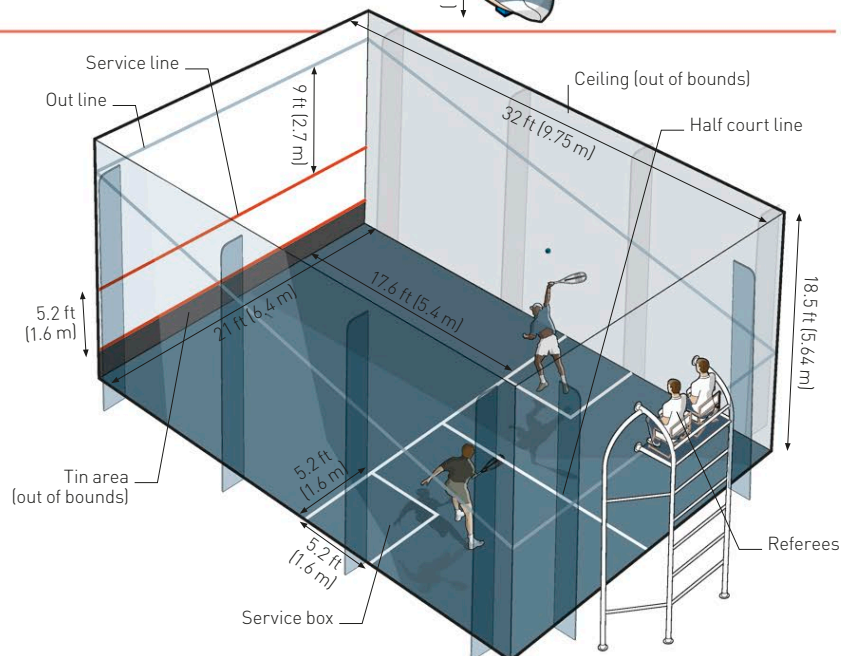
Squash is played on a four-walled court, and players take turns serving. They can win points if their opponent fails to hit the ball after it has bounced once or hits the ball out of bounds. A player needs 9 or 11 points to win the game, depending on the scoring system. If the score is tied at 10-10, a player needs to win by two points.



THE BEST OF 3 OR 5 GAMES



SINGLES (DOUBLES CAN BE PLAYED ON A BIGGER COURT)



SQUASH RACKET



SQUASH BALL

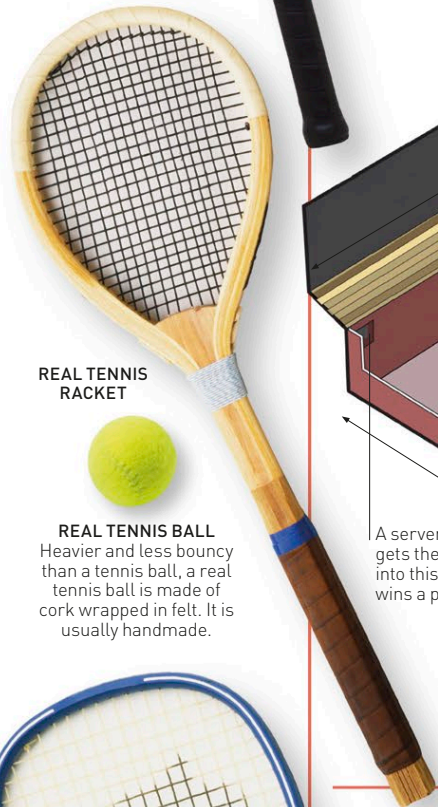
Squash balls are made of hollow rubber. A colored dot shows how fast or bouncy the ball is—orange is the slowest and blue is the fastest.





**BADMINTON RACKET**

**SHUTTLECOCK**  
The rounded base is made of cork covered in leather. The top has 16 feathers, which are often plastic.



**REAL TENNIS RACKET**

**REAL TENNIS BALL**  
Heavier and less bouncy than a tennis ball, a real tennis ball is made of cork wrapped in felt. It is usually handmade.



**RACQUETBALL RACKET**

**RACQUETBALL**  
Balls are made of rubber to make them bounce. They weigh about 1.4 oz (40 g).

## BADMINTON

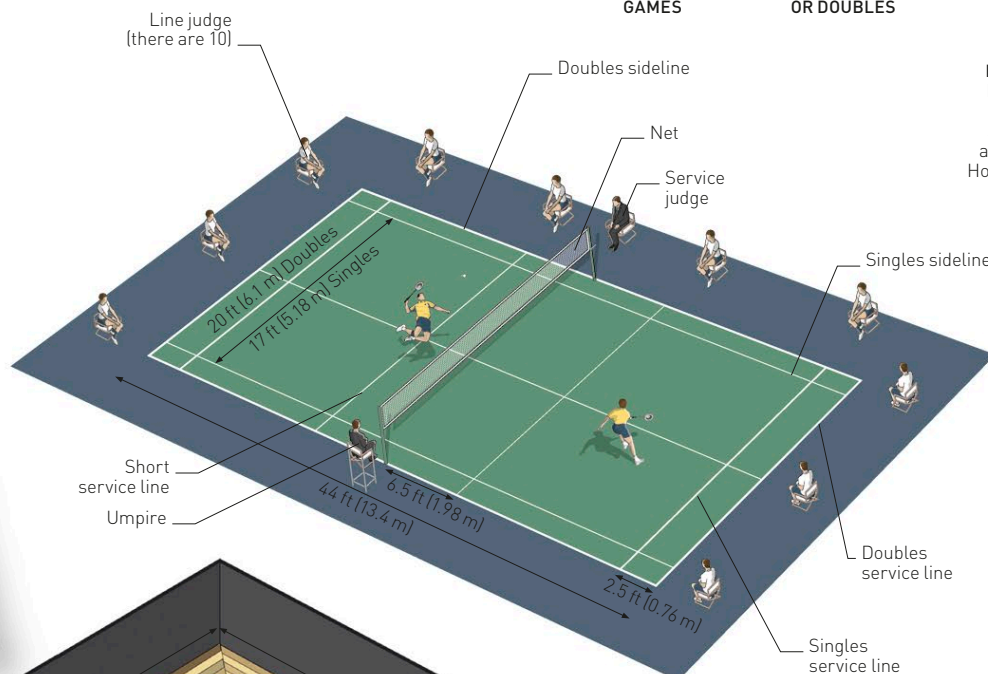
A player wins a point if his or her opponent fails to hit the shuttlecock or hits it out of play. The first player to win 21 points wins the game. However, if the score is tied at 20-20, a player must gain a two-point lead to win the game.



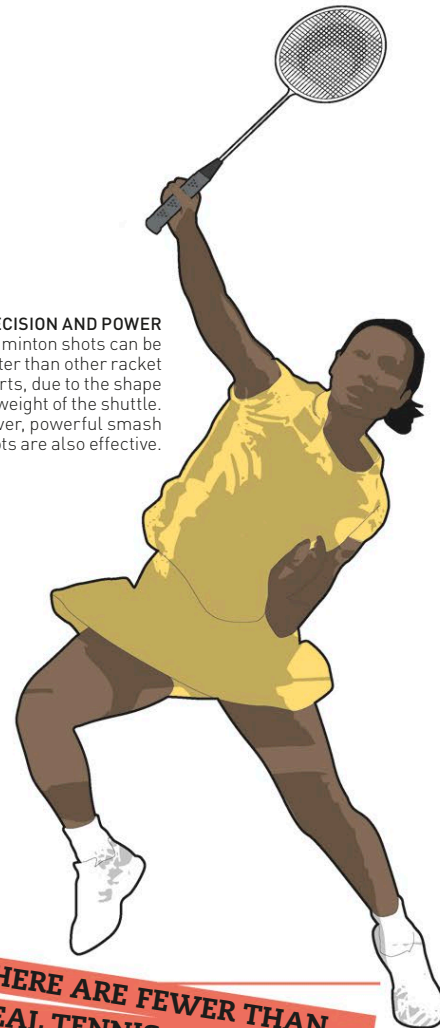
**BEST OF THREE GAMES**



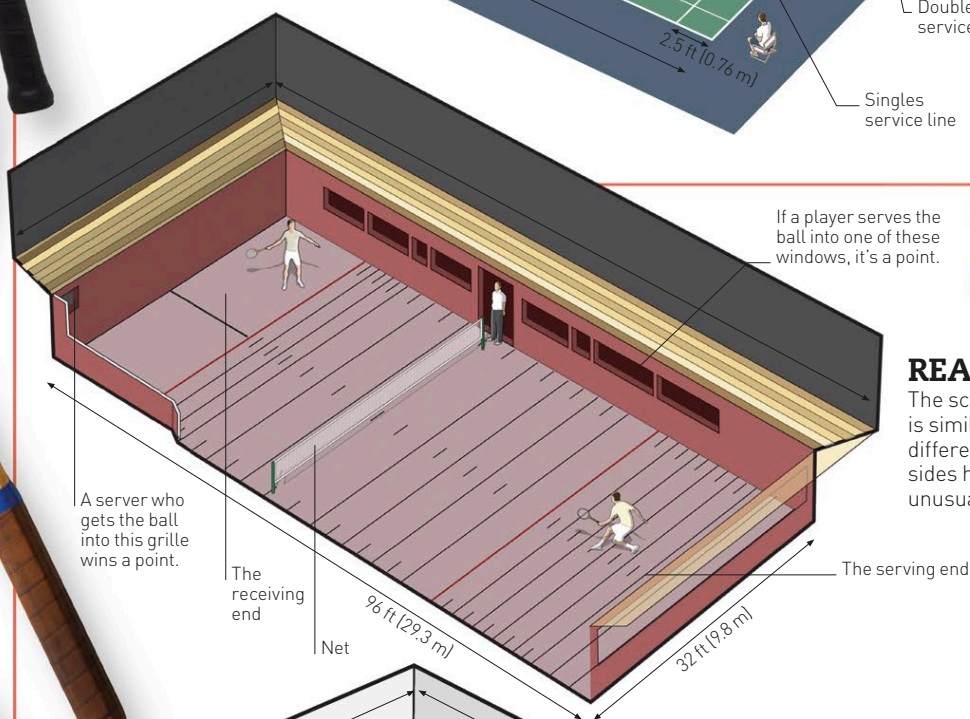
**SINGLES OR DOUBLES**



**PRECISION AND POWER**  
Badminton shots can be softer than other racket sports, due to the shape and weight of the shuttle. However, powerful smash shots are also effective.



**THERE ARE FEWER THAN 50 REAL TENNIS COURTS IN THE WORLD, AND NO TWO COURTS ARE IDENTICAL.**



## REAL TENNIS

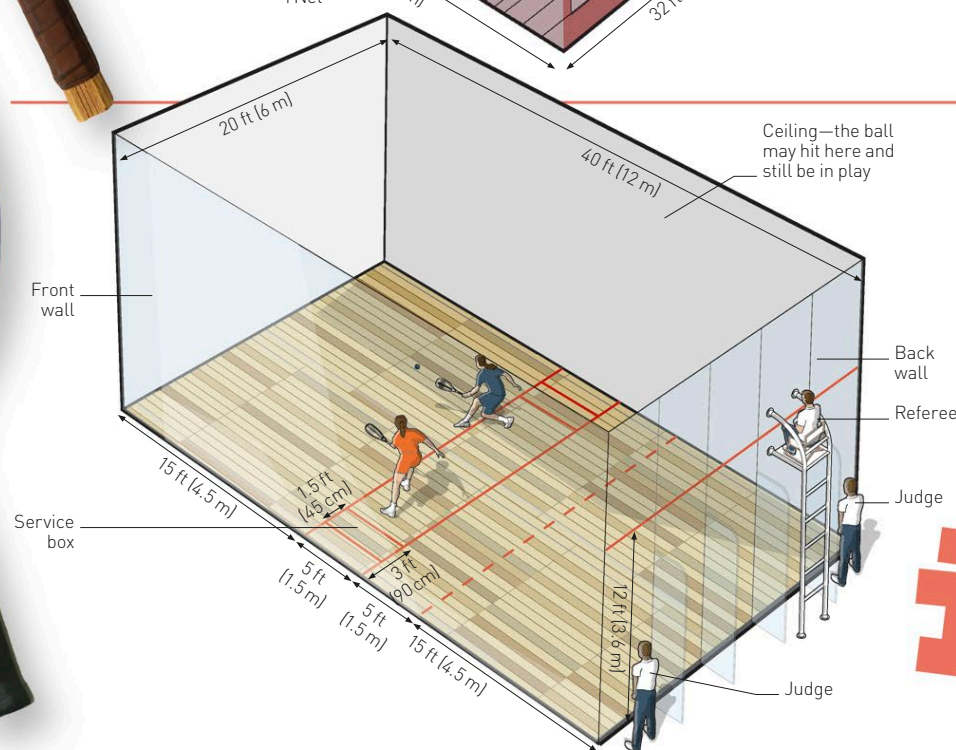
The scoring in real tennis (also known as Court Tennis) is similar to the modern game. However, the court is very different. It is enclosed on all four sides, and three of the sides have sloping roof areas. Courts also have several unusual features such as grilles and windows.



**THE BEST OF THREE OR FIVE SETS**



**SINGLES OR DOUBLES**



## RACQUETBALL

Played on a similar court to squash, the objective of racquetball is to hit the ball in such a way that an opponent cannot keep it in play. Points can only be scored by the server, but if the server fails to keep the ball in play, the serve passes to the other player. The first player to reach 15 points wins the game.



**THE BEST OF FIVE GAMES**



**SINGLES, DOUBLES, OR "IRONMAN" (2 VS. 1)**

**RACQUETBALL IS SO FAST THAT PLAYERS USUALLY WEAR GOGGLES TO PREVENT EYE INJURIES.**



# Tennis

Playing tennis is fun and helps you gain some sports skills. To play the game well, you have to be fast on your feet, quick-thinking, and sharp-eyed. World-class players make tennis exciting to watch, too.

## THE MATCH

A tennis match is played in games and sets between two or four people. A game is a series of points won or lost, and a set is a series of games. The player who wins the best out of three or five sets is the match winner. Matches have no time limit.



NO TIME LIMIT



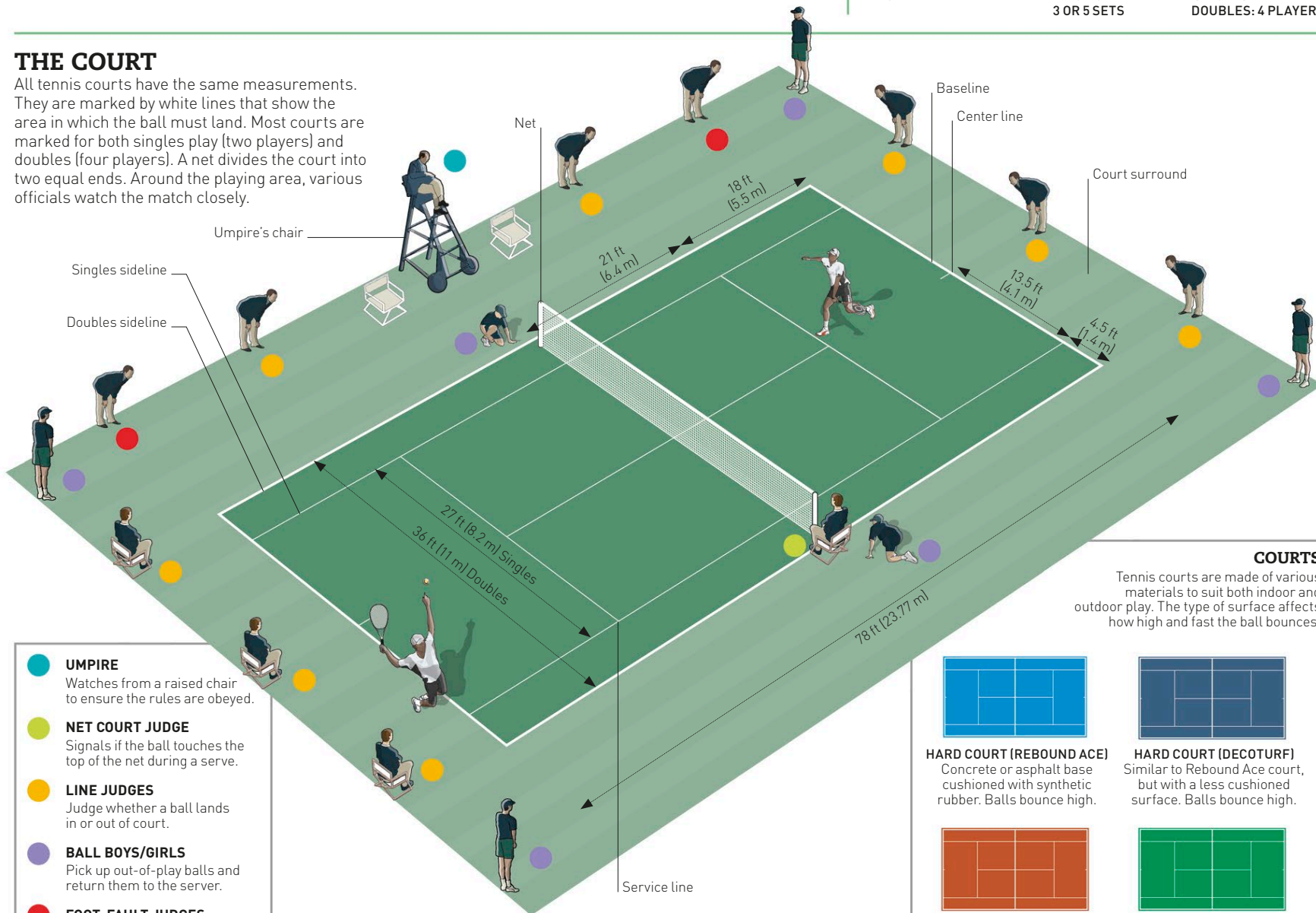
A MATCH CAN BE  
3 OR 5 SETS



SINGLES: 2 PLAYERS  
DOUBLES: 4 PLAYERS

## THE COURT

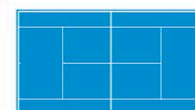
All tennis courts have the same measurements. They are marked by white lines that show the area in which the ball must land. Most courts are marked for both singles play (two players) and doubles (four players). A net divides the court into two equal ends. Around the playing area, various officials watch the match closely.



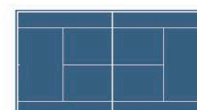
- UMPIRE**  
Watches from a raised chair to ensure the rules are obeyed.
- NET COURT JUDGE**  
Signals if the ball touches the top of the net during a serve.
- LINE JUDGES**  
Judge whether a ball lands in or out of court.
- BALL BOYS/GIRLS**  
Pick up out-of-play balls and return them to the server.
- FOOT-FAULT JUDGES**  
Check that a server does not step across the baseline before hitting the ball.

## COURTS

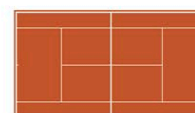
Tennis courts are made of various materials to suit both indoor and outdoor play. The type of surface affects how high and fast the ball bounces.



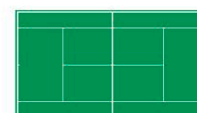
**HARD COURT (REBOUND ACE)**  
Concrete or asphalt base cushioned with synthetic rubber. Balls bounce high.



**HARD COURT (DECOTURF)**  
Similar to Rebound Ace court, but with a less cushioned surface. Balls bounce high.



**CLAY COURT**  
Balls bounce high on this surface but move at a relatively slow speed.



**GRASS COURT**  
Balls move fast with a lower bounce. This surface can be slippery.

## SCORING

Both players start with a score of zero, or "love." The first point you win scores 15. If you win a second point, the score is 30. A third point scores 40. One more point can win the game, provided the player is already two points ahead of their opponent.

Set markers				Score for game in progress		
1	2	3	4	SETS	GAMES	POINTS
6	7	6		R. FEDERER (1)	2	530
0	6	7		VS.	1	340
				R. NADAL (2)		

Completed sets: 1, 2, 3, 4  
Two sets were decided by tie-breaks: 1, 2  
Players' names: R. FEDERER (1), VS., R. NADAL (2)  
Score for set in progress: 2, 1

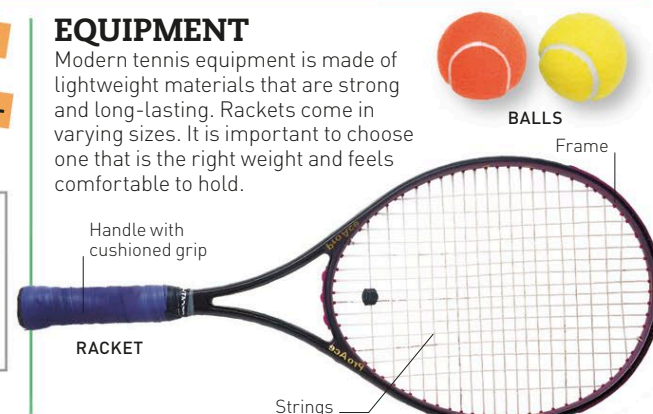
**THE "LOVE" SCORE IN TENNIS MAY COME FROM "L'OEUF," FRENCH FOR "EGG"—WHICH IS ZERO-SHAPED.**

## TIE-BREAK

If the score is six games all, a tie-break is played. This game has special rules. A tie-break, and the set, is won when a player wins seven points and is at least two points ahead. There is no tie-break in the final set.

## EQUIPMENT

Modern tennis equipment is made of lightweight materials that are strong and long-lasting. Rackets come in varying sizes. It is important to choose one that is the right weight and feels comfortable to hold.





## THE SERVE

Also called the service, this stroke is the most important one to learn. Every point in a game starts with the serve. It is a tricky technique to master. Even professionals do not hit the ball over the net every time—but a server is allowed to have two attempts per point.



**1 POSITION**  
The server stands behind the baseline, to the right of center.



**2 PREPARE**  
Turning sideways, the server holds out the racket and ball.



**3 TOSS**  
The server tosses the ball up and bends the racket arm back.



**4 THROW**  
The server throws the racket over their head and hits the ball.

## MAJOR WINNERS

The four biggest annual tennis tournaments, known as "Grand Slams," are: Wimbledon, the US Open, the Australian Open, and the French Open. Below are the top five singles Grand Slam winners as of 2020.

- 1 MARGARET COURT** Australia—24 wins
- 2 SERENA WILLIAMS** US—23 wins
- 3 STEFFI GRAF** Germany—22 wins
- 4 ROGER FEDERER** Switzerland—20 wins
- 5 RAFAEL NADAL** Spain—19 wins
- 5 HELEN WILLIS MOODY** US—19 wins

## FOREHAND DRIVE

Using the forehand is the skill that tennis players learn first. With practice, it can become a very powerful stroke. The ball must bounce once before the opponent hits it.



**1 RACKET BACK**  
The player takes the racket back and up, turning the shoulders and stepping forward.



**2 MEET THE BALL**  
The player swings the racket forward to meet the ball in front of the body before following through the stroke.

## FOREHAND VOLLEY

Volley shots are played close to the net. Players must hit the ball before it bounces. The action is short, fast, and punchy and does not use a big swing.



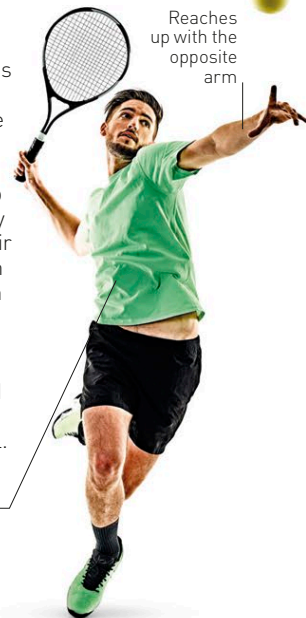
**1 REACH**  
The player reaches with the racket and steps forward, watching the ball.



**2 SHORT FOLLOW-THROUGH**  
After making contact with the ball, the player finishes the stroke with a short follow-through.

## THE SMASH

The smash shot uses an action similar to that of the serve. It hits the ball as it comes down from high in the air and requires fast thinking. The player may have to spring up to reach the ball. They must fully stretch their racket arm and reach up with the other arm to prepare for the smash. They then drop the racket head behind their back and then accelerate it forward to hit the ball.



Turns the body sideways and positions under the ball

Reaches up with the opposite arm

## BACKHAND DRIVE

Players use this stroke when their opponent hits the ball toward the side opposite their racket arm.



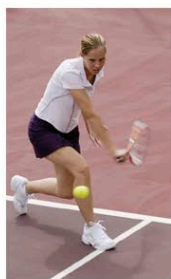
Turns the shoulders to the side while taking the racket back

**DOUBLE-HANDED BACKHAND**  
Two hands can give extra strength and power a backhand drive.

**1 SWING BACK**  
As the ball comes, the player turns their shoulders to the side and swings their racket back.

**2 STEP**  
With a firm grip on the racket, they step forward to meet the ball. They stretch out their racket arm to hit the ball in front of their body.

**3 FOLLOW THROUGH**  
Keeping the swing going, they follow through the shot with their racket, not taking their eyes off the ball until it is safely over the net.



## BACKHAND SLICE

The backhand slice is more challenging than the basic backhand. A ball hit with this stroke spins and lands low, so it can take players by surprise.



**1 BACK**  
The player takes the racket back as for the backhand drive, with the head angled slightly up.



**2 SLICE**  
Stepping into the shot and slipping the head of the racket under the ball, the player hits the ball just in front of the body.



**3 FOLLOW-THROUGH**  
Keeping the arm straight, the player follows through with a short chopping movement. This part of the stroke is important, as it drives the ball forward.



# Athletics

The athletics arena is home to three main different sports styles: running, jumping, and throwing. Competitors need speed, stamina, agility, or strength, depending on their chosen event. All-around athletes have all these skills.

## SET-UP

Athletics events are also known as “track and field events.” Running races take place on the track, and jumping and throwing events are held in an area known as the field. There are also two walking events on the track.



RUNNING



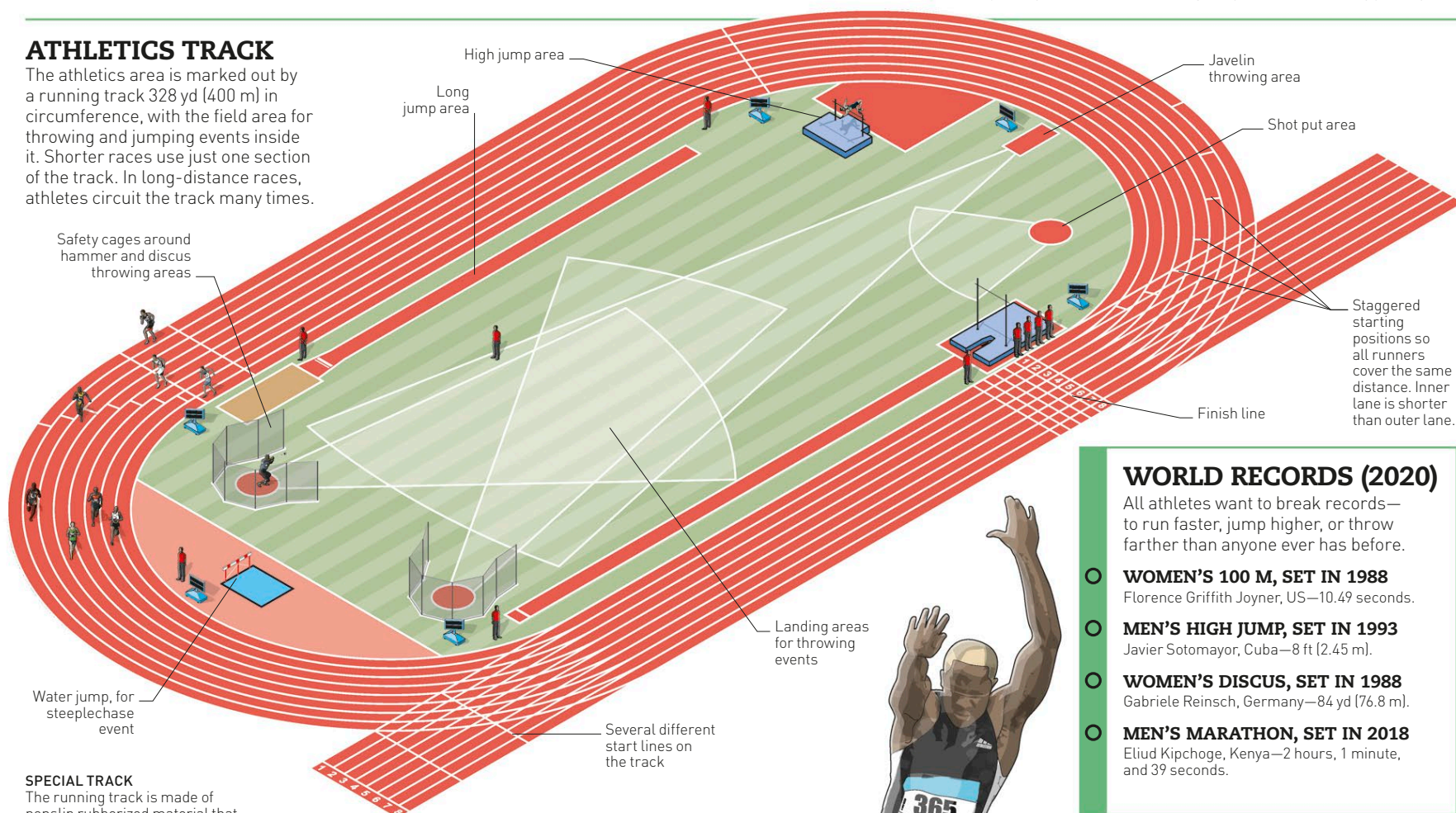
THROWING



JUMPING

## ATHLETICS TRACK

The athletics area is marked out by a running track 328 yd (400 m) in circumference, with the field area for throwing and jumping events inside it. Shorter races use just one section of the track. In long-distance races, athletes circuit the track many times.



## WORLD RECORDS (2020)

All athletes want to break records—to run faster, jump higher, or throw farther than anyone ever has before.

- **WOMEN'S 100 M, SET IN 1988**  
Florence Griffith Joyner, US—10.49 seconds.
- **MEN'S HIGH JUMP, SET IN 1993**  
Javier Sotomayor, Cuba—8 ft (2.45 m).
- **WOMEN'S DISCUS, SET IN 1988**  
Gabriele Reinsch, Germany—84 yd (76.8 m).
- **MEN'S MARATHON, SET IN 2018**  
Eliud Kipchoge, Kenya—2 hours, 1 minute, and 39 seconds.

## SPECIAL TRACK

The running track is made of nonslip rubberized material that helps prevent injuries.

## TRIPLE JUMP

This jump is also known as the “hop, step, and jump,” because that is exactly what the athletes do. They run down a track, hop forward, land on the same foot, step onto the other foot, and then jump as far as they can.



**HOP, STEP, JUMP**  
Power and rhythm are needed.

## LONG JUMP

Athletes competing in this event try to leap the farthest through the air from a running jump. They concentrate on five stages: their run-up, last two steps, takeoff, travel through the air, and landing.



**CAREFUL JUMP**  
Athletes must take off before the line.

## POLE VAULT

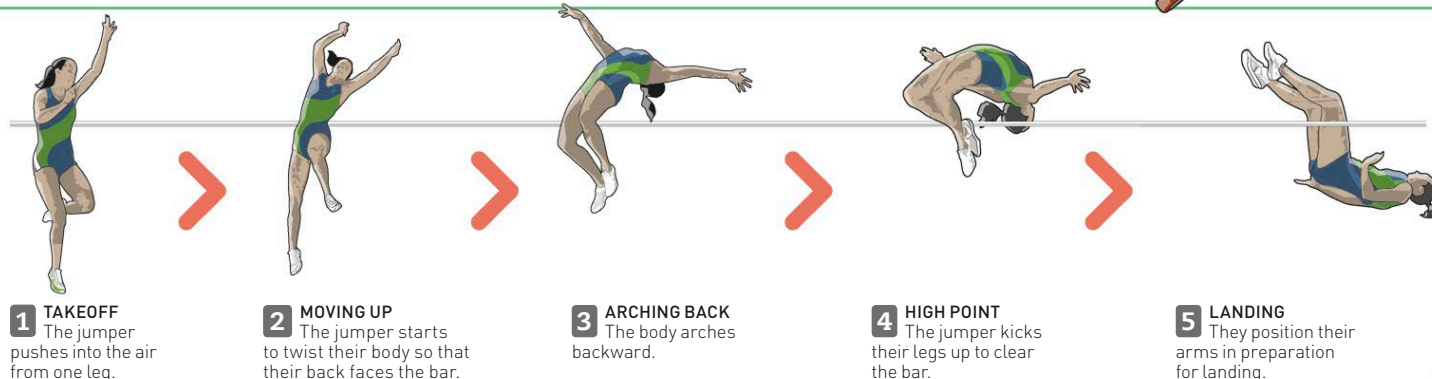
In this event, competitors use a bendy pole to clear a bar that is set higher and higher. The vaulter runs down the track with the pole, pushes the end into a box, and uses the pole as a lever to swing up and over the bar.



**HOLDING ON**  
The athlete uses the pole to vault higher.

## HIGH JUMP

This is a competition to see who can jump the highest. Athletes run up to a horizontal bar and try to clear it without it falling, often using a special technique called the Fosbury Flop (shown here). They land on a cushioned area to prevent injury.



**1 TAKEOFF**  
The jumper pushes into the air from one leg.

**2 MOVING UP**  
The jumper starts to twist their body so that their back faces the bar.

**3 ARCHING BACK**  
The body arches backward.

**4 HIGH POINT**  
The jumper kicks their legs up to clear the bar.

**5 LANDING**  
They position their arms in preparation for landing.



## JAVELIN

Athletes compete to see who can throw the javelin (which is a bit like a spear) the farthest down the field. Men throw a slightly longer javelin than women.

Javelin

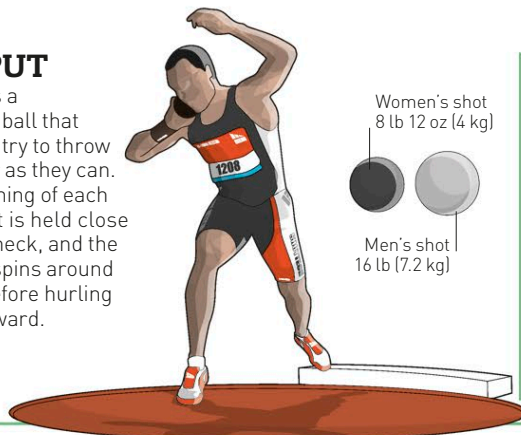


## SHOT PUT

The "shot" is a heavy metal ball that competitors try to throw ("put") as far as they can. At the beginning of each put, the shot is held close against the neck, and the shot putter spins around in a circle before hurling the shot forward.

Women's shot  
8 lb 12 oz (4 kg)

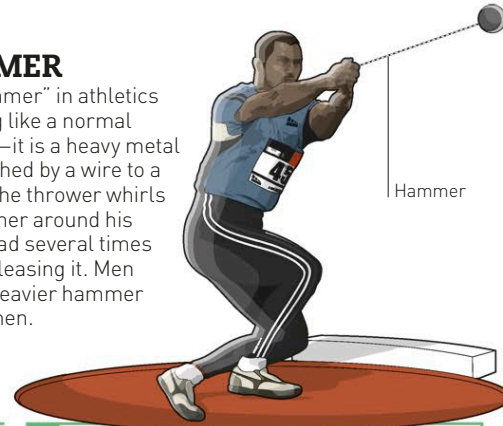
Men's shot  
16 lb (7.2 kg)



## HAMMER

The "hammer" in athletics is nothing like a normal hammer—it is a heavy metal ball attached by a wire to a handle. The thrower whirls the hammer around his or her head several times before releasing it. Men throw a heavier hammer than women.

Hammer



## DISCUS

A discus is a fairly flat, heavy disk that spins through the air when it is thrown hard. The women's discus weighs 2.2 lb (1 kg), while the men's weighs 4.4 lb (2 kg). The winner is the person who throws it farthest.



**1 PRELIMINARY SWING**  
Holding the discus in one hand, the athlete starts to swing it back and forward.



**2 TURNING CIRCLE**  
The athlete spins around one and a half times, gaining momentum.



**3 RELEASE**  
At the front of the circle, the athlete sends the discus flying into the air.



**4 FOLLOW-THROUGH**  
After releasing the discus, the athlete is careful to stay within the circle.

## MIDDLE-DISTANCE RUNNING

These races are run over 800–3,000 m, and some, like the steeplechase, include hurdles and water jumps. The runners start off in lanes but do not usually have to stay in their lane throughout the race.



## LONG-DISTANCE RUNNING

Races that are more than 3,000 m long are called "long-distance" races and demand great stamina. The events may take place in a stadium or along roads and paths. Many cities hold annual marathons, which are 26.2 miles (42.2 km) long.



## DISTANCE EVENTS

There are eight Olympic middle- and long-distance events on the track. The 3,000 m steeplechase includes 35 jumps, seven of which are water jumps.

800 m	10,000 m
1,500 m	Marathon (42.4 km)
3,000 m Steeplechase	20 km walk
5,000 m	50 km walk (men only)

## SPRINT EVENTS

In the Olympics, there are eight sprint events. Some include hurdles.

100 m	110 m hurdles (men only)
200 m	400 m hurdles
400 m	4 x 100 m relay
100 m hurdles (women only)	4 x 400 m relay

## SPRINTING

These fast races are run over distances from 60 m to 400 m. Sprinters push off from the blocks and hit top speed almost immediately.



**RUNNING ALONE**  
Most races involve individual runners.



**RUNNING A RELAY**  
Teams of four run one leg of the race each, passing on a baton.

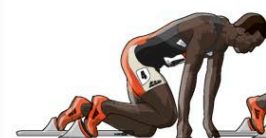
**HURDLES**  
Competitors have to jump hurdles while running.



**WHEN USAIN BOLT BROKE THE 100 M WORLD RECORD IN 2009, HE HIT AN ASTONISHING SPEED OF 40 FT (12.2 M) PER SECOND.**

## SPRINT START

In short sprints, getting off to a clean, fast start can make the difference between winning and losing the race.



**1 READY**  
The sprinter gets ready by crouching and setting both feet firmly against the blocks.



**2 GET SET**  
The athlete's body raises into a bridge, with the hips raised above the shoulders.



**3 GO!**  
On the starter's gun, the sprinter explodes out of the starting blocks.



# Winter sports

Sports have taken place on snow and ice for centuries. Today, most winter sports are variations of skiing, sledding, or ice skating. These sports have their own multisport tournament, the Winter Olympic Games, which takes place every four years.

## ALPINE SKIING

Alpine skiing is an exhilarating sport of speed and skill. There are five types of alpine ski competition. Two of the disciplines—downhill and Super-G—focus on speed. Slalom and giant slalom are technical events in which a competitor's skill will win the day. The fifth event, called combined (a mix of downhill and slalom), tests both speed and technique.

### TOP ALPINE SKIERS

#### ○ KJETIL ANDRÉ AAMODT (NORWAY)

The only alpine skier to win eight Olympic medals, four of them gold—in Super-G (1992, 2002, 2006) and combined (2002).

#### ○ JANICA KOSTELIC (CROATIA)

The only woman in history to win four Winter Olympic golds—three in 2002 and one in 2006.

#### ○ ALBERTO TOMBA (ITALY)

The dominant technical skier of the late 1980s and early 1990s.



## ALTERNATIVE SKIING METHODS

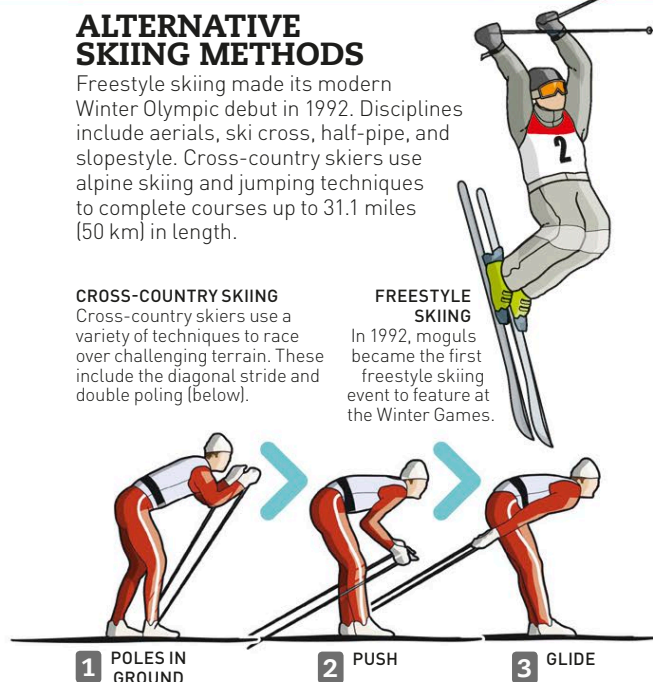
Freestyle skiing made its modern Winter Olympic debut in 1992. Disciplines include aerials, ski cross, half-pipe, and slopestyle. Cross-country skiers use alpine skiing and jumping techniques to complete courses up to 31.1 miles (50 km) in length.

### CROSS-COUNTRY SKIING

Cross-country skiers use a variety of techniques to race over challenging terrain. These include the diagonal stride and double poling (below).

### FREESTYLE SKIING

In 1992, moguls became the first freestyle skiing event to feature at the Winter Games.

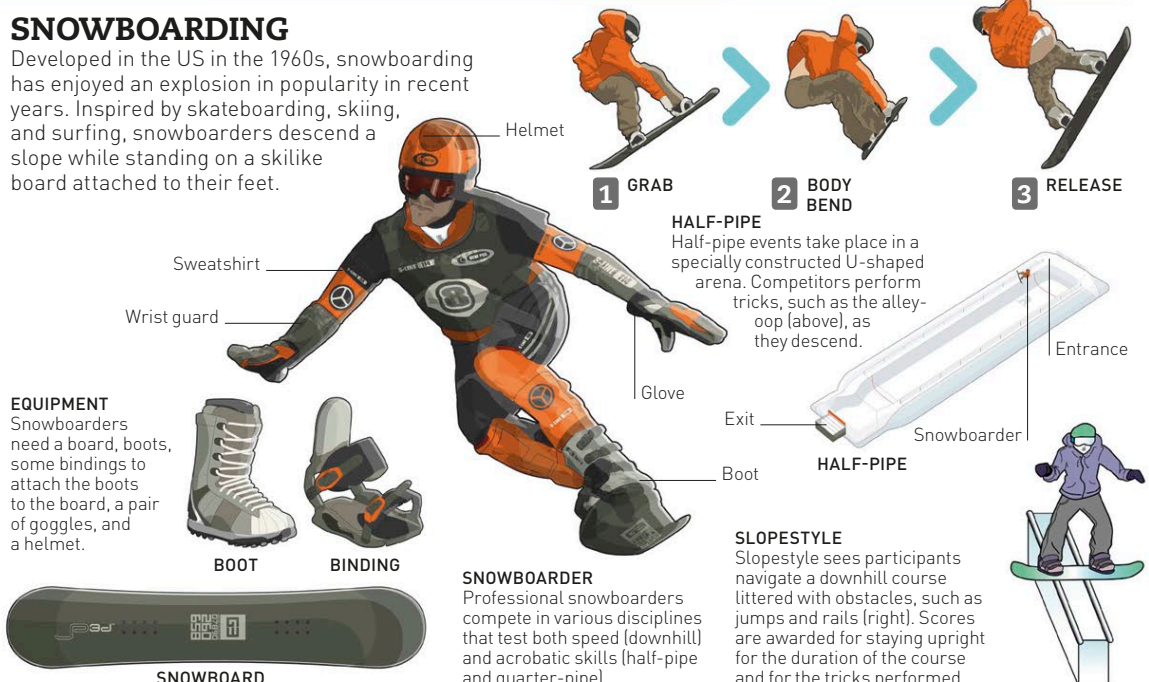


## SNOWBOARDING

Developed in the US in the 1960s, snowboarding has enjoyed an explosion in popularity in recent years. Inspired by skateboarding, skiing, and surfing, snowboarders descend a slope while standing on a skilike board attached to their feet.

### EQUIPMENT

Snowboarders need a board, boots, some bindings to attach the boots to the board, a pair of goggles, and a helmet.



### SNOWBOARDER

Professional snowboarders compete in various disciplines that test both speed (downhill) and acrobatic skills (half-pipe and quarter-pipe).

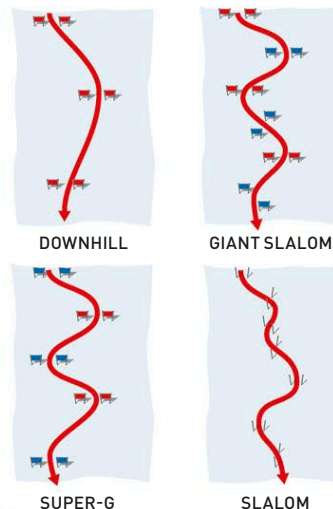
### EQUIPMENT

The standard equipment for alpine skiing includes skis (which have different shapes for different disciplines), poles, a helmet, goggles, boots, and bindings, which attach the boot to the ski.



### DIFFERENT COURSES

Every alpine-ski discipline tests different skills, so the courses for each are set out differently. A downhill course has the fewest gates (poles), whereas a slalom has many poles through which the skier must pass.



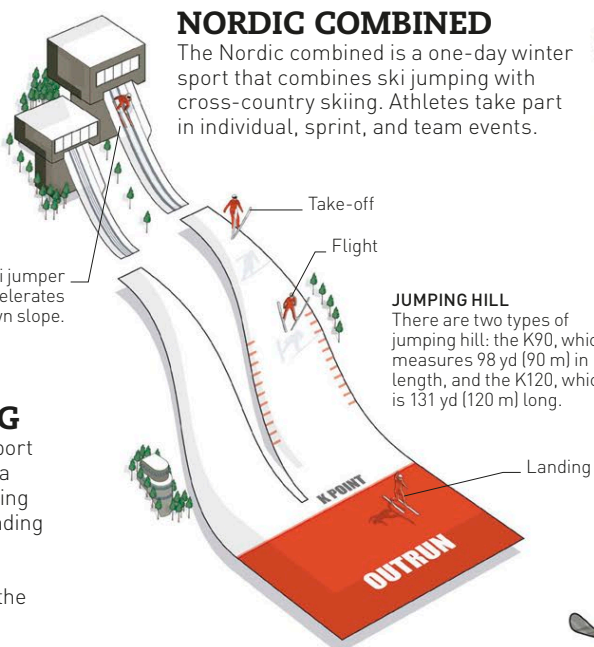
THE WORD SLALOM COMES FROM THE NORWEGIAN WORD SLALAM, MEANING "GENTLE SLOPE."





## SKI JUMPING

This is a spectacular sport that involves skiing down a steep slope, taking off, jumping as far as possible, and then landing smoothly without falling over. Ski jumpers are judged not only for the farthest distance jumped, but also for the style of their take-off, flight, and landing.

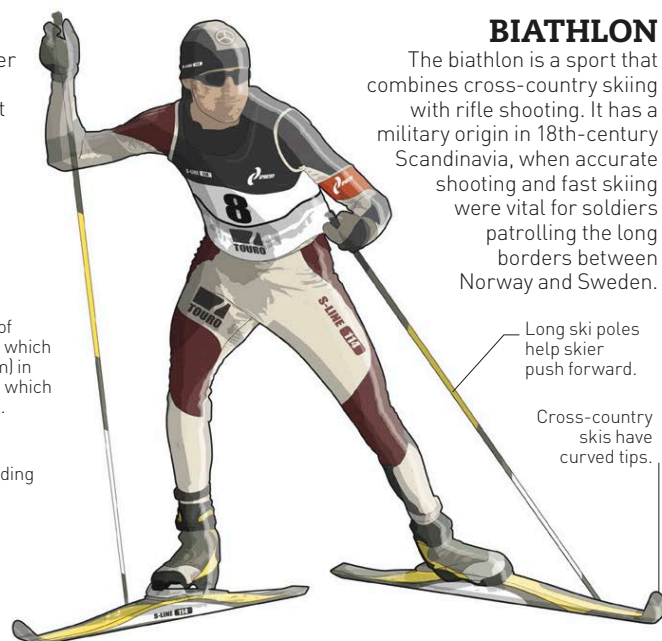


## NORDIC COMBINED

The Nordic combined is a one-day winter sport that combines ski jumping with cross-country skiing. Athletes take part in individual, sprint, and team events.

### JUMPING HILL

There are two types of jumping hill: the K90, which measures 98 yd (90 m) in length, and the K120, which is 131 yd (120 m) long.



## BIATHLON

The biathlon is a sport that combines cross-country skiing with rifle shooting. It has a military origin in 18th-century Scandinavia, when accurate shooting and fast skiing were vital for soldiers patrolling the long borders between Norway and Sweden.

## SLIDING SPORTS

Sliding sports are among the fastest winter sports. They include bobsled, luge, and skeleton. Competitors in each of these sports propel themselves down a specially constructed track and try to reach the bottom in the fastest time possible.

### BOBSLED

Bobsled was invented in Switzerland in the 19th century. The modern sport sees teams of two or four racing down ice-covered tracks in steerable sleds.



### 1 ROCK AND SLIDE

After taking up their positions, team members rock the sled and then push off down the launch pad.

### 2 FINAL PUSH

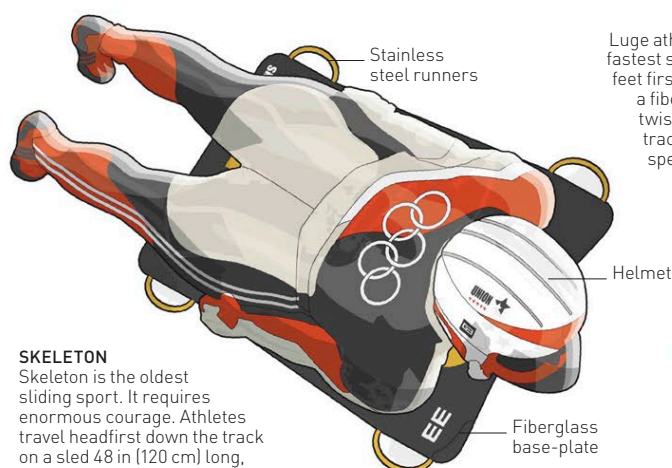
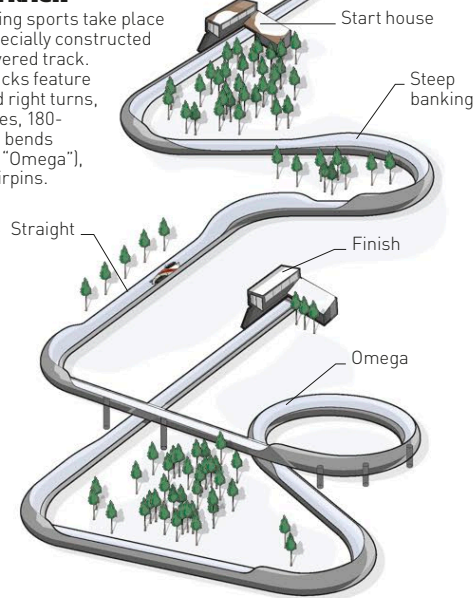
All members of the team must jump into the sled within 55 yd (50 m) of the start line.

### 3 FULL SPEED AHEAD

The driver sits at the front and steers the speeding sled.

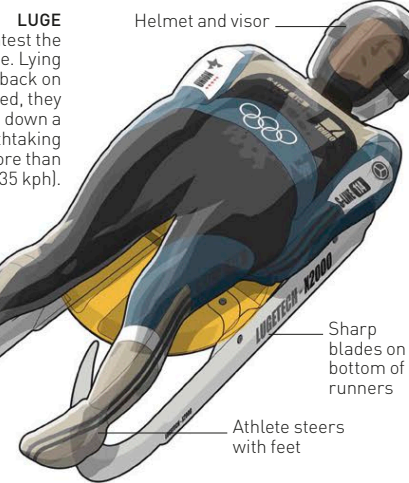
### THE TRACK

All sliding sports take place on a specially constructed ice-covered track. The tracks feature left and right turns, S-curves, 180-degree bends (called "Omega"), and hairpins.



### SKELETON

Skeleton is the oldest sliding sport. It requires enormous courage. Athletes travel headfirst down the track on a sled 48 in (120 cm) long, called a "skeleton."

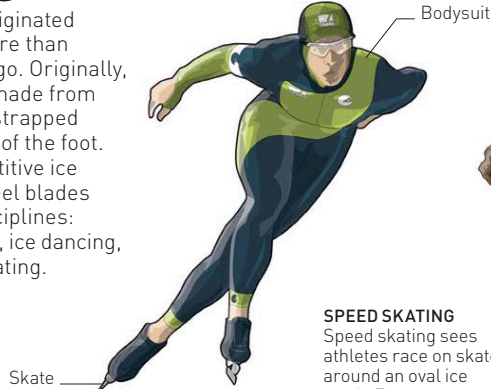


### LUGE

Luge athletes contest the fastest sport on ice. Lying feet first on their back on a fiberglass sled, they twist and turn down a track at breathtaking speeds of more than 85 mph (135 kph).

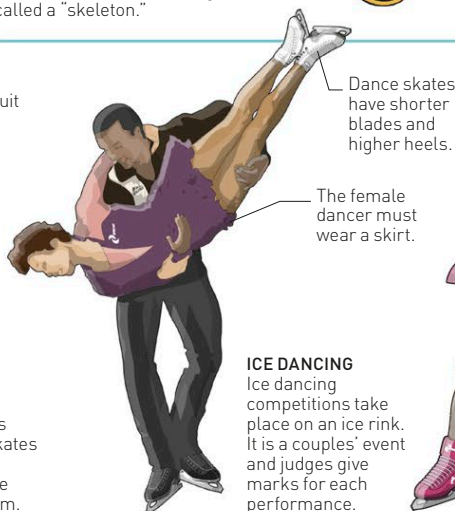
## SKATING

Ice skating originated in Finland more than 3,000 years ago. Originally, skates were made from animal bone strapped to the bottom of the foot. Today, competitive ice skating on steel blades has three disciplines: speed skating, ice dancing, and figure skating.



### SPEED SKATING

Speed skating sees athletes race on skates around an oval ice track. Events range from 500 m to 10 km.



### ICE DANCING

Ice dancing competitions take place on an ice rink. It is a couples' event and judges give marks for each performance.



### FIGURE SKATING

Single skaters or couples compete in two programs: one to test their technical ability and the other to demonstrate artistic expression.

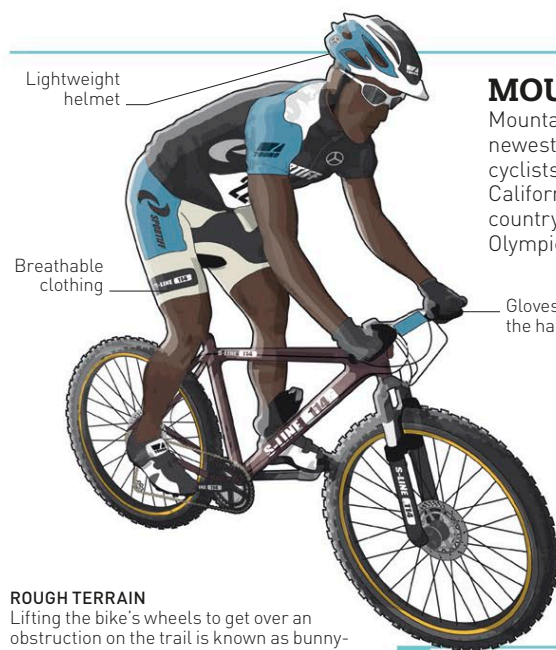
## TOP FIGURE SKATERS

- GILLIS GRAFSTRÖM (SWEDEN)**  
 Won three consecutive men's singles gold medals at the 1920, 1924, and 1928 Winter Olympic Games.
- SONJA HENIE (NORWAY)**  
 Dominated the women's singles event, winning Winter Olympic gold in 1928, 1932, and 1936.
- JAYNE TORVILL AND CHRISTOPHER DEAN (UK)**  
 The British ice-dancing pair received the only perfect score in the event's history following their routine at the 1984 Winter Olympic Games.



# Cycling

Cycling is a global sport enjoyed by people of all ages. Most ride for fun, but many compete in disciplines such as track or road racing or in BMX or mountain bike events.



Lightweight helmet

Breathable clothing

## MOUNTAIN BIKING

Mountain biking (MTB) is one of the newest cycling sports, started by cyclists riding off-road trails in California in the late 1970s. Cross-country mountain biking became an Olympic event in 1996.

Gloves cushion the hands.

### RIDER PROFILE

As well as stamina and strong pedaling power, mountain bikers need balance and excellent technical skills to negotiate difficult off-road terrain.

### ROUGH TERRAIN

Lifting the bike's wheels to get over an obstruction on the trail is known as bunny-hopping. The rider approaches the obstacle quickly, then lifts the handlebar and tucks their feet up under their body at the same time.



## EVENTS

MTB is still a pretty new sport and different types of competitions have been developed in recent years.

### CROSS-COUNTRY

Riders race each other for a fixed number of laps of a circuit. The first to cross the finish line is the winner.

### DOWNHILL

Competitors ride individually against the clock down a hillside course. The fastest time wins.

### TRIALS

Riders compete in various tests of poise, nerve, and artistry on their bikes and are awarded points by judges.

### ENDURO

Originating in France, a long-distance race in which only the downhill sections are timed and count toward the rider's finishing time.

### MOUNTAIN BIKE

A mountain bike must be sturdy to cope with bumpy trails but still light enough to be maneuverable.



Low frame height makes it easier to climb at low speed.

Up to 30 gears

Fat, knobby tires for good grip over rough ground

### RIDER PROFILE

BMX riders need to be flexible and fit. Freestylers have style and creative flair.

Gloves stop hands from slipping.

Full-length pants with padded knees



Helmet with mouth guard

## BMX

BMX (bicycle motocross) began as an offshoot of motocross (off-road motorcycle racing). Riders use specially designed bikes to perform freestyle tricks and stunts or to race over a dirt track or obstacle course.

### FLATLAND RIDING

A form of freestyle, flatland involves riders performing on flat surfaces with no ramps, jumps, or grindrails. It is probably the most technically demanding BMX discipline.

## EVENTS

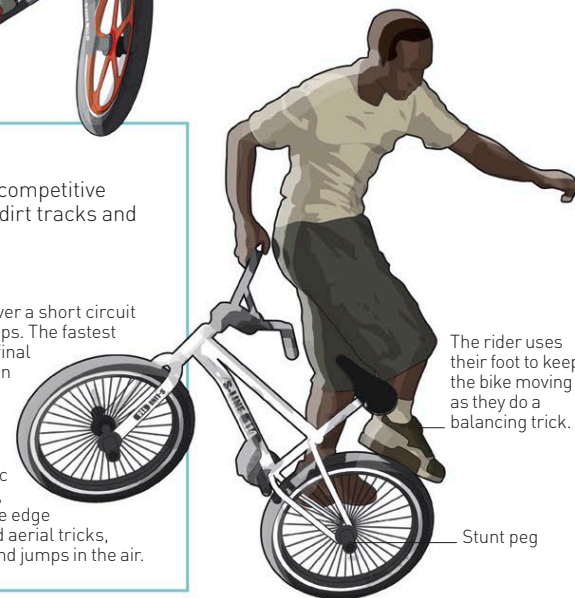
There are two types of competitive BMX riding—racing on dirt tracks and freestyle tricks.

### RACING

Eight riders race in heats over a short circuit with different turns and jumps. The fastest riders then compete in the final race. BMX racing became an Olympic sport in 2008.

### FREESTYLE

Divided into four main styles: base tricks (the basic moves); grind and lip tricks, performed on railings or the edge of a half-pipe structure; and aerial tricks, which are acrobatic turns and jumps in the air.



The rider uses their foot to keep the bike moving as they do a balancing trick.

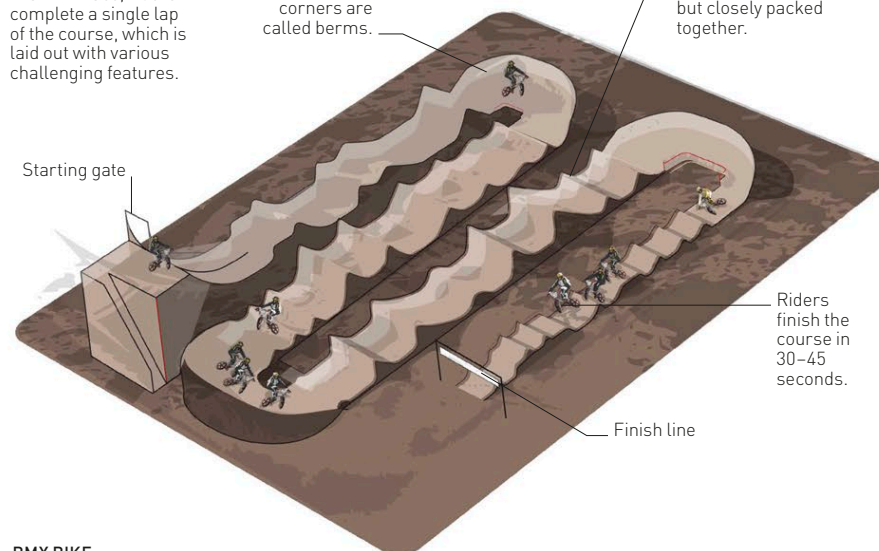
Stunt peg

### DIRT TRACK

In a BMX race, riders complete a single lap of the course, which is laid out with various challenging features.

Banked turns or corners are called berms.

Jumps are small but closely packed together.



Starting gate

Riders finish the course in 30–45 seconds.

Finish line

### BMX BIKE

Racing bikes are single-speed and designed for quick acceleration. Freestyle bikes are similar but often have stunt pegs attached for riders to stand on when performing tricks.

Single gear

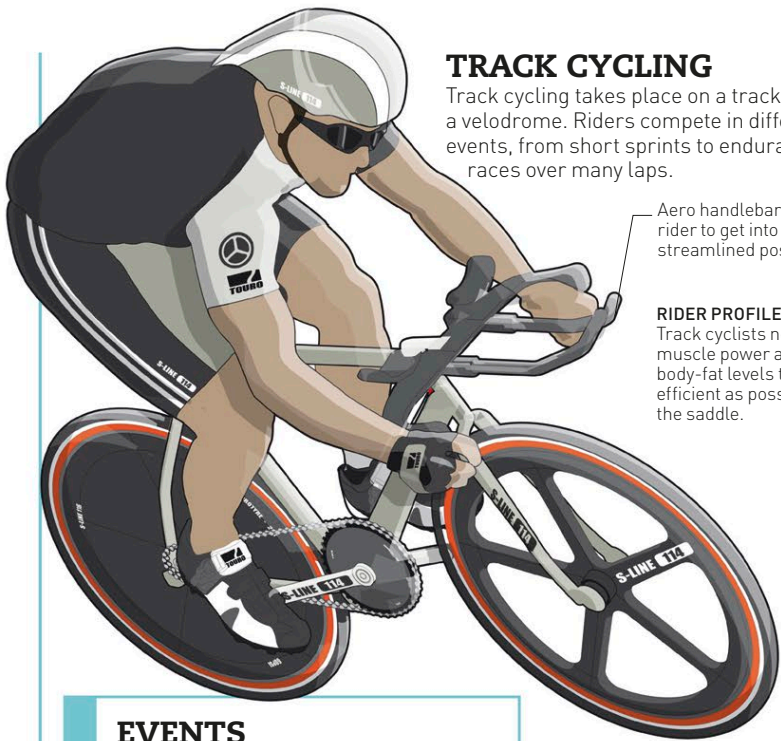
Sturdy frame

Solid handlebar grips

Small wheels allow fast acceleration.







## TRACK CYCLING

Track cycling takes place on a track called a velodrome. Riders compete in different events, from short sprints to endurance races over many laps.

Aero handlebars allow rider to get into a streamlined position.

### RIDER PROFILE

Track cyclists need high muscle power and low body-fat levels to be as efficient as possible in the saddle.

## EVENTS

There are 10 Olympic track cycling events, with men and women competing in each of the five events listed.

- **INDIVIDUAL SPRINT**  
Two riders race over three laps of the track.
- **TEAM SPRINT**  
Two teams of three riders race over three laps.
- **TEAM PURSUIT**  
Two teams of four riders race over 2.5 miles (4 km). Teams start on opposite sides of the track.
- **KEIRIN**  
Cyclists ride several laps behind a motorcycle pacemaker before sprinting to the finish.
- **OMNIUM**  
Twenty-four riders contest six different events: three sprints and three endurance races. The strongest overall rider wins.

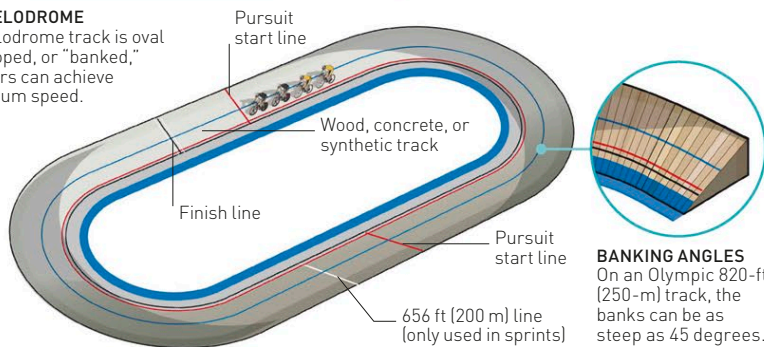


### MADISON

The Madison is a relay event for teams of two. When the riders change over, one uses their hand to propel the other into the race.

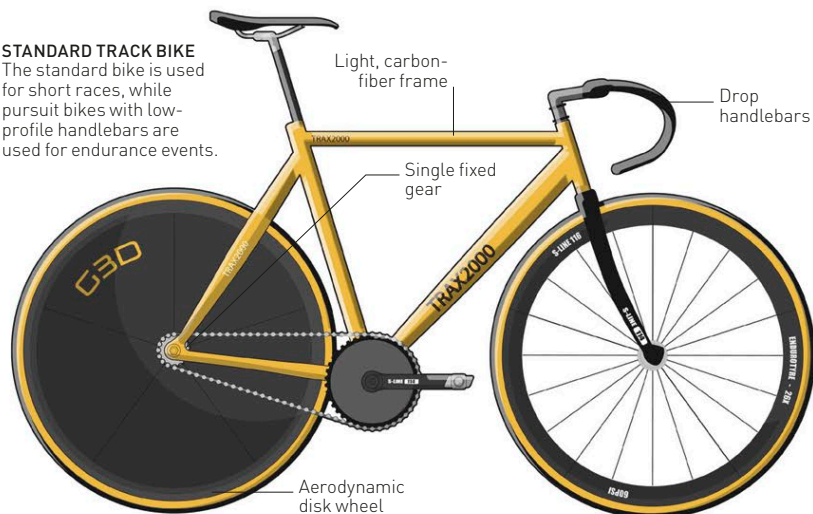
### THE VELODROME

The velodrome track is oval and sloped, or "banked," so riders can achieve maximum speed.



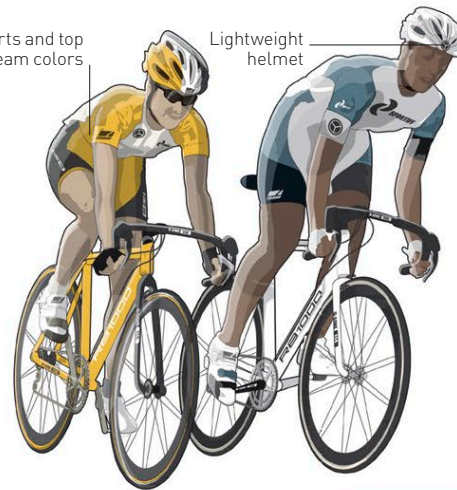
### STANDARD TRACK BIKE

The standard bike is used for short races, while pursuit bikes with low-profile handlebars are used for endurance events.



Shorts and top in team colors

Lightweight helmet



## ROAD RACING

Road racing is one of the most physically demanding of all sports. Multistage races can cover thousands of miles in a few weeks and include all-day mountain climbs and 50-mph (80-kph) sprints.

### RIDER PROFILE

Road racers have an enormous capacity for physical and mental endurance. They must eat a balanced diet with a lot of carbohydrates—riders eat up to 6,000 calories on race days to maintain energy levels.

## TOUR DE FRANCE

The Tour is the world's most famous road race. Riders cover about 2,175 miles (3,500 km) in 21 stages, finishing in Paris.



**POLKA DOT JERSEY**  
Awarded to the King of the Mountains, the best climber.



**WHITE JERSEY**  
Worn by the highest-placed young rider.



**GREEN JERSEY**  
Awarded to the best sprinter.



**YELLOW JERSEY**  
Worn by the overall leader.

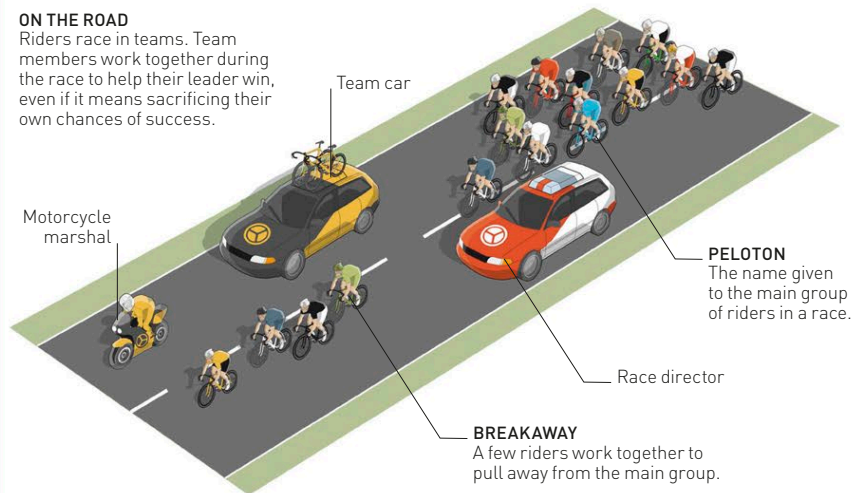
## RACE FORMATS

Road race formats range from one-day races to multistage endurance events. There are two Olympic events: the classic road race and the individual time trial.

- **STAGE RACE**  
A race over several stages in which the winner is the rider whose combined time is the quickest. May include sprint stages, mountain finishes, and individual or team time trials.
- **CLASSIC**  
One-day races of up to 168 miles (270 km), often ridden over difficult terrain, such as cobbled roads.
- **INDIVIDUAL TIME TRIAL**  
Competitors race individually against the clock.
- **CRITERIUM**  
A high-speed race, on a city-center circuit of less than 3 miles (5 km), over a set time (usually one hour) or a fixed number of laps.

### ON THE ROAD

Riders race in teams. Team members work together during the race to help their leader win, even if it means sacrificing their own chances of success.



### ROAD BIKE

Road bikes have to be strong, light, and comfortable enough to be ridden for long periods.



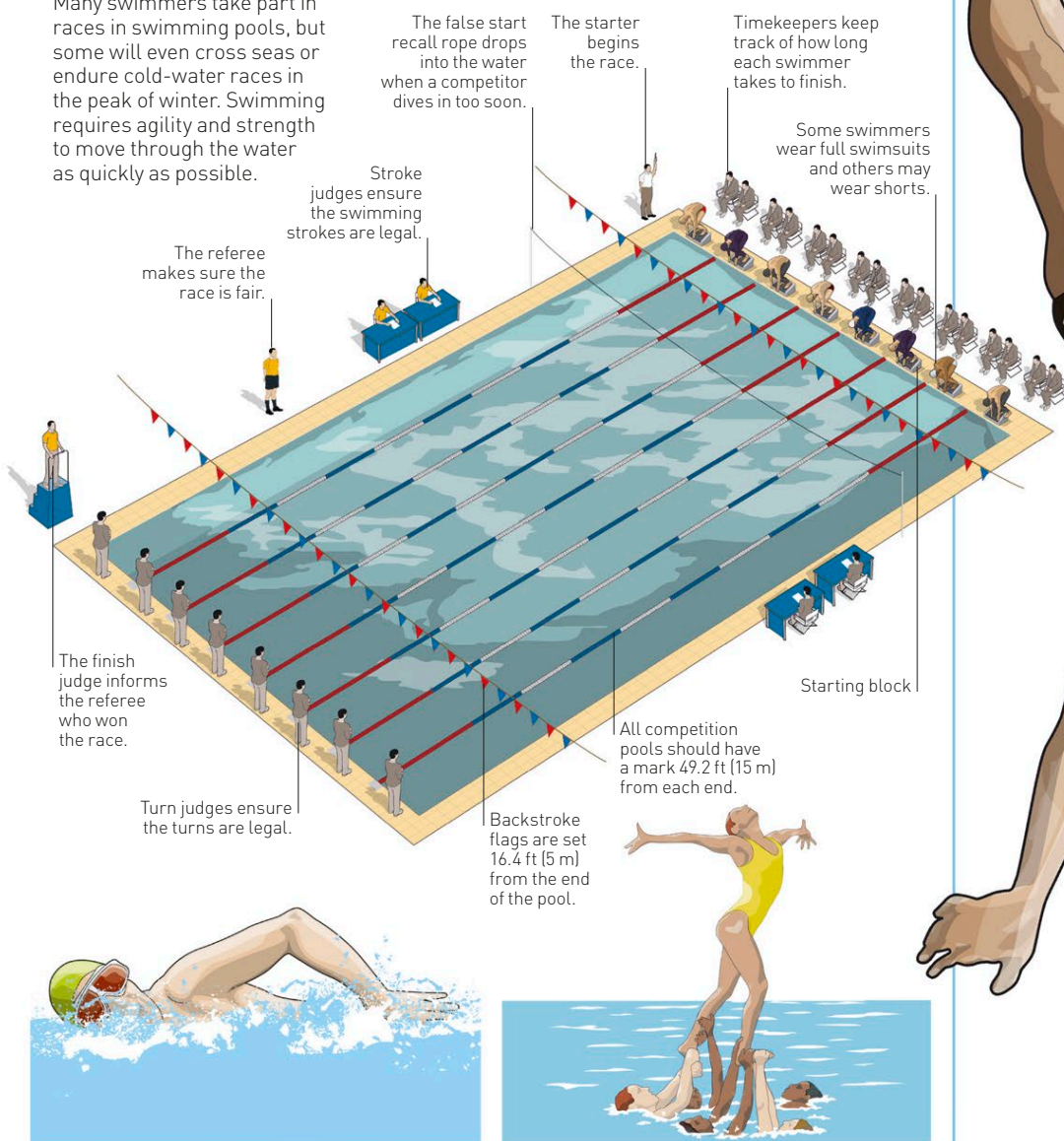


# Water sports

Water provides the perfect environment to show off sports skills, from impressive tricks on a board to acrobatic dives into the water. Water sports are exciting and require great balance, strength, and endurance to keep control in the water.

## SWIMMING

Many swimmers take part in races in swimming pools, but some will even cross seas or endure cold-water races in the peak of winter. Swimming requires agility and strength to move through the water as quickly as possible.



### SOLO SWIMMING

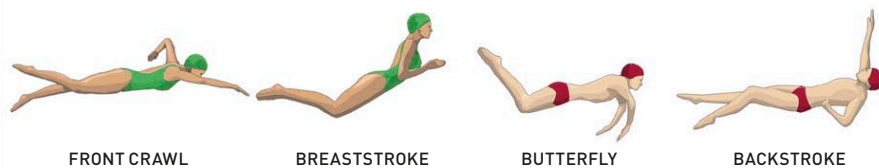
To glide through the water at great speed, swimmers must perfect their arm strokes and leg kicking so each movement propels them forward.

### SYNCHRONIZED SWIMMING

Synchronized swimmers must perform a graceful routine in perfect unison. Music is played both above and below the water to help them keep time.

## SWIMMING STROKES

There are swimming competitions for all four types of swimming strokes. The fastest stroke is the front crawl. In the individual medley, swimmers must swim all four strokes.



FRONT CRAWL

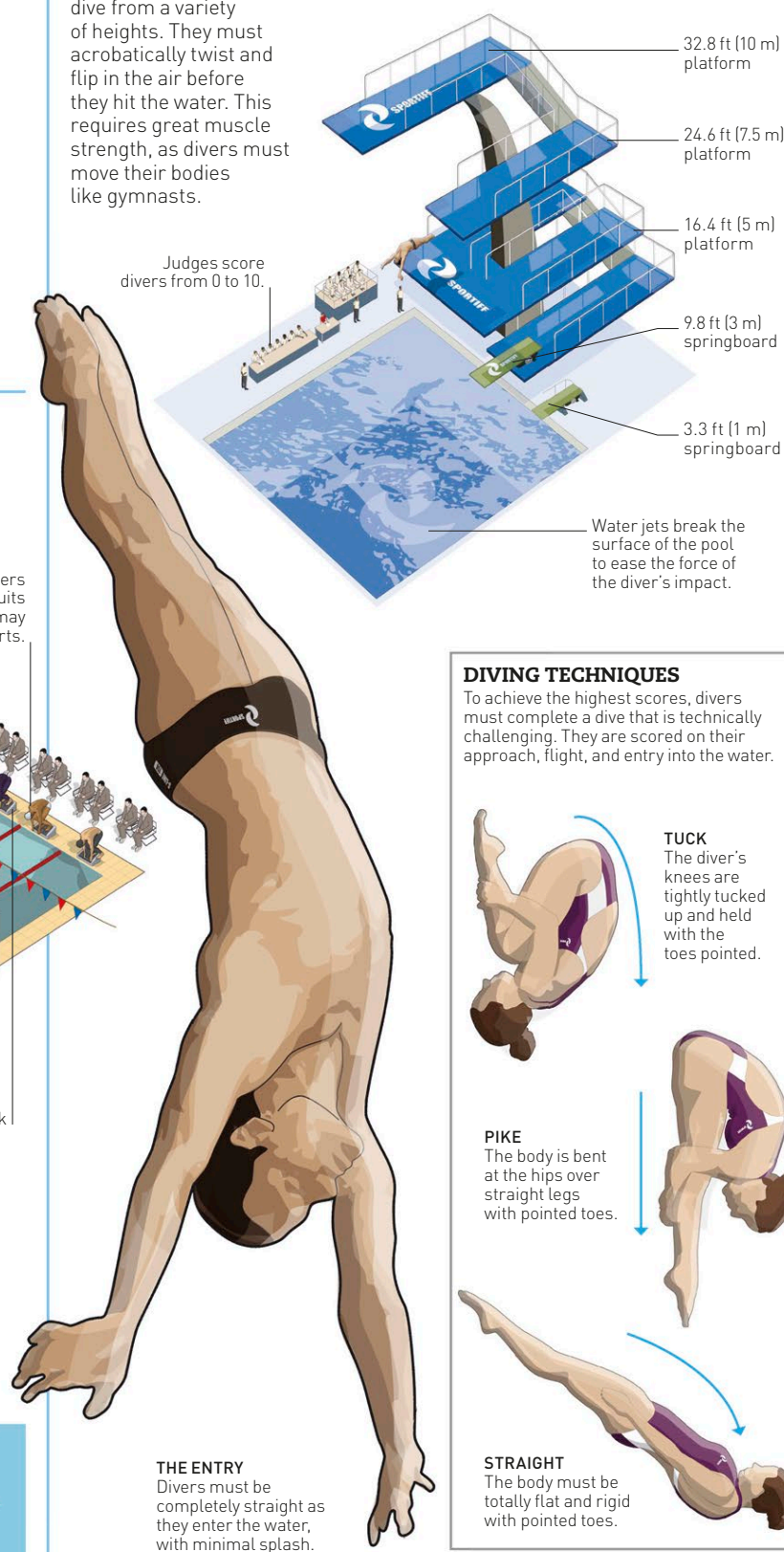
BREASTSTROKE

BUTTERFLY

BACKSTROKE

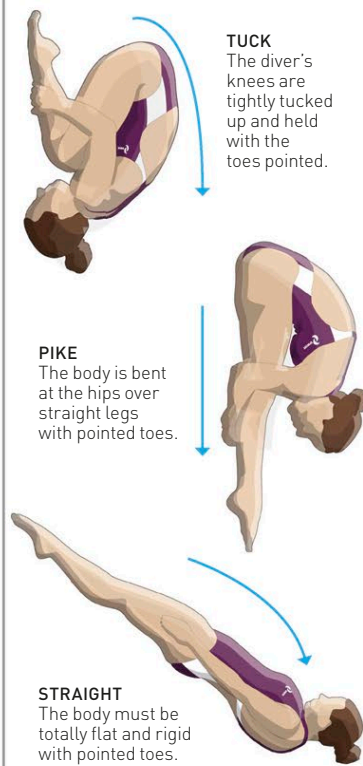
## DIVING

Competitive divers dive from a variety of heights. They must acrobatically twist and flip in the air before they hit the water. This requires great muscle strength, as divers must move their bodies like gymnasts.



## DIVING TECHNIQUES

To achieve the highest scores, divers must complete a dive that is technically challenging. They are scored on their approach, flight, and entry into the water.



### THE ENTRY

Divers must be completely straight as they enter the water, with minimal splash.

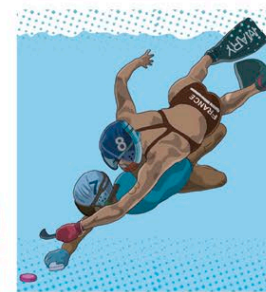
## BALL SPORTS

A number of team ball sports take place in water, such as water polo and underwater hockey. In water polo, players must tread water for long periods of time. In underwater hockey, they need to be able to dive underwater.



### WATER POLO

Teams score goals by throwing a ball into a net.



### UNDERWATER HOCKEY

Teams use snorkels and a stick to get the puck into the goal.



## BOARD SPORTS

Board sports are popular on lakes and along coasts, where people can use the power of the wind, waves, or boats to race along at high speeds or perform amazing tricks. They usually require excellent balance and strength to control the board and avoid falling off.



### SURFING

Surfers need good balance to control a surfboard with their feet. The strength of the breaking waves pushes the board forward.



### KITESURFING

Kitesurfers use the power of the wind to speed across the water and jump high into the air.



### WATER SKIING

Water skiers are pulled along behind a boat on one or two skis, or even barefoot. They compete in slalom, jumping, or trick events.



### WAKEBOARDING

Wakeboarders are pulled along on a board by a boat and use the boat's wake to perform flips and jumps.



### WINDSURFING

Windsurfers use a large sail to power them across the water in speed races or to perform impressive tricks.

### FLOATER

The floater is a popular trick to help surfers gain speed when surfing a wave or to clear a section of the wave. It is also a great way to set up for another trick.



**1** When you have some speed, point the board toward the wave when it is starting to break.



**2** Ride up to the lip of the wave at a 30-degree angle.



**3** Switch your weight from your back foot to your front foot to turn on the lip of the wave.



**4** Enter back into the wave by pushing your board flat on the face of the wave.

## ROWING

Rowers face backward and pull oars through the water to propel their boat as fast as possible. Typically, rowing is done in rivers or lakes, but some rowers even cross oceans.



### SCULLING

In sculling, rowers have one oar in each hand.



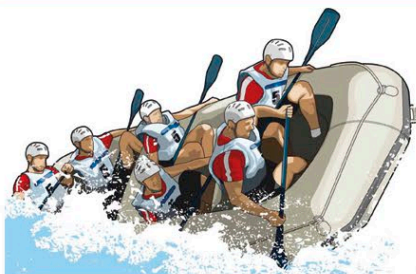
### ROWING

In sweep-oar rowing, each rower is responsible for one oar.

There can be up to eight people in a rowing team.

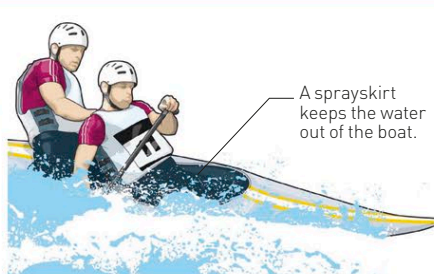
## WHITE WATER SPORTS

White water is made when rivers pass through rocky areas and create rapids. Adrenaline-seekers try to maneuver crafts such as kayaks, canoes, and rafts as they travel down turbulent rivers in races and slaloms (winding races), or just for fun.



### RAFTING

Groups can share the thrill of paddling an inflatable raft down the rapids.



### CANOEING

Canoeists use a paddle with one blade and are either in a sitting or kneeling position in their boat.

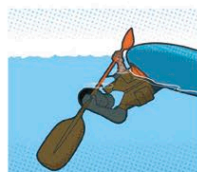
A sprayskirt keeps the water out of the boat.

### ESKIMO ROLL

Kayakers use an eskimo roll when they have capsized to turn the kayak the right way up.



**1 LEAN FORWARD**  
Lean against the kayak and hold the paddle out of the water.



**2 SWEEP**  
Sweep the paddle through the water and rotate your hips to pull the kayak up.



**3 STABILIZE**  
Use the paddle to make sure you are stable, then lift your head and body up.

**INUIT PEOPLE CREATED KAYAKS MORE THAN 4,000 YEARS AGO FROM WHALEBONE OR WOOD AND ANIMAL SKINS.**

### KAYAKING

Kayakers use a paddle with a blade at each end to move quickly through the water.



# Sailing

Sailing has been a mode of transport for thousands of years. Today, it is also an exciting sport and hobby that requires quick thinking, confidence, and strength. Sailors take part in a number of competitive races around the world, although many sail the seas simply for fun.

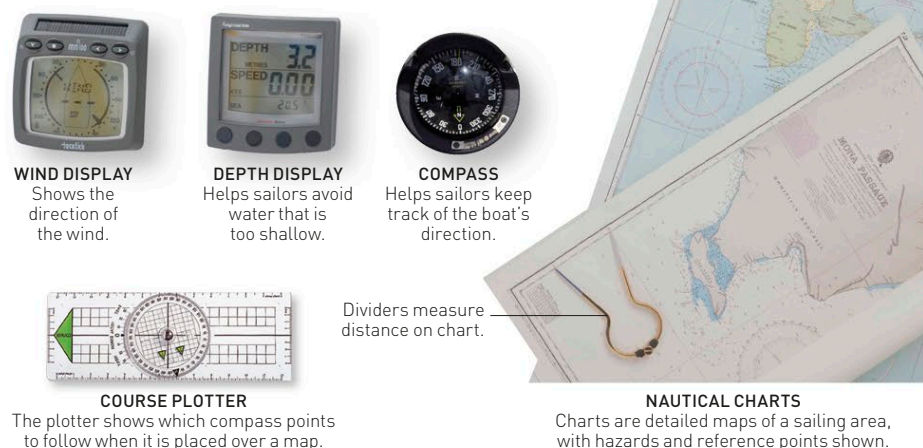
## SAILING CLOTHING

Special clothing helps sailors keep warm and dry when on the water, especially in bad weather. A buoyancy aid or life jacket is worn to keep sailors safe if they fall into the water.



## NAVIGATING

Tides, currents, and shallow waters can make the ocean a dangerous place. Many sailors use GPS (Global Positioning System) to plan their course, but in case this fails, knowing how to navigate is a vital skill.



## ANATOMY OF A BOAT

Knowing the names for different parts of a boat is important when sailing, especially if you are part of a team. It helps you communicate more clearly with each other so that you can travel faster and stay safe.





## TYPES OF BOATS

Boats are organized by class, which is determined by their length. Small boats are ideal for short-distance racing, as they move quickly. Large boats are better for long-distance sailing, as they can endure more treacherous seas than a small dinghy. Here are some popular classes of boat.



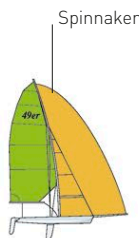
### LASER CLASS

A popular 14-ft (4.2-m) dinghy for solo sailing.



### 470 CLASS

A 15.4-ft (4.7-m) dinghy for a crew of two.



### 49ER CLASS

A 16-ft (4.9-m) dinghy with CCA spinnaker for speed.



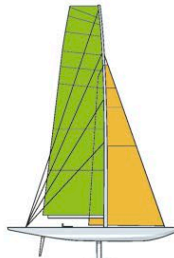
### TORNADO CLASS

A 20-ft (6.1-m) catamaran with two body sections that increase the boat's speed.



### OCEAN RACER (VOLVO 70) CLASS

A 70-ft (21.3-m) yacht with a 103-ft (31.5-m) mast.



### AMERICA'S CUP CLASS

A 79-ft (24-m) yacht used in the America's Cup race between 1992 and 2007.

**SAILING FOR SPORT RATHER THAN TRANSPORTATION OR WARFARE BEGAN IN THE NETHERLANDS IN THE 1600s.**

Spinnaker

Foresail

Port side

Bow

Starboard side

## USING THE WIND

Sailors can adjust their sails to make the most of the wind. The sails can be angled to capture the wind, so the boat is pushed forward in the direction it faces. A sailboat can travel in any direction except straight into the wind (the no-sail zone).

### KEY

#### No-sail zone

In this area, the boat would be sailing into the wind. The sails would not work and the boat would not move.

#### Close haul

The closest a boat can sail to the wind without entering the no-sail zone. Both sails are pulled in tight to the centerline.

#### Close reach

Similar to a close-hauled course, but the boat is turned away a little more from the wind and the sails are loosened further.

#### Beam reach

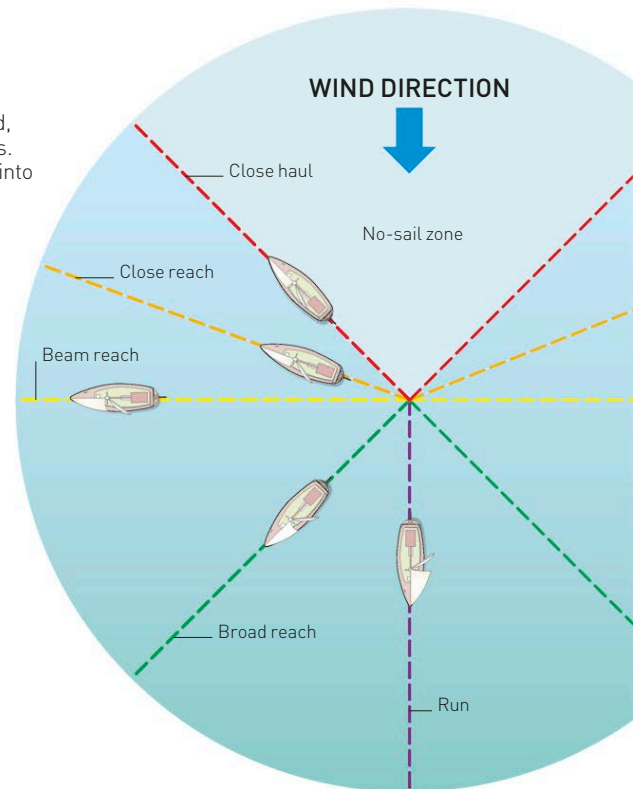
Sails are eased halfway and the wind is coming directly across the side of the boat.

#### Broad reach

Sails are nearly full and the boat is on a course away from the wind (downwind).

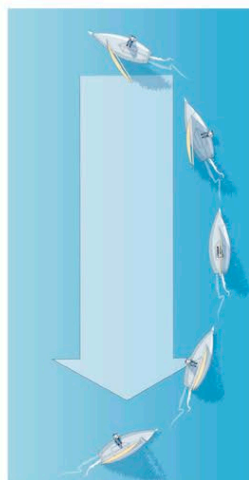
#### Run

Sails are full and the wind is directly behind the boat.



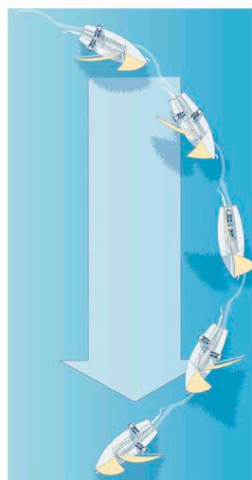
## TACKING AND JIBING

There are two ways of turning a boat: tacking and jibing. Tacking is a safer, slower way of turning, as it allows more control of the sails. Jibing is faster and is especially good for racing.



### TACKING

Turn the boat to face upwind.



### JIBING

Turn the boat to face downwind.

## RECORD BREAKERS

Since sailing began as a sport several hundred years ago, many sailors have set impressive around-the-world sailing records.

- **JOSHUA SLOCUM (CANADA), 1895–1898**  
The first person to sail solo around the world, with just three stops.
- **ROBIN KNOX-JOHNSTON (UK), 1969**  
The first person to sail solo around the world without stopping.
- **KAY COTTEE (AUSTRALIA), 1988**  
The first woman to sail solo around the world without stopping.
- **ELLEN MACARTHUR (UK), 2005**  
Became the fastest person to sail solo around the world without stopping, in 71 days, 14 hours, 18 minutes, and 33 seconds.
- **FRANÇOIS GABART (FRANCE), 2017**  
Set a new record in sailing by becoming the fastest person to sail solo around the world without stopping in 42 days, 16 hours, 40 minutes, and 35 seconds.

## OCEAN RACING

Ocean races can be extremely challenging and dangerous. They require both physical and mental strength, as sailors can be at sea for many weeks at a time.

### ROUTE DU RHUM

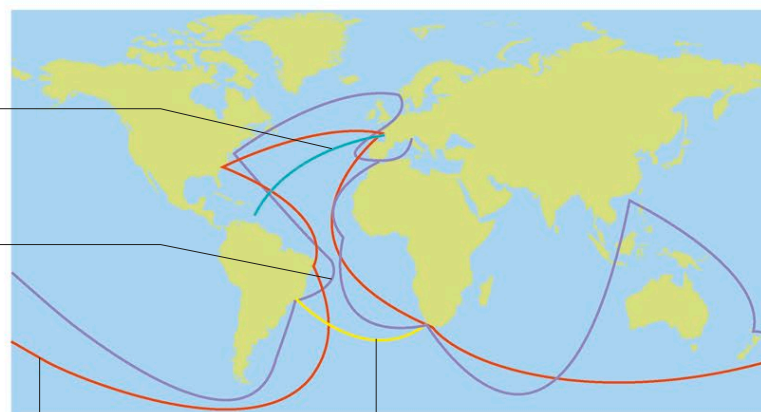
Singlehanded racers must work with fast winds in this high-speed journey across the Atlantic Ocean.

### VOLVO OCEAN RACE

In this extreme race, nine-person crews sail around the world day and night.

### KEY

- Velux 5 Oceans, 2010–2011
- South Atlantic Race, 2011
- Route du Rhum, 2018
- Volvo Ocean Race, 2021–2022 (planned)



### VELUX 5 OCEANS

This ambitious solo around-the-world race takes more than 100 days to finish.

### SOUTH ATLANTIC RACE

Teams in this race must face the strong winds and huge waves of the southern Atlantic Ocean.



# Fishing

Rain or shine, anglers spend hours waiting for a fish to take their bait. Some eat their catch, but many throw the fish back to help conserve fish stocks. So what is the big attraction? Anglers enjoy the peace and quiet, pitting their wits against the fish and having their skill rewarded.

## WHERE TO FISH

There are three main types of fishing: freshwater fishing (sometimes called coarse fishing), saltwater fishing, and fly-fishing. In freshwater and saltwater fishing, anglers use baits and lures to attract fish. In fly-fishing, they use imitation flies instead. Freshwater environments include ponds, lakes, streams, and rivers. Fly-fishing can happen in fresh or saltwater.



**STILL WATER**  
Ponds and lakes are home to carp, pike, and other freshwater species. Anglers fish from the bank or a boat.



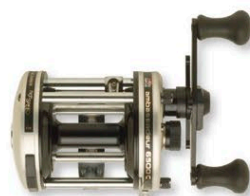
**RUNNING WATER**  
Streams and rivers are the place to catch salmon, trout, bream, and perch. Anglers fish from the bank or wade in.



**SALTWATER**  
Most saltwater fishing is from boats close to shore or out at sea. Anglers also sit on sea walls or wade in the shallows.

## RODS, REELS, AND LINES

A simple stick or length of bamboo can work as a rod, with a line and hook tied on—but most anglers have high-tech rods made of fiberglass or carbon fiber. They come apart for easy carrying and are used with a reel to wind in and stow the line. Multiplier reels allow faster winding than fixed spools, as each turn of the handle spins the drum several times. Super-fast fly reels are used for fly-fishing.



MULTIPLIER REEL



FIXED-SPOOL REEL



FLY REEL



FISHING LINES



FLOAT ROD (IN FOUR PIECES)

## FISHING TACKLE

A tackle box with a handle is essential for transporting equipment and keeping it all organized. The best designs open out so that the compartments are tiered.



## BAIT

Even everyday scraps of bread will attract fish, but there are better baits to use. Live types include worms and maggots. Sweetcorn, seeds, grains, and dog biscuits work well, too. "Boilies" are processed bait balls, high in protein, that come in many colors and flavors.



RED BOILIES



YELLOW BOILIES



DOG BISCUITS



SWEETCORN



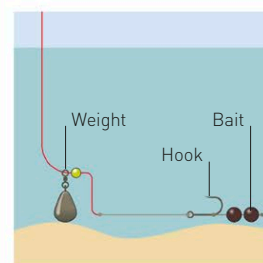
WORMS



WAX WORMS

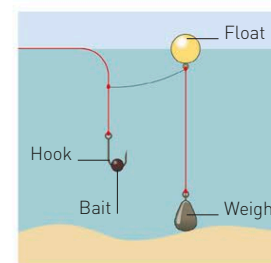
## WEIGHTS

Weights help bring the end of the line close to the fish. Anglers use them to anchor the bait on the bottom or keep it at a particular depth. Most weights are made of a soft metal called lead. Different shapes do different jobs. The smallest—split shot—slots, or crimps, on to the line under a float to position it in the flow of water. The combination of the line, hook, bait, and weight is called a rig.



HAIR RIG FOR CARP

Carp are wary fish. The bait is attached to the hook on a fine, weighted line. The fish sucks up the bait without feeling the hook.



CATFISH RIG

Catfish can be huge. Live bait is fixed to the hook. The baited rig is tied to a float that is secured by a weight on the riverbed.



LEAD WEIGHTS



SPLIT SHOT

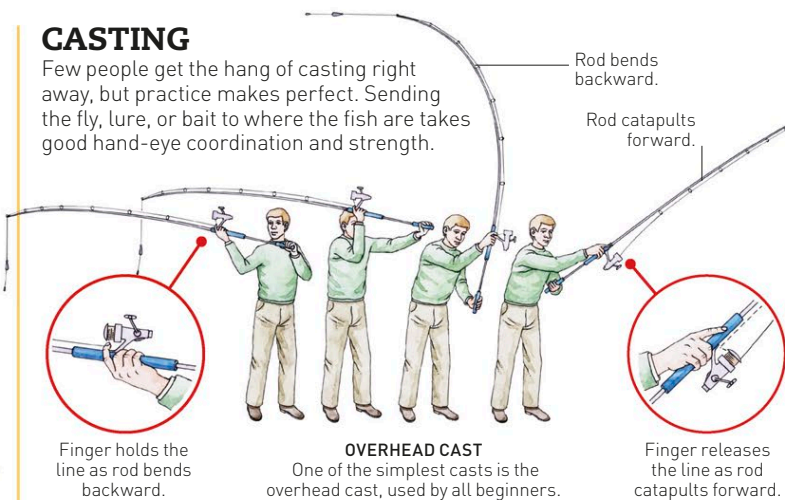


WIRE



## CASTING

Few people get the hang of casting right away, but practice makes perfect. Sending the fly, lure, or bait to where the fish are takes good hand-eye coordination and strength.



**OVERHEAD CAST**  
One of the simplest casts is the overhead cast, used by all beginners.

## BIGGEST CATCH

Big-game fishing happens out in the open ocean. Tuna, marlin, and swordfish are popular targets, and the aim is to catch the biggest fish possible. The record for the heaviest Atlantic bluefin tuna was set in 1979 by Canadian fisherman Ken Fraser, using a rod and line.



## WEIGHING

All anglers want to know how much their catch weighs—so they can compete with each other and with their own personal bests. For catch-and-release fishing, it is especially important to use scales that do not cause any extra distress.



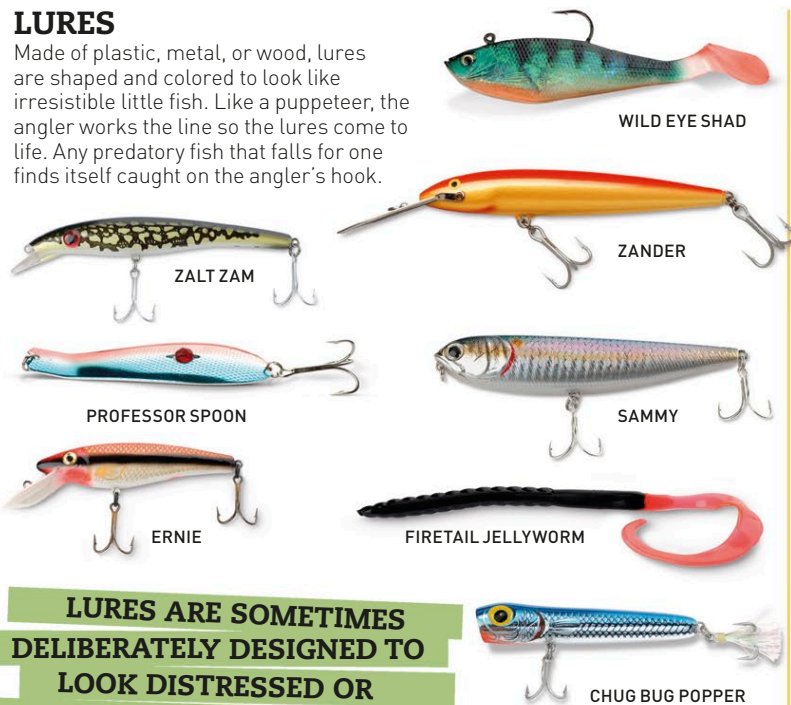
TRADITIONAL SCALES



PORTABLE SCALES

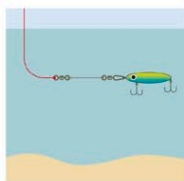
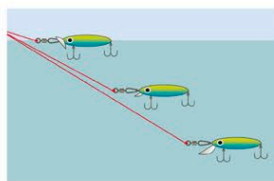
## LURES

Made of plastic, metal, or wood, lures are shaped and colored to look like irresistible little fish. Like a puppeteer, the angler works the line so the lures come to life. Any predatory fish that falls for one finds itself caught on the angler's hook.



**LURES ARE SOMETIMES DELIBERATELY DESIGNED TO LOOK DISTRESSED OR INJURED—LIKE EASY PREY.**

**DEPTHS**  
Lures can be weighted to "swim" at different depths so that they appeal to specific predators.



**PIKE LURE**  
Pike will go for a lure at any depth. The lure has to be on a wire line, as a pike has a fierce bite.

## FLOATS

Like weights, floats help suspend bait or a lure at a particular depth in the water. Some come ready-weighted, but others are used with lead weights or shot. Lighter floats are ideal for still water. Fast-moving water needs heavier floats.



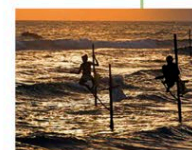
**COLORFUL FLOATS**  
Bright colors attract fish and also help the angler keep track of where the float is in the water.

## DIFFERENT FISHING METHODS

People have caught fish throughout history, gathering food from rivers and the sea just as they hunted animals on land. Over the centuries, people came up with many fascinating ways to catch fish.

### ON STILTS

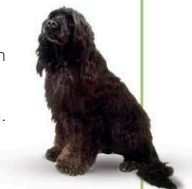
Stilt fishermen in Sri Lanka drive their poles into the sand just offshore, then perch at the top and cast their lines. With this technique, they try and avoid being seen by the fish.



STILTS

### USING SUCKER FISH

Remoras are suckerfish that hitch a ride on larger fish. In Africa, some fishermen use them on their fishing lines. When they feel the remora has attached its sucker to a big fish, they haul it in.



PORTUGUESE WATER DOG

### WITH DOGS

Fishermen along the coast of Portugal traditionally used water dogs to herd fish into their nets.

### USING CORMORANTS

Chinese and Japanese fishermen use trained cormorants. A throat snare stops the birds swallowing bigger fish but is loose enough to let them eat smaller ones.



CORMORANTS

### WITH DOLPHINS

A pod of dolphins in Laguna, Brazil, helps the local fishermen by driving shoals of mullet toward the shore. The dolphins even leap out of the water to tell the people the right moment to cast their nets.

## FLY-FISHING

Fly-fishing began as a way of catching river salmon and trout. Today, it is popular for a huge range of fresh- and saltwater species. The angler uses fake flies to tempt the fish. Some are cast on to the surface of the water (dry flies), and some into the water (wet flies). Flies can be lifelike (deceivers) or come in crazy colors (attractors).



**ADULT MAYFLY**  
(freshwater)



**DAMSEL NYMPH**  
(freshwater)



**CARP FLY**  
(freshwater)  
Mimics dog-biscuit bait.



**SUPER BUZZER SUPREME**  
(freshwater)  
Looks like a midge pupa.



**F-FLY**  
(freshwater)  
Resembles a just-hatched insect stranded on the surface.



**DEPTH CHARGE CZECH MATES**  
(freshwater)  
Mimics a caddis fly larva.



**SQUID WHITE**  
(saltwater)  
Looks like a squid.



**SURF CANDY FLY**  
(saltwater)  
Imitates any baitfish.



**WILLS SKITTAL TAN**  
(saltwater)  
Imitates a shrimp.



**CREASE FLY**  
(saltwater)

## ATTRACTORS

Attractors are often brightly colored. The angler usually moves them around a lot to tempt fish to attack.

Legs make ripples on the surface.



**CHERNOBYL ANT**  
(freshwater)

Rubber legs create movement.



**DEER HOPPER**  
(freshwater)

Big, buoyant eyes



**CACTUS BOOBY**  
(freshwater)



**PIWI POPPER**  
(saltwater)



# Combat sports

Many sports, both ancient and modern, have their roots in traditional fighting techniques. These combat sports teach strength and discipline and help students learn how to defend themselves. Some are better known as martial arts.

## TYPES OF COMBAT SPORTS

Some combat sports have developed from very old ways of fighting, while others have been around for just a few decades. Most focus on one of three types of attack: punches, kicks, and other strikes; throwing, holding, and pinning; or using weapons.

## PUNCHES, KICKS, AND OTHER STRIKES

### KUNG FU: TAOLU

Kung fu takes many forms. The most popular is taolu, a form of the Chinese martial arts, called *wushu*.

### KUNG FU: SANSHOU

Sanshou is a Chinese martial art similar to kickboxing. It is never practiced with weapons.

### KUNG FU: T'AI CHI

Based on slow, flowing movements, this is a gentle, meditative form of kung fu.

### BOXING

The ancient Greeks boxed, but modern boxing follows rules set in 19th century England.

### THAI BOXING

Unlike Western boxers, Thai boxers attack with feet, elbows, and knees, as well as fists.

### CAPOEIRA

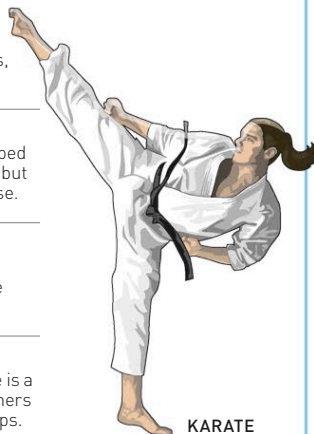
African slaves in Brazil developed capoeira. It looks like a dance, but it is really a form of self-defense.

### TAEKWONDO

The name of this 20th-century Korean martial art means "the way of the foot and fist."

### KARATE

Originating from Japan, karate is a form of self-defense. Practitioners do not use any weapons or props.



KARATE

## THROWING, HOLDING, AND PINNING

### JUJITSU

This Japanese martial art drew on ancient Indian and Chinese fighting techniques.

### JUDO

Based on jujitsu, judo developed in the 1800s. It involves throwing, grappling, and striking.

### SUMO WRESTLING

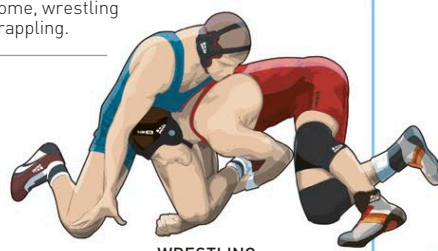
This sport is most associated with Japan, but it originated in China in the 3rd century BCE.

### WRESTLING

As popular today as it was in ancient Greece and Rome, wrestling involves one-to-one grappling.

### SOMBO

Much like wrestling, this Russian combat sport also involves punches and kicks.



WRESTLING

## USING WEAPONS

### KALARIPAYIT

One of the world's oldest martial arts, kalaripayit developed in ancient India.

### FENCING

This sport developed from sword fighting in the 1500s. Many of its terms are French.

### KYUDO

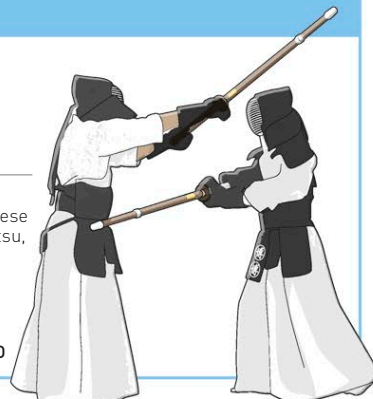
Samurai warriors practiced an early form of kyudo, which is similar to archery.

### ESKRIMA

Meaning "skirmish," eskrima was developed in the Philippines in the 16th century.

### KENDO

Full of ritual, this Japanese sport is based on kenjutsu, an 11th-century form of sword-fighting.



KENDO

## KUNG FU: TAOLU

Taolu is a form of kung fu in which competitors show off routines on a padded mat. Their moves include punches, balances, jumps, sweeps, and throws. Some moves are performed bare-handed, and some with weapons.

### TAOLU WEAPONS

In taolu, competitors handle various traditional Chinese weapons. Working alone or in pairs, they aim to be as graceful as possible.

GUN (TYPE OF STAFF), 7 ft (210 cm)

JIAN (SWORD), 3.4 ft (103 cm)

DAO (CURVED SWORD), 3.25 ft (98 cm)

NANDAO (BROADSWORD), 3.25 ft (97 cm)



Swishing tassels emphasize the moves.

Chinese tunic worn over loose pants

Taijijian sword is 43 in (110 cm) long.

### SEATED STANCE

In this stance, called *xie bu*, the competitor wraps one thigh over the other. The front foot stays flat on the floor.

### CROUCH STANCE

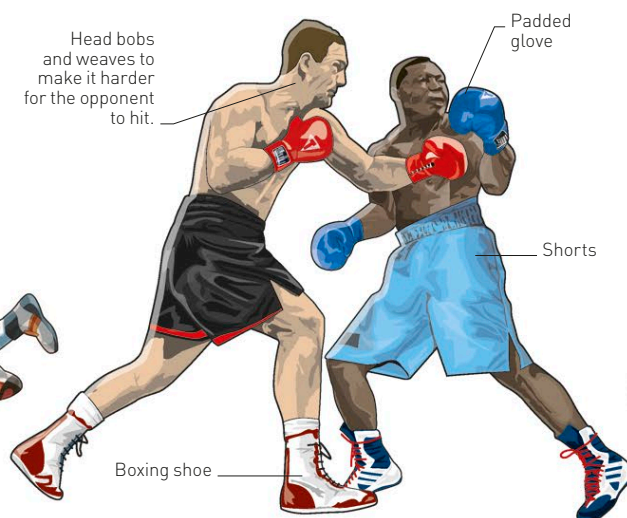
This move, known as *pu bu*, is a very low squat. One arm arches over the head to counterbalance the crouching.

### HORSE STANCE

This powerful position is known as *ma bu* in Chinese. The tops of the thighs must stay parallel to the floor.

## BOXING

In boxing, two opponents try to punch each other while avoiding punches themselves. They score points for different punches to their opponent's head and upper body. The winner is the boxer who scores the most points or who knocks out his or her opponent.



Head bobs and weaves to make it harder for the opponent to hit.

Padded glove

Shorts

Boxing shoe

### FIGHTING GEAR

Groin guards are optional, but gloves and mouth guards must be worn. Head guards are mandatory for women's contests.



GROIN GUARD



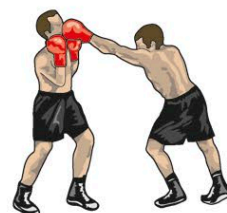
GLOVES



MOUTH GUARD



HEAD GUARD



### JAB

A stiff jab is the basic punch used by all boxers. For a perfect jab, the boxer has to fully extend their arm.



### HOOK

Hooks are delivered to the side of the head or body. The best hooks are those an opponent does not see coming.



### UPPERCUT

This powerful punch is delivered on to the opponent's chin from below. It often results in a knockout.



## JUDO

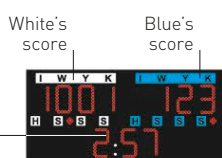
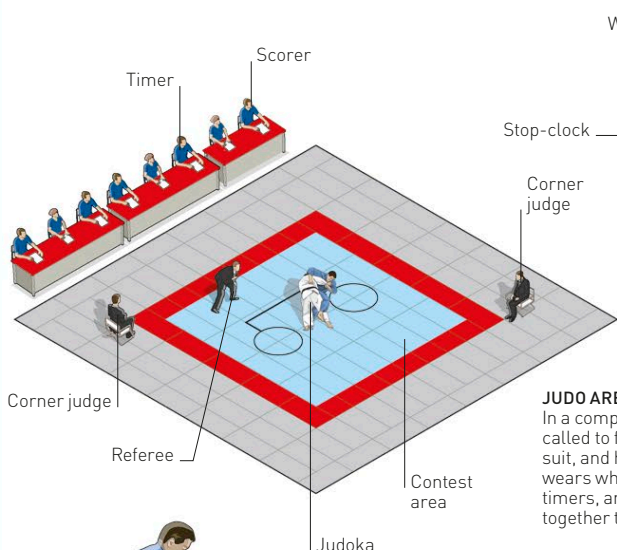
In the Japanese art of judo, two opponents (called judoka) try to throw each other to the ground, pin each other down, or force a submission. There are no weapons, and kicks and punches are not allowed.

Heavy cotton jacket, known as an *uwagi*

Color of belt shows the judoka's rank.

Legwear called *zubon*

**JUDO BECAME AN OFFICIAL OLYMPIC SPORT AT THE 1964 OLYMPIC GAMES IN TOKYO, JAPAN.**



**SCOREBOARD**  
The scoreboard shows each judoka's points, which are called *ippon*, and their penalties.

### JUDO ARENA

In a competition, the first judoka called to fight wears a blue judo suit, and his or her opponent wears white. Judges, referees, timers, and scorers work together to award scores.



#### O-GOSHI

In the *o-goshi*, or hip throw, the judoka uses his or her hip as a pivot point to throw the opponent to the floor.



#### KESA GATAME

Many throws end with a pin. *Kesa gatame* involves wrapping an arm around the opponent's neck.

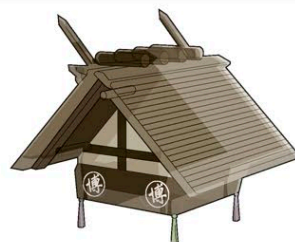


#### OKURI-ERI-JIME

Submissions are dangerous moves. In *okuri-eri-jime*, the judoka grips his or her opponent in a stranglehold.

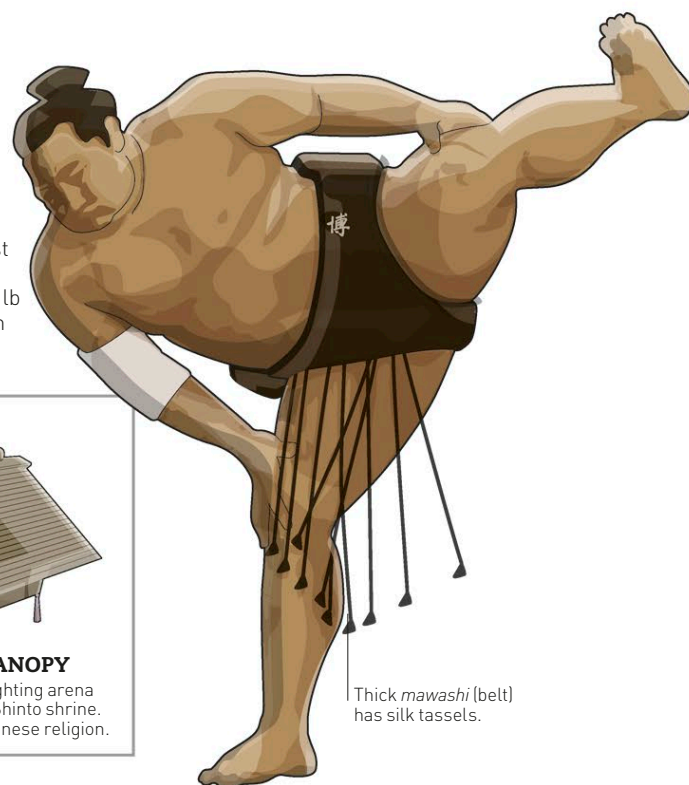
## SUMO

In sumo wrestling, the aim is to stay in the ring with only the feet touching the ground. The two opponents try to push each other off balance or out of the ring. One of the heaviest sumo stars, Konishiki Yasokichi, weighed 633 lb (287 kg) and was known as the "Dump Truck."



### TSURIYANE CANOPY

The canopy over the fighting arena looks like the roof of a Shinto shrine. Shinto is an ancient Japanese religion.



Thick *mawashi* (belt) has silk tassels.



#### YORIKIRI

This move involves seizing the opponent's *mawashi* and trying to march them out of the ring.



#### UWATENAGE

In this attack, the wrestler grips their opponent's *mawashi* and pulls them down while turning their own upper body.

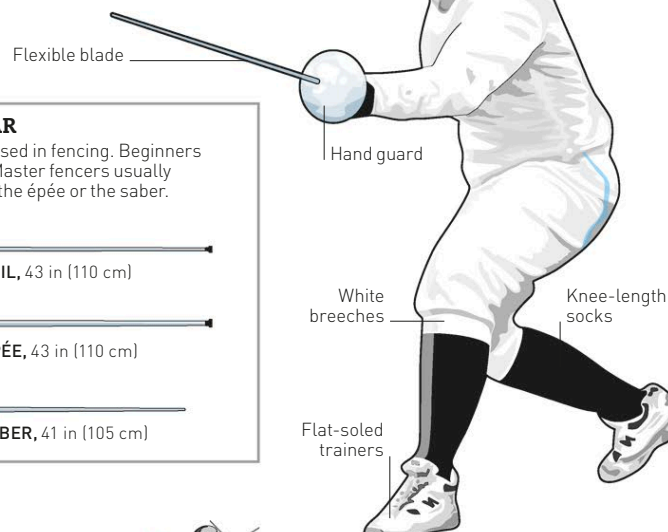


#### HATAKIKOMI

As one wrestler charges, the other steps to the side and then slaps the opponent's back or arm so they fall over.

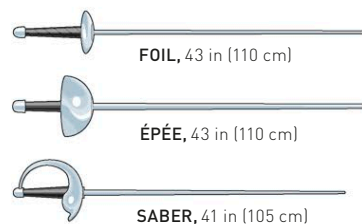
## FENCING

Two opponents face each other with special swords in this traditional sport. Matches take place on a narrow, raised platform, and the fencers score points by touching target areas on their opponent's torso.



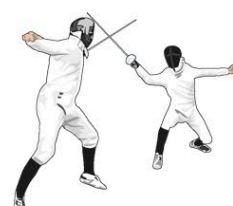
### FIGHTING GEAR

Three swords are used in fencing. Beginners start with the foil. Master fencers usually specialize in either the *épée* or the *saber*.



#### ATTACK

The fencer extends his or her sword arm toward the opponent. A lunge forward adds force to the attack.



#### PARRY

The parry is a defensive move that blocks the opponent's attack and may expose him or her to a counterattack.



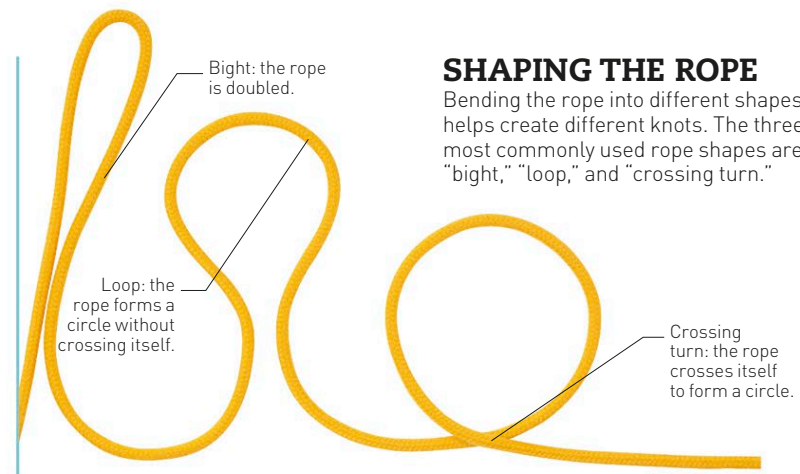
#### RIPOSTE

After a parry, the follow-up counterattack is known as a *riposte*. The name comes from the French word for "reply."



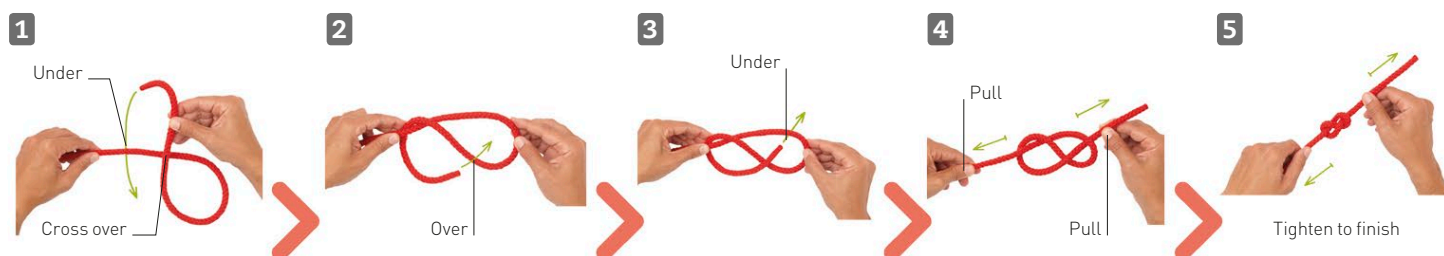
# Knots

Knowing how to tie knots is a fun skill that is useful in many situations. For activities such as climbing or sailing, ropes tied with the right knots are vital for safety. More everyday uses for knots range from putting up a tent to making decorations or even tying shoelaces.



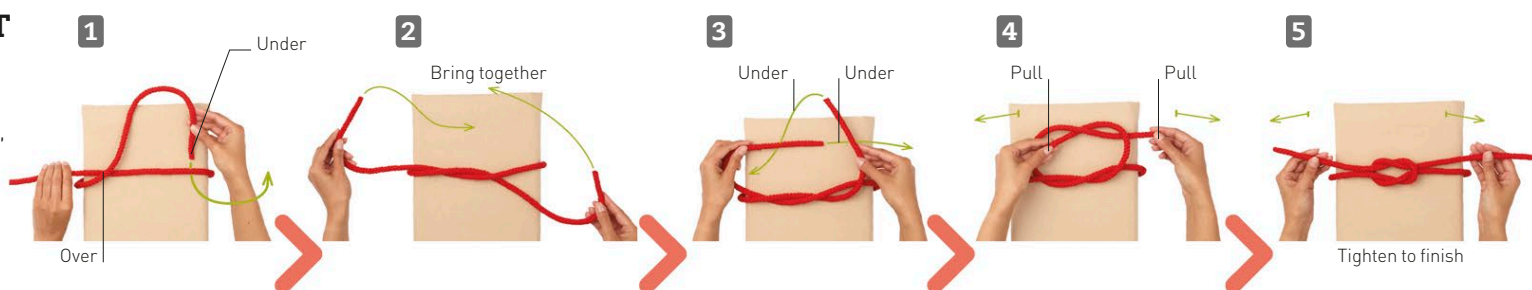
## FIGURE-EIGHT

Easy to tie and untie, the figure-eight is a simple stopper knot that can be used to stop rope from slipping through a hole. It is an important knot for sailors and rock climbers.



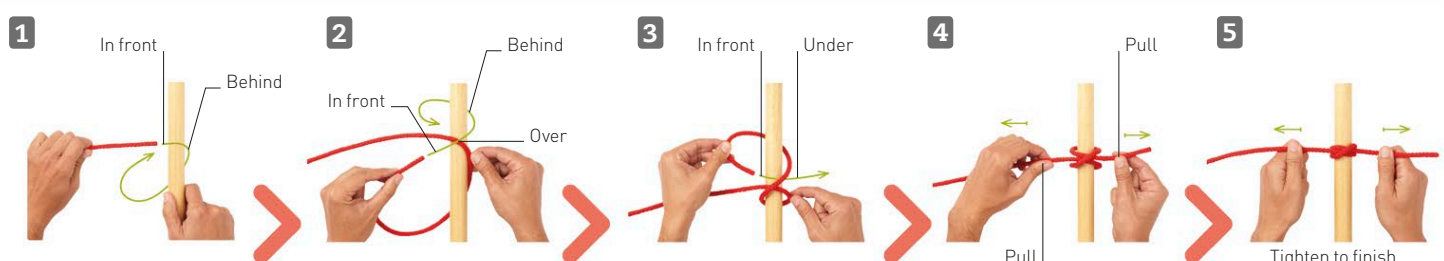
## SQUARE KNOT

This binding knot is quick to do. It is used for securing rope or string around an object, so it is perfect for tying up parcels. Square knots are also known as reef knots.



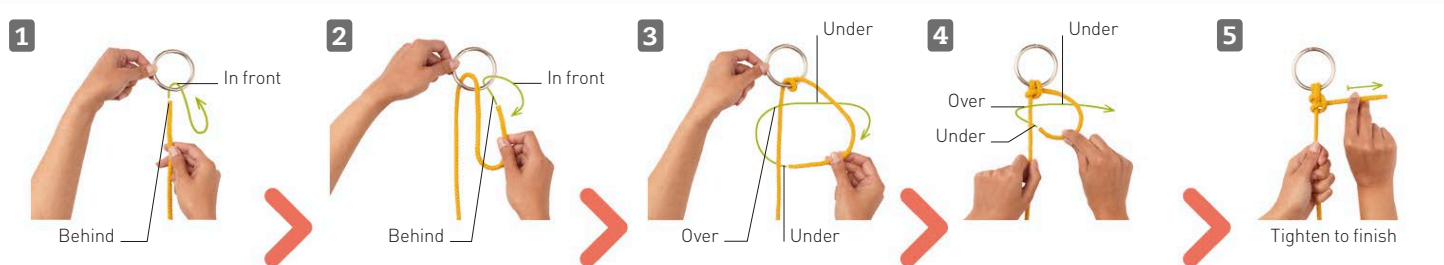
## CLOVE HITCH

The clove hitch is a binding knot that is used when only one end of a rope is available to work with. It is tied to secure the end of a rope to a post or similar and is often used by climbers.



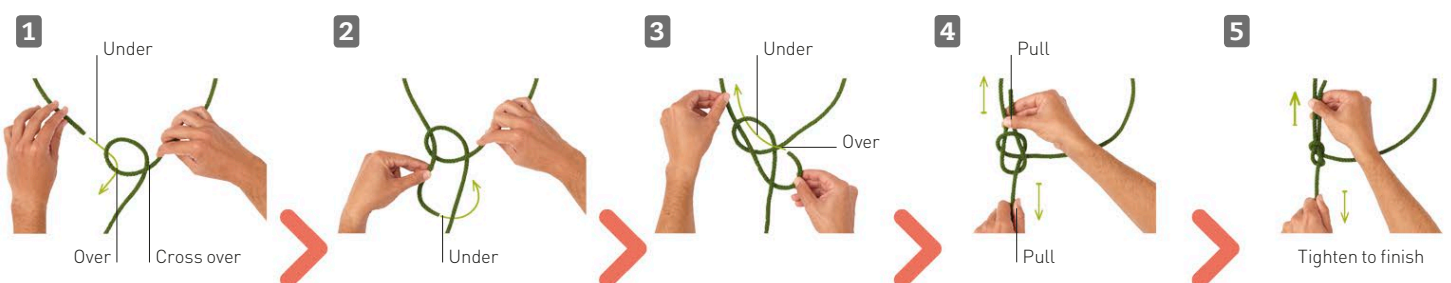
## ROUND TURN AND TWO HALF-HITCHES

This is a weight-bearing knot that could be used for attaching a rope to a fixed object. For example, you could tie a swing to the branch of a tree using this knot.



## BOWLINE

The bowline is a handy loop knot (knot for making a secure loop with a rope) with many uses, from mooring a boat to hanging up a hammock. It is quick to tie and untie.





## STOPPER KNOTS

These prevent a rope from slipping through a hole or unraveling at the end. Stopper knots can also be used for decoration. Some are tricky to undo.



DIAMOND



STOPPER



SINK STOPPER



WALL KNOT



MANROPE



STEVEDORE



MONKEY'S FIST



MATTHEW WALKER



FIGURE-EIGHT

## BINDING KNOTS

Handy for many purposes, binding knots are particularly useful for tying things together in bundles. Some types are ideal for making bows on gift packages or tying shoelaces.



TIMBER HITCH



BOA



CLOVE HITCH



SAILOR'S



THIEF



PACKER'S



TRUE LOVER'S



SQUARE



SLIPPED SQUARE



SURGEON'S



GRANNY



TURQUOISE TURTLE



DOUBLE-SLIPPED SQUARE



SAILOR'S CROSS

## BEND KNOTS

These knots are designed to join two pieces of rope together. They are used by mountaineers on safety lines and other pieces of climbing equipment. Some bend knots secure fastenings between ropes of different thicknesses.



SHEET BEND



CARRICK BEND



BLOOD



TUCKED SHEET BEND



HUNTER'S BEND



LANYARD



WATER



DOUBLE SHEET BEND



FISHERMAN'S

## HITCH KNOTS

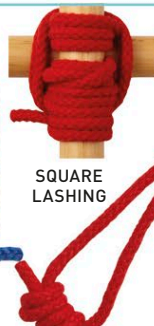
A hitch ties a rope to something else, such as a pole or a ring. Fishermen often use hitches to fasten hooks onto fishing lines.



ROLLING HITCH



SHEAR LASHING



SQUARE LASHING



KLEMHEIST



BUNTLINE HITCH



COW HITCH



COW HITCH WITH TOGGLE



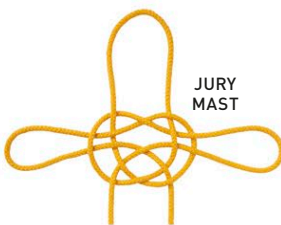
MUNTER HITCH



SHEEPSHANK

## LOOP KNOTS

Loop knots are used to attach ropes to other objects. For this reason, they are popular with climbers, sailors, and fishermen.



JURY MAST



PORTUGUESE BOWLINE



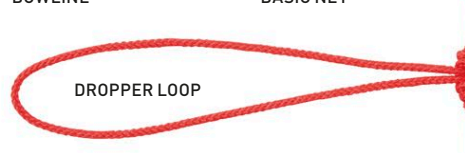
ANGLER'S LOOP



BOWLINE



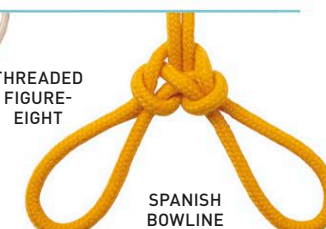
BASIC NET



DROPPER LOOP



THREADED FIGURE-EIGHT



SPANISH BOWLINE



ALPINE BUTTERFLY



# Games

Long before the Internet, computer games, and TV, people invented games. Board and card games have been around for hundreds or even thousands of years and are as challenging and fun to play today as they ever were.

## CARD GAMES

Easy to carry and used all over the world, decks of cards are the starting point for thousands of different games. Digital versions of many traditional games can also be played online.



**CARDS FROM AROUND THE WORLD**  
European packs have 52 cards in four suits—hearts, clubs, diamonds, and spades. Other cards have pictures or shapes.

EUROPEAN CARDS



### CHINESE CHECKERS

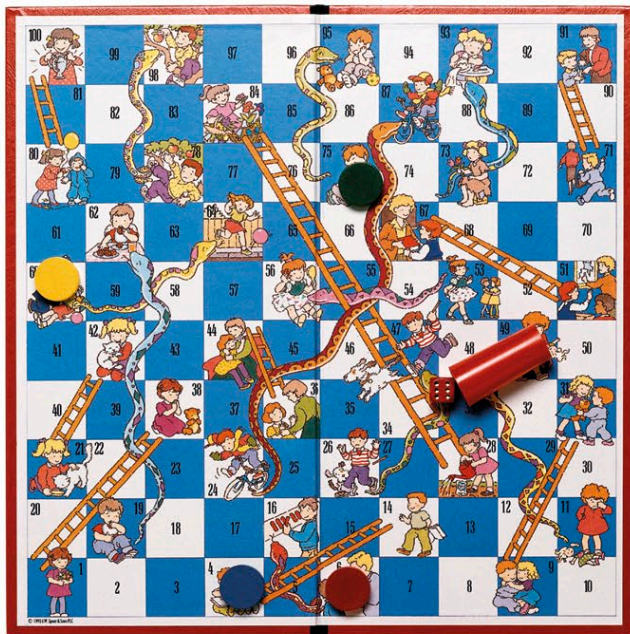
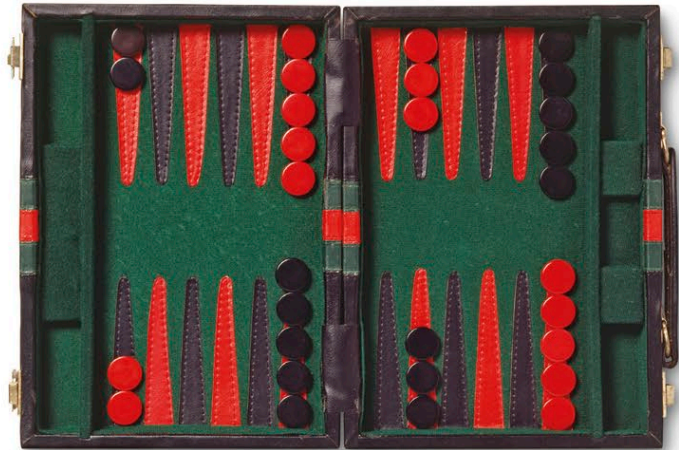
The aim of this game is to race your colored pegs across the board to the opposite point of the star. You can move along one hole at a time or hop over pegs in your path.

## TABLE-TOP GAMES

These competitive games have flat boards, small pieces, and can take hours of concentration before someone wins. Over the years, games like these became a focus for social get-togethers. They are still a great way to gather people around a table to have fun.

### BACKGAMMON

This game for two players is one of the oldest in the world. It involves a mixture of strategy and luck as players roll dice and then decide how to move their counters. The winner is the first player to clear their pieces off the board.



### CHUTES AND LADDERS

Players throw a die to move up the board and, hopefully, land on a ladder to skip rows. But watch out for the chutes!

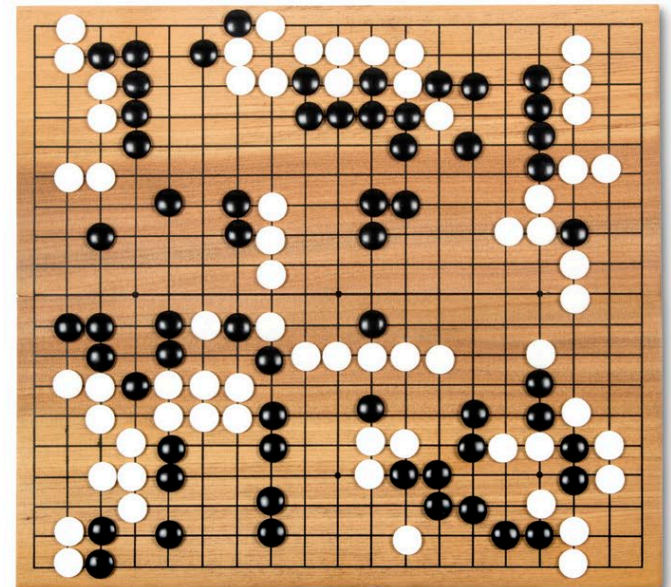
### GO GAME

Go starts with an empty board. Players place their stones where the lines cross to build territories. Or they surround and capture enemy stones.



### CHECKERS

The aim of this game is to grab all your opponent's pieces by jumping over them diagonally as you cross the board.



## PLAYING PIECES

The earliest games were played with anything that was on hand — pebbles, shells, sticks, and bones. Nowadays, many games have written rules, boards, tiles, counters, marbles, or pegs.

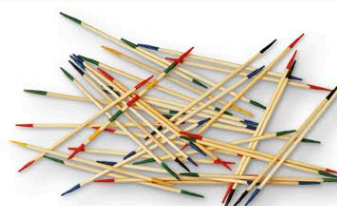
### MANCALA

There are hundreds of different versions of mancala. Players move seeds or stones along pits on the board and try to collect the largest store.



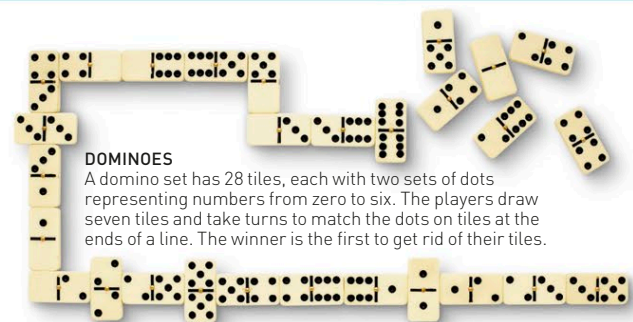
### MAHJONG

In this ancient Chinese game, four players take turns to pick up and discard tiles. The aim is to collect sets of different types.



### PICK-UP STICKS

The sticks are dropped in a heap, and each player in turn tries to pull a stick from the pile without disturbing the rest. The player with the most sticks wins.



### DOMINOES

A domino set has 28 tiles, each with two sets of dots representing numbers from zero to six. The players draw seven tiles and take turns to match the dots on tiles at the ends of a line. The winner is the first to get rid of their tiles.

### MARBLE SOLITAIRE

The aim of this game for one person is to clear the board by jumping marbles over each other to remove them. The game is complete when just one marble is left in the center hole.







JAPANESE HANAFUDA OR FLOWER CARDS

## POPULAR CARD GAMES

In most games, winning is a mix of memory, skill, and luck in how the cards fall.

NAME	TYPE	PLAYERS	OBJECTIVE
Rummy	draw-and-discard	2 or more	combine cards into sets
Bridge	trick-taking	4 players	highest score
Poker	trick-taking	2 or more	hand rankings
Solitaire	building sets	1 player	complete all 4 sets
Canasta	draw-and-discard	4 players	highest score

## A GAME OF CHESS

In a chess game, each player has a black or white army and takes turns to move pieces to attack the other player's king. The aim is to put the king into checkmate—a position where he cannot move to safety. Along the way, players capture enemy pieces and try to keep their own pieces safe.

Black queen sits on black square.

Light square in back corner is always on player's right-hand side.

**CHESS CLOCKS**  
These clocks control the time spent on each move. The player stops their own timer after a move and starts their opponent's.



Front row has eight pawns.

### CHESS BOARD SET-UP

The 16 pieces sit on black and white squares in two rows with the eight pawns in the front row. In the back row, two bishops, knights, and rooks sit on either side of the queen and the king.

White queen sits on white square.  
King   Bishop   Knight   Rook

## CHESS PIECES

There are 32 pieces in a set—16 black and 16 white. Each player has one king, one queen, two rooks, two knights, two bishops, and eight pawns.



FULL SET OF BLACK PIECES



### KING

The most valuable piece on the board, the king can move one square in any direction. It cannot move into a square occupied by a piece of the same color or into "check"—a position where it is under threat by an opposing player.



### QUEEN

The queen is the most powerful piece on the board. She can move in any direction and for any number of squares as long as her path is clear of her own pieces. If she captures an opponent's piece, her move is over.



### BISHOP

The bishop is topped by a miter (bishop's head-dress). It can move any distance diagonally, as long as its path is clear. The bishop starts on a light or dark square and must stay on the same color throughout the game.



### KNIGHT

The knight is useful because it can jump over pieces in its path. It moves two squares in any direction and then sideways one square to the left or right. In effect, it sits in the corner of a rectangle three squares by two and jumps to the opposite corner.



### ROOK OR CASTLE

Sitting in the corner of the board at the beginning of the game, the rook (or castle) can move backward, forward, left, and right as far as it needs to. Its path has to be clear of pieces of the same color. The rooks are often used to protect each other.



### PAWN

Pawns are the smallest and least valuable pieces. Throughout the game, a pawn can move just one square at a time forward from its starting position. But for its very first move, the pawn has the option of moving two squares forward.

## GAMES THROUGH THE AGES

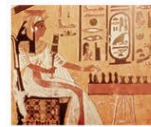
Archaeologists have found ancient game pieces that are more than 5,000 years old. Prehistoric people played games even earlier, with bones that were used like dice.



Backgammon

3100 BCE

The oldest known board game, senet is a favorite pastime in ancient Egypt.



Senet in tomb painting

3100 BCE

3000 BCE

A board game similar to backgammon is played.

500 BCE

Pachisi, an ancient Indian game, is mentioned in the epic poem *The Mahabharata*.

200 BCE

A pottery Go board from this era has been found in Shaanxi Province, China.

600 CE

An ancestor of the game of chess, chaturanga is referred to in Indian writings.

800s

Playing cards appear in China's Tang Dynasty.



Hnefatafl

1220s

The Scandinavian strategy game hnefatafl is mentioned in the Norse Saga.

1200s

The first mention of the game of dominoes appears in a Chinese text.



Checkers

1492

A knight and lady are shown playing checkers in a medieval book.

1600s

A card game called cribbage, played with a scorekeeping board, is invented.

1874

Parcheesi, a version of the Indian game pachisi, is introduced to the US.



1933

Criss Cross Words (later Scrabble) is invented by a US architect.

1978

Space Invaders becomes a blockbuster arcade video game.

1980

Arcade game Pac-Man is released in Japan.

2000

World of Warcraft is created—a MMORPG (massively multiplayer online role-playing game).

2011

The multi-award-winning computer game Minecraft is released.

2025

2000

Computer gamers can decorate a home and choose how to live in *The Sims*, a follow-up to *SimCity*.

2017

The online multiplayer battle game *Fortnite* is launched. It quickly attracts millions of players, becoming one of the most iconic games of the decade.



Rubik's Cube



# Magic

Magicians perform tricks and illusions to amaze an audience by making the impossible seem possible and the unbelievable believable. With practice and a little skill, anyone can learn a few magic tricks to impress friends and family. The golden rule of magic is never to reveal how your trick works.

## MAGIC TOOLS

All magicians have a few pieces of essential equipment in their tool box as aids for tricks and for showmanship. A deck of playing cards and a set of cups and balls are probably the most important. Wands are also popular.

WAND



DECK OF CARDS

SCARVES



PIECE OF ROPE



BOW TIE



BAG OF COINS



CUPS AND BALLS

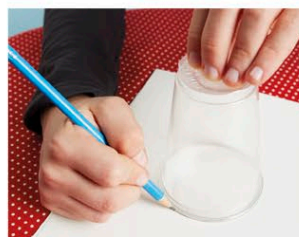


TOP HAT AND RABBIT

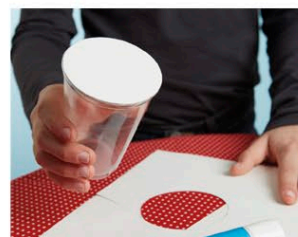


## DISAPPEARING COIN TRICK

In this vanishing trick, you will convince your audience that a coin has disappeared, when in reality it is hidden. You will need scissors, two sheets of paper or index card, glue, a pencil, a handkerchief, a coin, and a clear plastic cup.



- 1 DRAW A CIRCLE**  
Place the plastic cup upside down on one of the pieces of paper or index card and draw around it with your pencil. Cut out the circle.



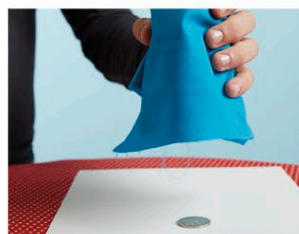
- 2 GLUE THE CIRCLE**  
Glue the paper circle to the rim of the cup. You can discard the remains of the piece of paper or card.



- 3 PLACE THE OBJECTS**  
Place the cup upside down on the second piece of paper or card. Put the handkerchief and coin there, too.



- 4 BEGIN THE PERFORMANCE**  
Now you are ready to begin the trick. Gather the audience, then put the handkerchief over the cup.



- 5 HIDE THE COIN**  
Completely cover the cup with the handkerchief and place it over the coin. You might want to wave your wand or say some magic words now.



- 6 SLOWLY REVEAL**  
Gently remove the handkerchief from the cup, taking care not to move the cup itself.



- 7 NO COIN!**  
If you are careful, your audience won't guess that the coin is actually underneath the paper circle.

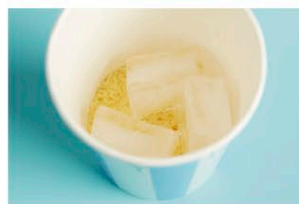
**MAKE SURE ALL YOUR TOOLS ARE READY AND IN PLACE BEFORE STARTING ANY MAGIC TRICK.**

## WATER TO ICE

This is a simple transformation trick. You will need a paper cup, ice, sponge, scissors, and a small jug of water. Practice first so you know how much water your piece of sponge will absorb.



- 1 ADD THE SPONGE**  
Cut a piece of sponge to fit snugly inside your paper cup. This will absorb the water you pour in.



- 2 PLACE THE ICE**  
Put a few ice cubes on top of the sponge in the base of the cup. Gather your audience now, before the ice melts.



- 3 POUR THE WATER**  
Ask your audience to watch you pouring water from the jug into your cup, making sure they can't see into the cup.



- 4 VOILÀ!**  
Say some magic words or wave your wand, then tip the cup upside down and the ice cubes will tumble out.



## MAGIC EFFECTS

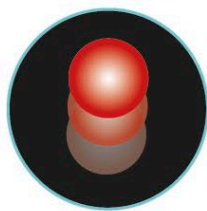
There are thousands of different magic tricks, and magicians are always thinking up new ones. All magicians perform their magic using effects. The simplest tricks rely on just one effect, but more complicated tricks use several effects at once.



**PRODUCTION**  
Making something—or someone—appear out of nowhere.



**VANISHING**  
The opposite of production—making a thing or person disappear.



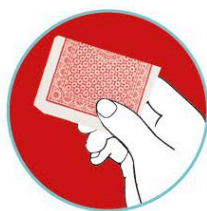
**LEVITATION OR SUSPENSION**  
Making something or someone appear to fly or float in midair.



**PREDICTION**  
Seeming to know what is about to happen, such as which card will be picked.



**TRANSFORMATION**  
Changing one thing into something else, such as a person into an animal.



**RESTORATION**  
“Magically” repairing a torn or broken object.



**ESCAPOLOGY**  
Escaping from restraints such as handcuffs or traps such as cages.



**TELEPORTATION**  
Moving something from one place to another without seeming to handle it.

## MAGIC SKILLS

Entertaining the audience is a magician's first task. Once the audience is under his or her spell, the magician uses sleight of hand—distraction and deception—to make it appear that real magic is being performed.



### SHOWMANSHIP

A good magician amuses and entertains the audience. Props such as hats and wands come in useful, and so does “chatter”—telling jokes or asking questions.



### SLEIGHT OF HAND

The magician takes advantage of “blind spots” in the audience's vision and uses fast, fluid hand movements to hide or disguise an action.

## MAGICIANS

The first stars of stage magic invented their own amazing tricks. Today's top magicians continue this tradition, devising different illusions to delight and enthrall audiences.

### LULU HURST (1869–1950)

Lulu Hurst was an American stage magician known for performing acts that were considered supernatural. Using stage tricks based on simple physics, she would move multiple men on a chair.

### HARRY HOUDINI (1874–1926)

The greatest escapologist the world has ever known, Houdini could free himself from anything—handcuffs, leg irons, cages, straitjackets, prison cells, and even a sealed milk can.



HOUDINI

### DANTE THE GREAT (1883–1955)

Dante's amazing shows of tricks and illusions included a huge cast of musicians, jugglers, acrobats, birds, and animals.

### CRISS ANGEL (1967–)

“Magician of the Century” Criss Angel's stunts include walking on water, floating between two buildings, making an elephant disappear, and being run over by a steamroller while lying on a bed of glass.

### DAVID BLAINE (1973–)

Blaine performs amazing feats of endurance such as being encased in ice, buried alive, or surrounded by deadly electric currents.

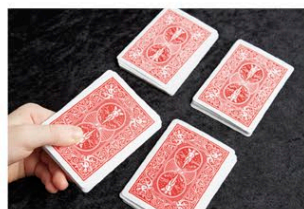
## RAISING ACES

This teleportation trick makes it look as though you can conjure up the aces from a deck of cards. Carry out the first step in secret, then ask for a volunteer. After the steps, when they turn over the top card of each pile, four aces are revealed.



### 1 PREPARE THE DECK

Remove all four aces and place them on the top of the deck face down.



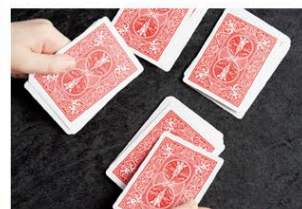
### 2 FOUR PILES

Ask your volunteer to divide the deck into four roughly equal piles. Keep track of which pile contains the aces.



### 3 TOP THREE CARDS

Ask the volunteer to choose one of the three piles that don't contain the aces. Get him or her to take the top three cards and move them to the bottom of the pile.



### 4 DEAL ONE CARD

Have your volunteer deal one card from their pile on to each of the other three piles. For the other piles without aces, have them repeat step 3 and the first part of step 4.



### 5 REVEAL THE ACES

Let the volunteer take the pile with the aces, pick the top three cards in it and move it to the bottom of the pile, and deal one card from the pile on to each of the other three piles. Ask them to turn over the top card of each pile.

## HEAT IS ON

This coin trick uses the effect of prediction to make your audience believe you have hidden mind-reading powers. You will need a bag of cool coins—put the coins in the fridge for a few minutes before you start.



### 1 GATHER THE AUDIENCE

Ask an audience member to pick a coin from the bag, hold it tightly, and think hard about its appearance.



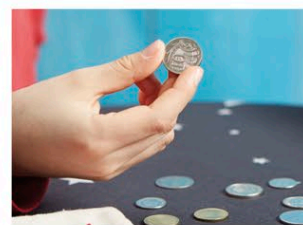
### 2 MIX THEM UP

Ask your volunteer to put the coin back in the bag, then tip out all the coins.



### 3 MISLEAD THE AUDIENCE

Pick up each coin and look at it, pretending to concentrate hard.



### 4 SHOW THE COIN

The coin that is warm to the touch is the one your volunteer picked up, of course!

## THE MAGIC STRING

This trick uses the effect of restoration to appear to make a cut piece of string whole again. You will need a short length and a longer length of string and scissors.



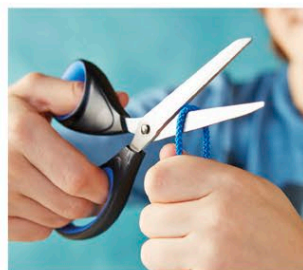
### 1 SHORT STRING

Take the short length of string and hide it in the palm of your left hand.



### 2 LONG STRING

Place the longer length in your left hand below the shorter, so the shorter loop sticks out.



### 3 CUT THE STRING

Ask a volunteer to cut through the loop that's sticking out.



### 4 HIDE IT

Secretly tuck the cut pieces into the palm of your hand and pull out the long string.



### 5 RESTORE THE STRING

Show your audience the long string while keeping the shorter length hidden in your hand.



# Horse riding

There are many ways to enjoy riding a horse, from playing team games and jumping over obstacles to going for a quiet canter in the countryside. Learning how to look after and handle a horse safely and correctly is part of becoming a good rider.

## TACK

The equipment worn by a horse is known as tack. The bridle, which has a mouthpiece called a bit, allows the rider to control the horse's head. The saddle spreads the rider's weight evenly across the horse's back. There are many different styles of tack for different purposes.



## RIDING GEAR

A safety hat or helmet is the most important part of a rider's clothing. Boots should have a low heel to stop the feet from slipping through the stirrups. Chaps (leggings) worn over riding pants or jodhpurs protect the lower legs.

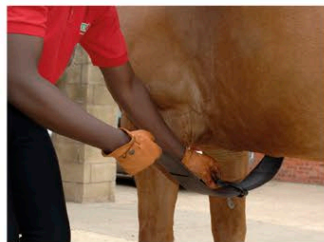


## PUTTING ON A SADDLE

It is important to know how to put on a saddle correctly. A badly positioned saddle can hurt a horse's back and be unsafe for the rider. Both before and after mounting, the rider should check that the girth (the strap that goes under the horse's belly) is tight enough.



**1 POSITION THE SADDLE**  
Place the numnah and saddle farther forward than the final position. Move both backward together.



**2 PICK UP GIRTH**  
Bring down the girth on the far side and pick up the end from the near side. Make sure it is not twisted.



**3 FASTEN BUCKLES**  
Buckle the girth to the straps on the saddle. Pull it tight but without wrinkling the horse's skin.

## GROOMING TOOLS

There are various specially designed tools for grooming horses. They include a stiff "dandy" brush and a rubber curry comb for cleaning off mud, softer brushes for removing dust and scurf, and a pick for dislodging dirt from hooves.



## FEEDING A HORSE

The natural food of horses is grass, but a hard-working horse needs more. Extra foodstuffs include hay for fiber, grains such as oats, and nutritious pellets and mixes.





## MOUNTING

For a new rider, the first challenge is getting into the saddle. Learning how to mount a horse quickly and safely takes lots of practice. The rider should always begin from the left-hand or "near" side of the horse.



**1 LIFT FOOT**  
Face the horse's rear. Hold the stirrup in the right hand and put the left foot in it.



**2 HOP**  
Hold the front of the saddle and hop around to face forward. Use the right arm for support.



**3 SPRING**  
Spring up and swing the right leg over the horse's back. Land gently in the saddle.

## DISMOUNTING

Getting off a horse feels easier than getting on. However, for safety and the horse's comfort, the correct technique must be used. The rider dismounts on the near side and should never attempt to jump off while the horse is moving.



**1 FEET OUT**  
Holding the front of the saddle, take both feet out of the stirrups and lean forward.



**2 SWING**  
Lift the right leg and swing it carefully over the horse's back.



**3 SLIDE**  
Slide or drop down the horse's side and land lightly, facing forward.

**THE HIGH-JUMP  
RECORD FOR  
A HORSE IS 8 FT  
1¼ IN (2.47 M).**



## JUMPING

Learning to jump on horseback is one of the biggest thrills for any rider. Most horses find it fun, too.

## FOUR PACES

Horses have four main natural paces, or ways of moving at different speeds. These are walk, trot, canter, and gallop. At each pace, the horse's feet touch the ground in a repeated sequence of steps.



WALK: AVERAGE SPEED 3-4 MPH (5-6.5 KPH)



TROT: AVERAGE SPEED 8-10 MPH (13-16 KPH)



CANTER: AVERAGE SPEED 10-17 MPH (16-27 KPH)



GALLOP: AVERAGE SPEED 25-30 MPH (40-48 KPH)

## HORSE SPORTS

Games and sports with horses are popular worldwide. They include racing, team games, and competitions between individual riders, such as jumping and cross-country events.



### POLO

Team game in which riders strike a ball with mallets.



### STEEPLECHASE

Race over obstacles such as fences and ditches.



### DRESSAGE

Competition to show how well a horse moves.



### EVENTING

Sport combining dressage, cross-country riding, and showjumping.



### HARNESS RACE

Racing with two-wheeled carts called sulkies.



### HORSEBALL

Team game in which riders shoot a ball into a net.



### RODEO

Contest based on traditional cowboy skills.









# History





# The first humans

Millions of years ago, a group of apes began to walk upright. They were our ancestors, the first humanlike animals on the planet. Over time, their bodies adapted to walking upright and their brains grew larger until finally they evolved into our species, *Homo sapiens*.

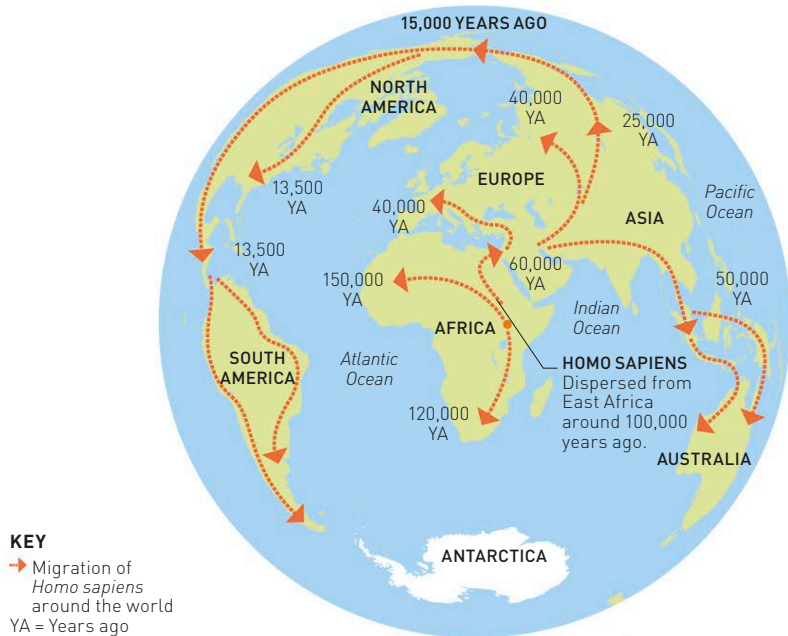
## LATE ARRIVALS

Our planet was formed just over 4.5 billion years ago. If the whole of Earth's history were squeezed into an hour, most life forms would not develop until the last 10 minutes. Humans would not appear until the very last fraction of the last second of the hour.



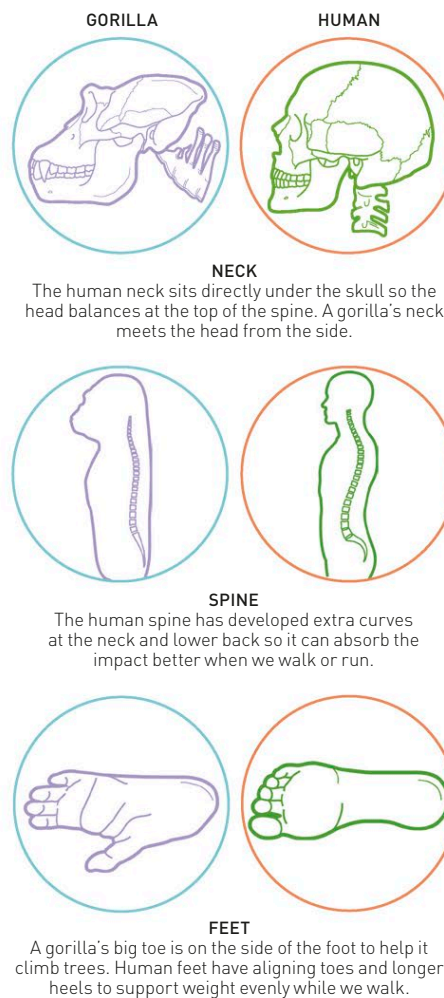
## OUT OF AFRICA

*Homo sapiens*, our species, first evolved in Africa around 300,000 years ago. About 200,000 years later, they began to move away to make new settlements until humans were living on all the world's continents except Antarctica.



## ON TWO FEET

Humans walk on two legs, unlike other primates (apes), who are either climbers or walk using all four feet. As a result of walking upright, humans' bodies have developed very differently from those of their ape relatives.



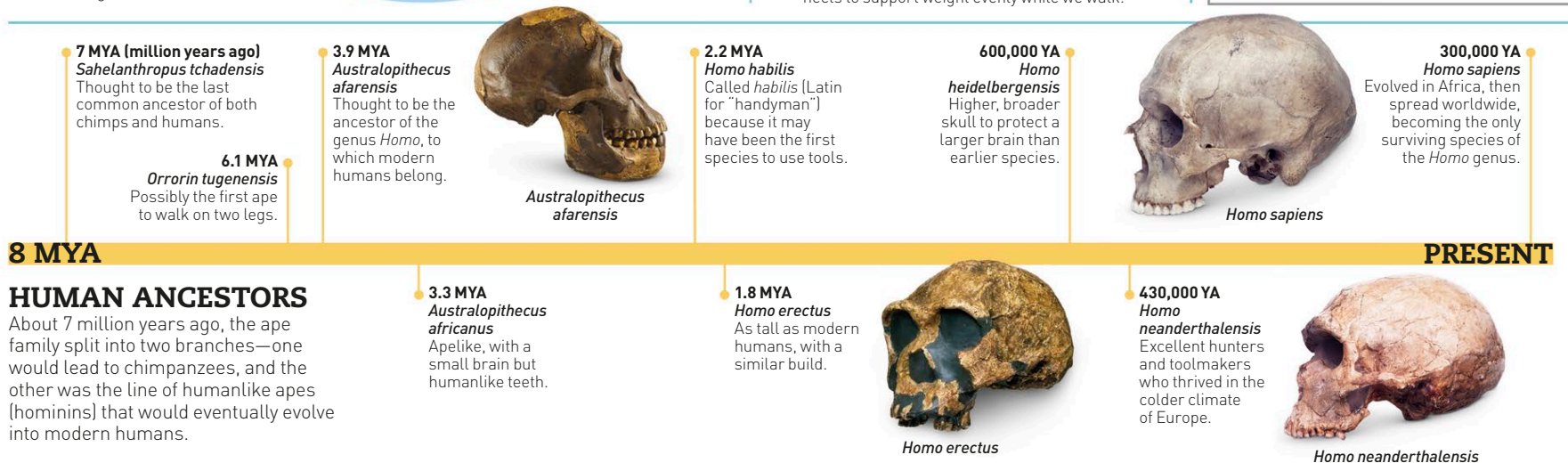
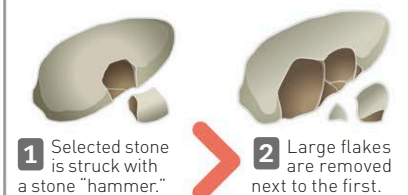
## EARLY TOOLS

Early humans learned how to make tools by striking a stone with another one to make a cutting edge. Humans began to make different tools for different tasks, such as digging, sawing, or opening nuts.



## HOW TO MAKE A HANDAXE

It took skill and experience to select a suitable stone, then chip it to make a sharp, usable tool.



## 8 MYA

## HUMAN ANCESTORS

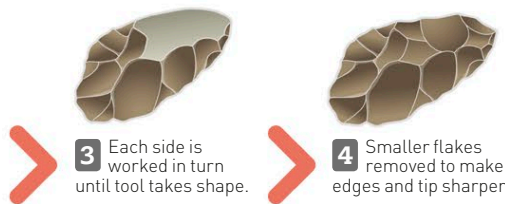
About 7 million years ago, the ape family split into two branches—one would lead to chimpanzees, and the other was the line of humanlike apes (hominins) that would eventually evolve into modern humans.

## PRESENT





**HANDAX**  
A general-purpose tool, the first to be made by humans.



**3** Each side is worked in turn until tool takes shape.

**4** Smaller flakes removed to make edges and tip sharper.

## HUNTER-GATHERERS

Early humans had to find food either by hunting animals or by gathering wild plants. They developed tools to help them, from diggers for rooting out edible plants from the soil to harpoons for spearing fish.



ADZE (WOOD CUTTER)

BARBED HARPOON

FLINT ARROWHEADS

SPEAR TIP

REINDEER ANTLER SPEAR

DIGGING TOOL

## FIRST FARMERS

Gradually, humans learned that instead of moving around constantly looking for food, they could stay in one place and become farmers, growing crops and raising animals to eat. Farming changed forever the way humans lived.



PART OF A BREAD OVEN

IRON SICKLE

BRONZE SICKLE

STONE SICKLE  
For cutting crops.

STONE AX  
Used to clear trees before planting crops.

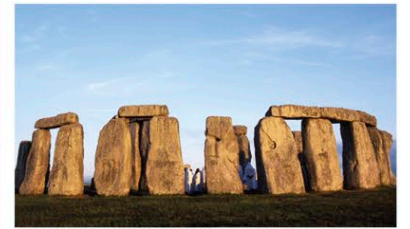
TYPICAL BREAD

REPLICA OF STONE QUERN  
For grinding wheat to make bread.

## ANCIENT MONUMENTS

Many prehistoric sites still exist around the world. It is difficult to know exactly what some sites were used for, as they were built long before humans started keeping written records.

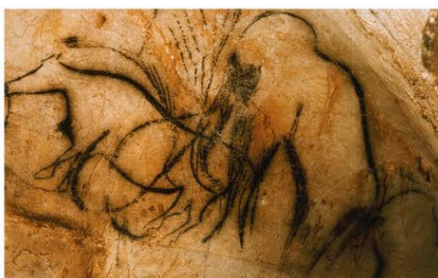
- STONEHENGE, ENGLAND**  
A ring of gigantic stones, built about 5,000 years ago, as part of an ancient burial ground or as a place of worship.
- CARNAC, FRANCE**  
A small area of three fields containing more than 3,000 granite megaliths (standing stones) arranged in rows.
- Ġgantija Temples, MALTA**  
Two remarkably well preserved structures, built from limestone during the Neolithic Age (c.3600–3200 BCE).
- GÖBEKLI TEPE, TURKEY**  
The world's oldest known temple, built about 11,000 years ago near the ancient city of Şanlıurfa.
- NEWGRANGE, IRELAND**  
A Neolithic burial site featuring a huge, circular mound containing a tomb and surrounded by 97 highly decorated stones.



STONE CIRCLE AT STONEHENGE

## ART

Early humans created the world's first art. They used paint made from colored minerals in rocks to draw animals on the walls of their caves. They also carved animals or human figures out of rocks and bones.



CAVE PAINTING, FRANCE



HORSE HEAD CARVING



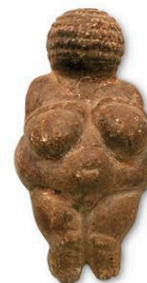
CARVED BONE SHOWING BISON HUNT



MAMMOTH CARVING



PAINTED POT, ROMANIA



CARVED FEMALE FIGURES, OFTEN CALLED "VENUS FIGURINES"



MARBLE FIGURE, GREECE



## BETWEEN TWO RIVERS

The region of Mesopotamia lay in the fertile flood plain between the rivers Tigris and Euphrates. The name Mesopotamia means "between two rivers" in Greek.

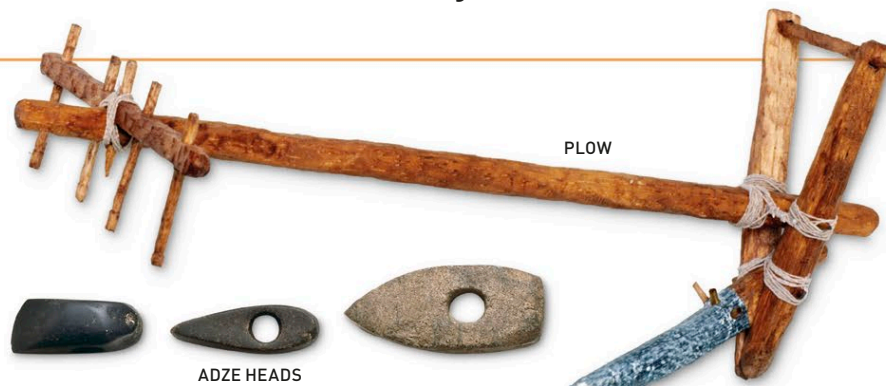


# Early civilizations

The world's earliest civilization emerged more than 6,000 years ago in an area of Mesopotamia (modern-day Iraq) called Sumer. For the first time, people lived and worked together in cities, governed by a king who made laws that everyone had to follow.

## FROM HUNTING TO FARMING

When roaming hunter-gatherers started planting crops, they began to settle in one place and made farming tools instead of hunting weapons. Villages, towns, and eventually cities were established.



## GREAT CITIES

As the Sumerian settlements grew, they formed cities, some of which became large and powerful city-states. Each city-state had its own leader, who ruled on behalf of the city's god.

### URUK

Uruk was one of the first major cities in the world. Its most famous king was Gilgamesh, who was also the hero of one of the world's first known poems, *The Epic of Gilgamesh*.

### AKKAD

This city was the center of the world's first empire. In 2330 BCE, the Akkadians conquered many of their neighboring city-states and took control of Mesopotamia.

### BABYLON

The capital of the Babylonian Empire. At its peak around 550 BCE, the city's population was about 200,000.

### NIMRUD

For a time, Nimrud was the capital of the Assyrian Empire. The magnificent palace of King Shalmaneser III covered over 538,196 sq ft (50,000 sq m) and had more than 200 rooms.

### UR

This was the site of a huge ziggurat (pyramid-shaped temple) and the Royal Tombs, which contained some of the finest Mesopotamian art ever discovered.

**THE SUMERIANS CREATED THE FIRST CALENDAR BY DIVIDING THE YEAR INTO 12, BASED ON THE MOON'S MOVEMENTS.**

## BABYLON'S WONDERS

In 580 BCE, King Nebuchadnezzar of Babylon built a number of huge buildings in his capital, turning Babylon into the most magnificent city in the ancient world.

### ISHTAR GATE

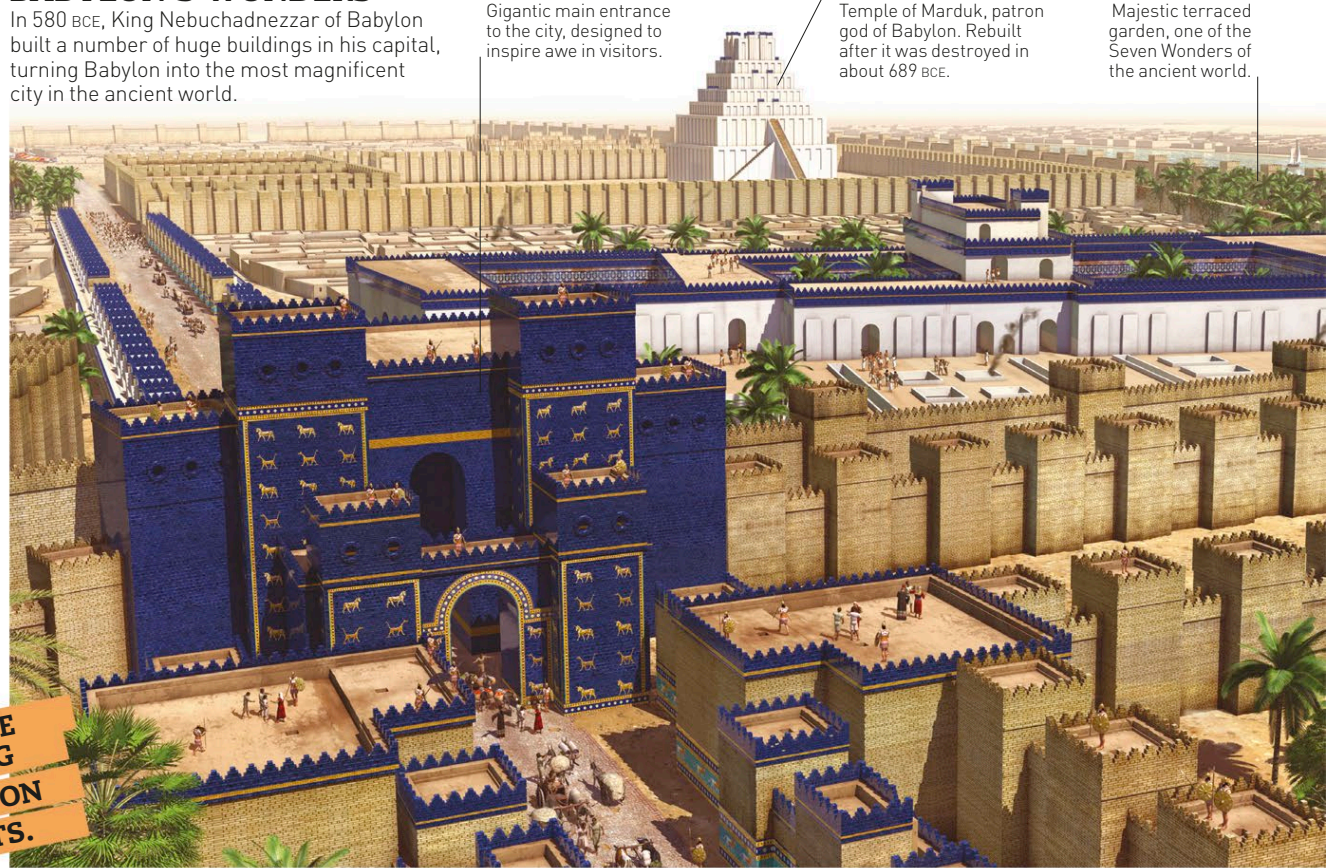
Gigantic main entrance to the city, designed to inspire awe in visitors.

### ETEMENANKI ZIGGURAT

Temple of Marduk, patron god of Babylon. Rebuilt after it was destroyed in about 689 BCE.

### HANGING GARDENS

Majestic terraced garden, one of the Seven Wonders of the ancient world.



**7000 BCE**  
People start to grow crops on a large scale in Mesopotamia.

**5300 BCE**  
Large villages and small towns appear in Sumer.



**3300 BCE**  
Sumerians invent a form of writing.

**3000 BCE**  
Greece: early civilizations appear.

**2334 BCE**  
King Sargon of Akkad conquers Sumer, creating the world's first empire.



**c.2100 BCE**  
The great ziggurat (temple) built at Ur.



**539 BCE**  
Mesopotamia becomes part of Persia.

**7000 BCE**

## CRADLE OF CIVILIZATION

The plain between the two great rivers of Mesopotamia was very fertile, with rich soil, a warm climate, reliable rainfall, and a wide range of plants and animals. It was the perfect place for early humans to put away their hunting spears and settle down in farming communities instead.

**4000 BCE**  
The Sumerians build several cities in southern Mesopotamia.

**3100 BCE**  
Egypt: the pharaohs unite Egypt into a single state.

**2800 BCE**  
Peru: earliest civilization in the Americas.

**2600 BCE**  
Northwest India: Indus civilization reaches its peak.

**2200 BCE**  
China: first kingdom established.

**c. 2500–2000 BCE**  
Huge cemetery complex built at Ur.

**1300–1200 BCE**  
Assyrians conquer much of Mesopotamia.

**753 BCE**  
City of Rome founded.

Ornament from Royal Graves, Ur



Sedu (Assyrian god)





## CODE OF LAW

King Hammurabi of Babylon laid down a set of strict rules that is one of the oldest recorded codes of law in the world.



**NO RUNAWAYS**  
If you helped a slave to run away, you would be put to death.



**HANDS OFF!**  
If a son hit his father, his hands would be chopped off.



**TEMPLE OF DOOM**  
If you stole from a temple, you would be sentenced to death.

## INVENTION OF THE WHEEL

Nobody knows exactly when the wheel was invented, but by 3500 BCE, it was being used horizontally to make clay pots in Sumer. About 300 years later, wheels came into use vertically on chariots.

RECONSTRUCTION OF AN EARLY WHEEL

## DAILY LIFE

Cups, bowls, and vases for everyday use were made of clay, but richer homes used vessels made of stone or metal. Silver was imported from nearby Anatolia to make luxury tableware.



BRONZE BULL'S HEAD



SILVER BOWL



STONE POT



ALABASTER VASE



SOAPSTONE TUMBLER



SCORPION DESIGN CUP



CYLINDER SEAL (LEFT) WITH IMPRESSION (RIGHT) OF GODS FIGHTING LIONS



## GODS AND RELIGION

The Sumerians worshipped many gods, but the most important were the guardians of each city-state. Gods were worshipped in huge temples called ziggurats, which dominated the flat landscape for miles.



**UTU**  
God of the Sun and of justice.



**ENLIL**  
God of wind and storms.

## EARLY WRITING

The first known form of writing comes from Sumer. The first symbols were recognizable pictures of objects (pictograms), but these developed into a system of simpler wedge shapes, called cuneiform.

PICTOGRAPH c.3100 BCE	CUNEIFORM c.700 BCE
WATER	
HAND	
BARLEY	
BREAD	
DAY	

## WEALTH AND POWER

Much of the Mesopotamian art and crafts that survive today was found in a royal cemetery in the city of Ur. These treasures tell us about the skill and artistry of the craftsmen who made them, as well as the wealth of the people buried with their valuable possessions.



QUEEN PUABI'S FINERY



SILVER HAIR COMB

FLY MOTIF NECKLACE



BEAD BELT

"RAM IN A THICKET"  
Gold, silver, shell, and lapis sculpture.

## WAR AND WARRIORS

The different city-states of Mesopotamia competed with one another for land and vital resources, such as water, and this often led to fighting and war. Warring cities began to organize trained groups of men to fight—the world's first armies. Soldiers wore bronze or leather helmets and carried large shields and bronze spears or bows and arrows.

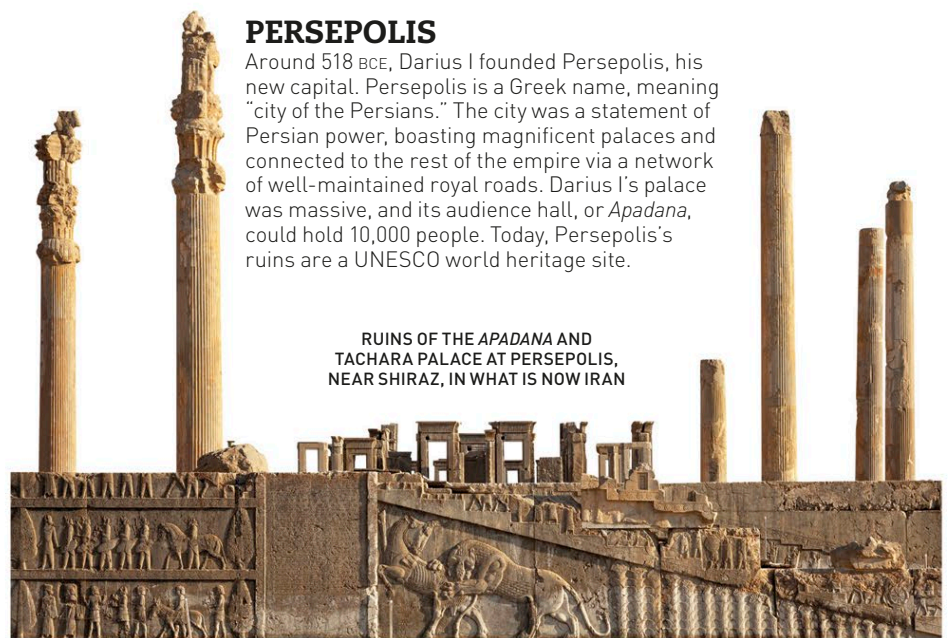


ARCHERS ON A CHARIOT



# Ancient Persia

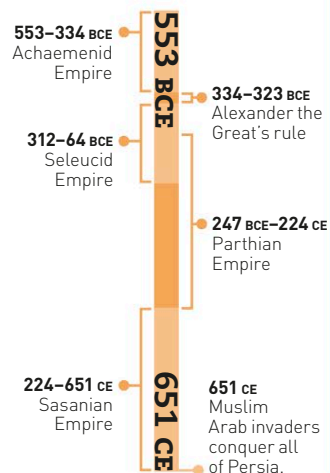
In 553 BCE, King Cyrus II of Persis, a state in the kingdom of Media (in modern-day Iran), overthrew Media's ruler, Astyages. With Persis at its center, the Achaemenid Empire was formed, covering what later became known as Persia. This was the world's first major empire. Over the next thousand years, many empires centered in Persia would emerge.



RUINS OF THE APADANA AND TACHARA PALACE AT PERSEPOLIS, NEAR SHIRAZ, IN WHAT IS NOW IRAN

## TIMELINE

Persia was ruled by many dynasties before its conquest by the Muslim Arabs.



## ACHAEMENID EXPANSION

After defeating Astyages in 553 BCE, Cyrus II (r. 559–530 BCE) brought the kingdoms of Media, Babylon, Egypt, and Lydia under his rule. The Achaemenid Empire reached its greatest extent under Darius I (r. 522–486 BCE). It fell in 334 BCE, when Alexander the Great of Macedon defeated Darius III.



**1 STATE OF PERSIS**  
In the 6th century BCE, the modern-day region of Iran was inhabited by the Medes and Persians. Persis was a part of the Median Kingdom. The state was ruled by a Persian king, who was the subject of the king of Media.

## KEY

- Kingdom of Persis
- Kingdom of Media
- Achaemenid Empire at its peak
- Royal Road, built under Darius I, ran from Sardis to Susa, a distance of 1,677 miles (2,799 km).



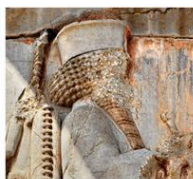
**2 ACHAEMENID EMPIRE**  
Cyrus II united neighboring kingdoms under one rule, but the Achaemenid Empire flourished most under Darius I. At its peak, it spanned three continents, stretching from Egypt and Greece to India.

## POWERFUL RULERS

Persian empires rose and fell under rulers from different dynasties. They were mostly tolerant of the varied religious beliefs and practices of their subjects.



**CYRUS II**  
Founder of the Achaemenid Empire. He came to be called Cyrus the Great.



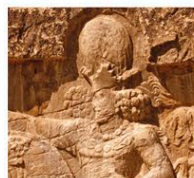
**DARIUS I**  
He divided the empire into *satrapies* (provinces) in order to govern it better.



**SELEUCUS I Nicator**  
A general under Alexander the Great, he founded the Seleucid Empire in 312 BCE.



**MITHRIDATES II**  
This Parthian king broadened his empire and gained control of the Silk Road trade route.



**SHAPUR I**  
Expanding the Sasanian Empire, Shapur I even conquered a few Roman provinces.

## THE IMMORTALS

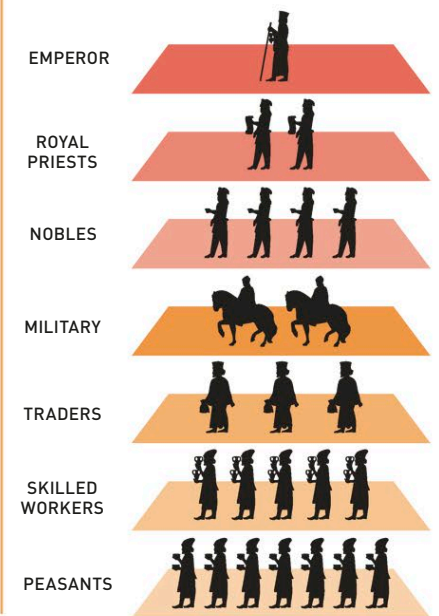
Darius I had an elite force of 10,000 soldiers called the Immortals. Any fallen soldiers would be replaced quickly, maintaining their number at 10,000.



MOSAIC DEPICTS THE IMMORTALS

## PERSIAN SOCIETY

The emperor was supreme. Then came the royal priests, followed by nobles who governed the provinces, helping the emperor rule. The military came next, one rung above the traders and skilled workers.





## DAILY LIFE

Subjects under Persian rule paid taxes and abided by the laws of the land. They were free to follow their way of life. The royals and nobles lived extravagantly, wearing fine garments and jewelry. Farmers tilled small plots of land, while craftspeople were skilled at metalworking, carving, and brick-making.



**BOWL**  
Achaemenid,  
c.6th–5th century BCE



**SILVER COIN**  
Seleucid,  
c.136–135 BCE



**GOLD CLOTHING ORNAMENT**  
Achaemenid,  
c.6th–4th century BCE



**JAR**  
Sasanian,  
c.6th–7th century CE



**EARRING**  
Parthian,  
c.1st–2nd century CE



**HORN-SHAPED VESSEL**  
Achaemenid,  
c.5th century BCE



**PLATE**  
Sasanian,  
c.5th–6th century CE



**SILVER VESSEL**  
Sasanian,  
c.6th–7th century CE



**FORK**  
Sasanian,  
c.6th–7th century CE



**CHESS PIECE**  
Sasanian,  
c.3rd–7th century CE

The Egyptian god  
Bes is shown in  
this necklace.



**NECKLACE**  
Achaemenid,  
c.6th–4th century BCE



**PLAQUE WORN  
ON LEATHER BELT**  
Achaemenid,  
c.6th–4th century BCE



**GLAZED BRICK**  
Achaemenid,  
c.521–360 BCE

## ZOROASTRIANISM

The main religion of the Persians was based on the teachings of the philosopher Zoroaster. It taught that all good comes from the supreme god, Ahura Mazda, who was the creator of the world. With the coming of the Muslim Arabs, Islam replaced Zoroastrianism as the main religion in Persia.

**ZOROASTRIANISM WAS  
POSSIBLY THE FIRST  
RELIGION TO CENTER  
AROUND A SINGLE, SUPREME GOD.**



**THE FARAVAHAR, SYMBOL  
OF ZOROASTRIANISM**

Three rows of feathers stand for  
good thoughts, words, and deeds.

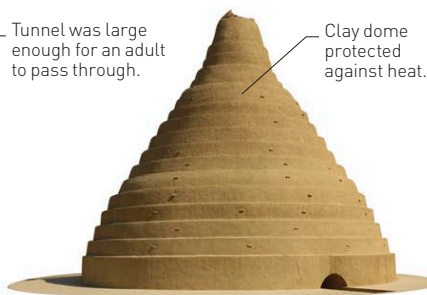
Bearded figure is  
said to represent  
the human soul.

## INVALUABLE CONTRIBUTIONS

Cyrus II was the first ruler to establish a set of rights for the people. But Persia made great advances in science and technology, as well as society. Roads and canals were developed, helping soldiers and traders move quickly. Educational academies, postal systems, and highways were built. Landscaped gardens and windmills were developed.



**QANAT (IRRIGATION SYSTEM)**  
The underground *qanat* tunnels brought water from freshwater sources to the farms.



**YAKHCHAL (EARLY REFRIGERATOR)**  
This dome with an underground pit stayed so cold that it was used to store ice, and later, food.

## PERSIAN WOMEN

Women in ancient Persia had the same rights as men. They were educated and could own property. Many were leaders.

- **ATUSA SHAHBANU (550–475 BCE)**  
Atusa was Darius I's wife and the mother of Xerxes I. She was a successful businesswoman. She was in charge of palace affairs and had a say in the royal military as well.
- **IRDABAMA (520–470 BCE)**  
One of the wealthiest and most successful businesswomen in ancient Persia, Irdabama was a noblewoman who mainly traded in wine and grain. She was the employer of a few hundred laborers.
- **GRAND ADMIRAL ARTEMISIA (500–450 BCE)**  
An admiral in Xerxes I's navy, Artemisia showed great courage in the Battle of Salamis against Greece in 480 BCE. She had keen military intelligence and warned Xerxes I against this sea battle, which the Persians eventually lost.
- **SURA (c.3RD CENTURY CE)**  
Sura was the daughter of the last Parthian emperor Artabanus V and a general in his army. When another general revolted against Artabanus, Sura fought the rebel until she died on the battlefield.
- **AZADOKHT SHAHBANU (c.240–270 CE)**  
Azadokht Shahbanu was the wife of the Sasanian ruler Shapur I. Together they established the Academy of Gundishapur, an institute of higher learning. Scholars believe she brought Greek physicians to teach there.
- **QUEEN BORAN (c.590–632 CE)**  
Purandokht or Queen Boran was the first empress of the Sasanian Empire. She took control of the empire after her father was killed by her brother.



## FAMOUS PHAROHS

The kings and queens of ancient Egypt did not call themselves pharaohs, but that is the name we use today. They wielded an enormous amount of power. They made every law, held the title of highest priest in the land, and were worshipped as though they were gods.



**KHUFU**  
Reigned c.2589–2566 BCE  
Builder of the Great Pyramid at Giza.



**KHAFRA**  
Reigned c.2558–2532 BCE  
Khufu's son. His face may be the model for the Sphinx.



**HATSHEPSUT**  
Reigned c.1478–1458 BCE  
One of only a few female pharaohs.

**TUTANKHAMUN**  
Reigned c.1336–1327 BCE  
The famous boy-king came to the throne when he was just 9 years old. His fabulous gold mask was found in his tomb.



**TUTANKHAMUN**  
Reigned c.1336–1327 BCE  
The famous boy-king came to the throne when he was just 9 years old. His fabulous gold mask was found in his tomb.



**AMENHOTEP III**  
Reigned c.1390–1353 BCE  
Helped make Egypt prosperous.



**AKHENATEN**  
Reigned c.1348–1338 BCE  
Rejected traditional Egyptian gods.



**RAMESES II**  
Reigned c.1279–1213 BCE  
Ordered many huge building projects.



**CLEOPATRA VII**  
Reigned 51–30 BCE  
Last pharaoh. Killed herself after defeat by Rome.

# Ancient Egypt

More than 5,000 years ago, two regions of the Nile river valley—Upper and Lower Egypt—were united under a common ruler. This was the birth of the empire of pharaohs and pyramids, one of the greatest powers of the ancient world.

## PYRAMIDS

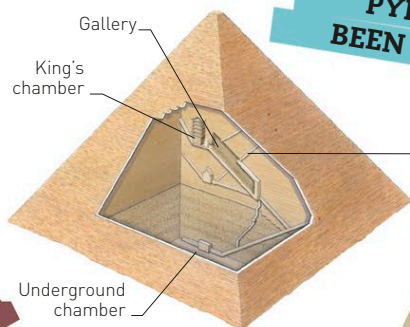
When an Egyptian ruler died, the body was buried inside a massive pyramid. Taking up to 30 years to build, pyramids went through various changes of design over the centuries. People who were not royal were buried in simpler tombs.



**MASTABA**  
Boxlike brick or stone grave.



**STEPPED PYRAMID**  
An early model, built in layers.



**SMOOTH-SIDED PYRAMID**  
The classic structure, cased with blocks of limestone.

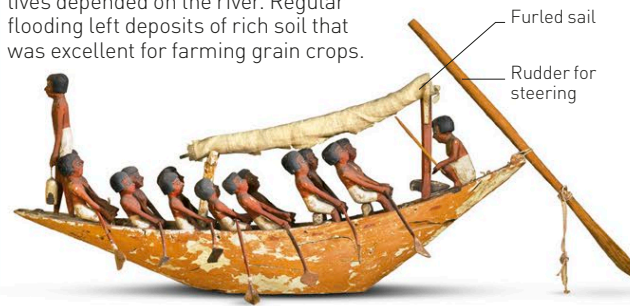


**"BENT" PYRAMID**  
Midway between stepped and smooth.

NEARLY 120  
ANCIENT EGYPTIAN  
PYRAMIDS HAVE  
BEEN DISCOVERED.

## THE RIVER NILE

Living along both banks of the Nile, the Egyptians occupied a rare fertile strip of land amid vast areas of desert. Their lives depended on the river. Regular flooding left deposits of rich soil that was excellent for farming grain crops.



**ROWBOAT**  
Wooden boats were used for transport and fishing.

Furled sail  
Rudder for steering

## MUMMY-MAKING

The ancient Egyptians believed that a dead person's soul needed its body in the afterlife. Mummifying, which only the rich could afford, was an elaborate way of preserving a body to stop it from crumbling away.



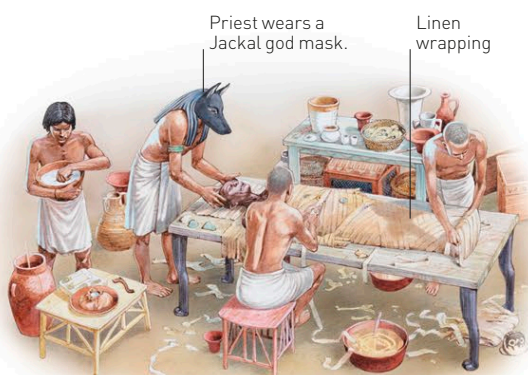
Canopic jar is a pot topped with a god's head.



**2 WASHING**  
Once dry, the body was washed in wine and rubbed with scents and oils.



**3 PROTECTING**  
Protective amulets, like this symbolic pillar, were placed with the body.



**4 WRAPPING**  
Strips of fine linen were wrapped around the entire body and coated with resin.

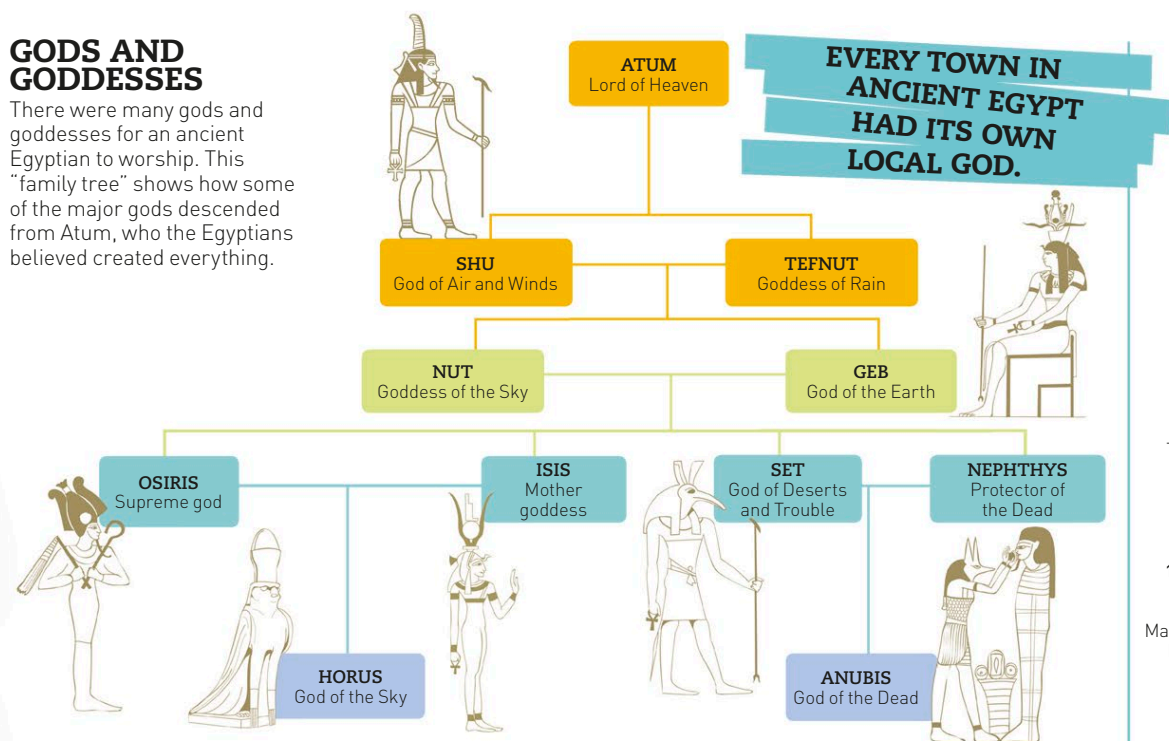


**5 BURIAL**  
The mummy was put in an inner, body-shaped case and then an outer coffin, both decorated with pictures and symbols.



## GODS AND GODDESSES

There were many gods and goddesses for an ancient Egyptian to worship. This "family tree" shows how some of the major gods descended from Atum, who the Egyptians believed created everything.



## HIEROGLYPHS

Ancient Egyptian writing used pictures or signs called hieroglyphs. Each one could mean a sound, a word, or an action. This table shows some hieroglyphs and how they might be pronounced today. Instead of writing on paper, the Egyptians used flattened sheets of a type of reed called papyrus.

a	a	b	kh	h	tj	d	a/i
g	h	kh	j	k	m	n	w/u
p	k	r	sh	s	t	f	s

## JEWELRY

The ancient Egyptians prized jewelry. Rings, necklaces, and amulets in the form of sacred symbols were popular. Jewelry worn by rich people was often made of gold and valuable stones.



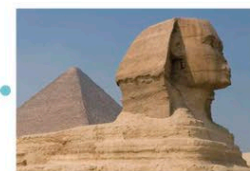
## HISTORY OF ANCIENT EGYPT

The ancient Egyptian civilization lasted for more than 3,000 years, with hundreds of different rulers, both good and bad. Historians have divided up this very long timespan into periods, kingdoms, and major dynasties (ruling families).

### EARLY DYNASTIC PERIOD

c.3100-2686 BCE  
Organized government under the rule of the pharaohs begins. People start to use hieroglyphs.

3000 BCE



The Sphinx at Giza

### OLD KINGDOM

2686-2200 BCE  
The great pyramids and the Sphinx are built at Giza.



Slab for mixing ointment, made around 2000 BCE

### 1ST INTERMEDIATE PERIOD

2200-2055 BCE  
Many power struggles between dynasties.

### MIDDLE KINGDOM

2040-1650 BCE  
Life is more settled. Improved irrigation produces better crops.



Bead collar

### 2ND INTERMEDIATE PERIOD

1674-1550 BCE  
More unrest, with wars and invasions.



Arrowheads

### NEW KINGDOM

1550-1069 BCE  
Egypt conquers many lands. Famous pharaohs include Tutankhamun.



Statuette of slave girl

### 3RD INTERMEDIATE PERIOD

1069-664 BCE  
Assyrians conquer Egypt.

### LATE PERIOD

664-332 BCE  
Time of much temple building and animal mummifying.



Bronze statue, which may have held a cat mummy

### PTOLEMAIC DYNASTY

332-30 BCE  
Cleopatra VII, the last pharaoh, dies. Rome conquers Egypt.

30 BCE



Painted mummy case, portraying the dead person

Scenes from the Underworld

Spread wings were a common decoration.

Traditional sacred symbols of cross and pillar



## TIMELINE

The ancient Greek civilization existed for 2,500 years. The Greeks built huge city-states, formed new colonies, and fought many battles before they were finally conquered by the Romans.

**2200–1450 BCE**  
Height of Minoan palace culture in Crete.



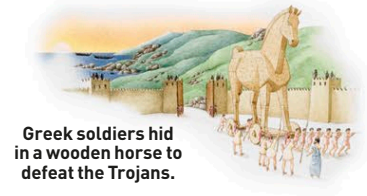
Model of a Minoan house

**1450 BCE**  
Mycenaeans invade Crete and occupy the Minoan palaces. They also build their own palace settlements in the Peloponnese region.



Fortified palace of Mycenae

**1350 BCE**  
At the peak of the Mycenaean period, the city of Mycenae has a population of around 10,000.



Greek soldiers hid in a wooden horse to defeat the Trojans.

**1184 BCE**  
According to Homer, Greece defeats Troy in a war that has lasted more than 10 years.

## 2500 BCE

**MINOAN PERIOD**  
2500–1450 BCE

Minoan civilization flourishes in Crete. The Minoans are clever traders and build large palace complexes, but these are destroyed by invaders.

**MYCENAEAN PERIOD**  
1600–1200 BCE

The Mycenaeans build fortified palaces. Armed with bronze weapons, they expand into Crete, but their cities fall to new invaders from the north.

**DARK AGES**  
1200–800 BCE

The Mycenaean culture collapses around 1200 BCE, and Greece enters a dark age. Settlements become smaller, and there are no written records.

# Ancient Greece

The Greeks were one of the most advanced civilizations in the ancient world, inventing politics, philosophy, theater, athletics, and the study of history. Their stories and plays still exist today, along with the remains of beautiful temples and buildings.



## CITY-STATES

For most of its history, ancient Greece was divided into city-states. Each city ruled the villages and farmlands around it with their own system of government and chose one god as a special protector.

### WARRING STATES

The city-states of Athens and Sparta were bitter rivals and fought several wars against each other.

**THE CITY-STATE OF ATHENS WAS 20 TIMES LARGER THAN THE SMALLEST GREEK COMMUNITIES.**

## DAILY LIFE

Farmers and fishermen provided food, while in the city, traders sold leather goods, pots, weapons, and jewelry. Well-born women ran the household, helped by slaves.



MODELS DRESSED AS ANCIENT GREEKS



SILVER ATHENIAN COIN



COIN FROM KNOSSOS



GOLD ALEXANDRIAN COIN



FISH PLATE



REPLICA OF A GREEK PENDANT



GOLD EARRING



SMALL POT FOR OIL OR PERFUME



WINE JUG



CLASSICAL OIL CONTAINER



SANDAL-SHAPED PERFUME BOTTLE



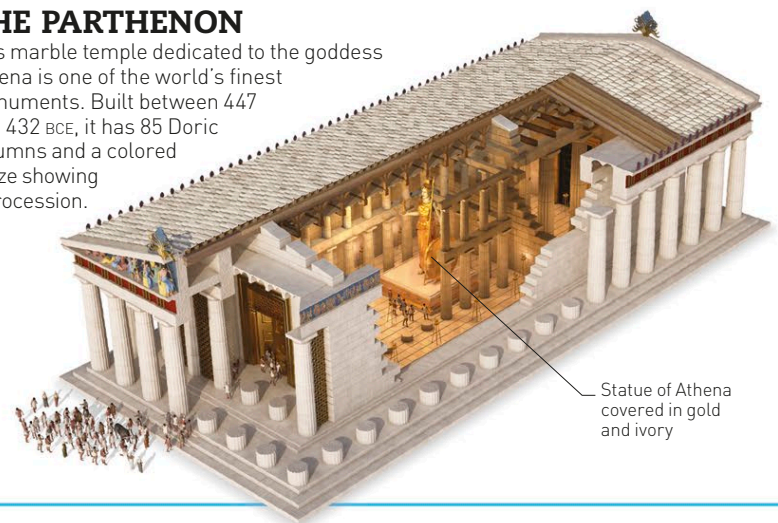
POWDER BOX



EARTHENWARE COOKING STOVE

## THE PARTHENON

This marble temple dedicated to the goddess Athena is one of the world's finest monuments. Built between 447 and 432 BCE, it has 85 Doric columns and a colored frieze showing a procession.



Statue of Athena covered in gold and ivory

## OLYMPIC GAMES

The Olympic Games were held in honor of the god Zeus. They took place every fourth year from 776 BCE at a site called Olympia.



**DAY 1**  
On the first day of the games, competitors and judges swore an oath to compete fairly, and boys took part in running and boxing contests.



**DAY 2**  
The second day was for chariot and horse races and the pentathlon—long jump, discus, javelin, running, and wrestling.



**DAY 3**  
On the third day, 100 oxen were sacrificed to Zeus. Running races included the 200-meter "stade" race—the oldest contest in the games.



**DAY 4**  
Wrestling and boxing filled the fourth day. Pankration was a kind of wrestling in which kicking and strangling were allowed.



**DAY 5**  
On the final day, the winning athletes went to the Temple of Zeus to be crowned with olive wreaths.



800–775 BCE

The Greeks create new colonies in the eastern Mediterranean and southern Italy.



Greek trireme

750–700 BCE

The first great works of Greek literature are composed by Homer—*The Iliad* and *The Odyssey*.



Oil lamp decorated with images from *The Odyssey*

620–510 BCE

Many Greek city-states are ruled by tyrants who hold absolute power.

490 BCE

The Persian King Darius I invades Greece but is defeated by the Athenians at the Battle of Marathon.

431–404 BCE

Sparta and Athens fight the Peloponnesian War, with great loss of life on both sides.

371 BCE

General Epaminondas defeats the Spartans at Leuctra. Thebes becomes Greece's most powerful city-state.

338 BCE

Philip, King of Macedon, defeats Athens and Thebes at Chaeronea and conquers most of Greece.

334–323 BCE

Philip's son Alexander the Great invades and conquers the Persian Empire.

31 BCE

Rome captures all the Greek colonies, ending with Egypt in 31 BCE.



Alexander the Great on his horse Bucephalus

31 BCE

#### ARCHAIC PERIOD

800–500 BCE

By around 800 BCE, Greece begins to recover. City-states hold political power, backed by armies of citizen-soldiers. The Greeks begin to found colonies abroad.

#### CLASSICAL PERIOD

500–323 BCE

During the classical period, literature, art, politics, athletics, and theater flourish, especially around the main center, Athens.

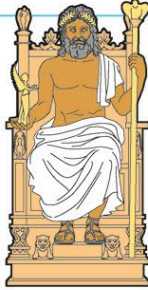
#### HELLENISTIC PERIOD

323–31 BCE

The Hellenistic Age begins with Alexander the Great, in 323 BCE, and Greek culture spreads throughout the Middle East.

## GODS

The Greeks had many gods, ruled over by Zeus and his wife Hera. Festivals and sacrifices were important in the daily religious life of the city-states. Women rarely had any role in public life, but a few were priestesses who played an important part in rituals and celebrations.



ZEUS

## GREEK ALPHABET

The ancient Greeks had an alphabet of 24 letters—the first to have vowels as well as consonants. The word “alphabet” comes from the first two letters, alpha and beta.

Α	Β	Γ	Δ	Ε	Ζ
ALPHA	BETA	GAMMA	DELTA	EPSILON	ZETA
Η	Θ	Ι	Κ	Λ	Μ
ETA	THETA	IOTA	KAPPA	LAMBDA	MU
Ν	Ξ	Ο	Π	Ρ	Σ
NU	XI	OMICRON	PI	RHO	SIGMA
Τ	Υ	Φ	Χ	Ψ	Ω
TAU	UPSILON	PHI	CHI	PSI	OMEGA

## WAR AND ARMOR

The main fighting force of the Greek city-states were hoplites, heavily armored foot soldiers who carried a large round shield, or *hoplon*. They fought in phalanxes (shield walls) several rows deep to protect the soldiers.



HOPLITE BODY ARMOR

WEAPON CALLED KOPIS IN SHEATH



XIPHOS, ANCIENT GREEK SWORD



WARRIOR SHIELD (HOPLON)



SOLDIER'S AX AND SANDAL



ANCIENT GREEK ARMY HELMET

## GREAT THINKERS

Around 600 BCE, Greek thinkers began to use logic instead of religion to think about the world and how it works. Their ideas were the beginning of philosophy.

### ○ PYTHAGORAS (c.570–495 BCE)

A theorem for working out the length of the sides of a right-angled triangle still bears the name of Pythagoras. He also believed that numbers had mystical powers.

### ○ SOCRATES (469–399 BCE)

This Athenian philosopher taught his students to question the power of Athens' ruling classes. He was put to death for his views.

### ○ PLATO (427–347 BCE)

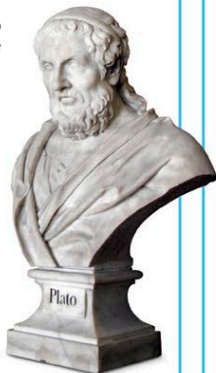
Socrates' pupil Plato believed people should live their lives trying to reach absolute moral goodness. His ideas are still studied today.

### ○ ARISTOTLE (384–322 BCE)

This pupil of Plato founded a school called the Lyceum. He wrote many important works about biology, zoology, physics, logic, and politics.

### ○ ARCHIMEDES (c.287–212 BCE)

This engineer and mathematician invented a screw pump that drew up water and wrote a theorem to calculate the area of a circle.



PLATO



# Greek myths

Some of the oldest and best-known stories in the world are the myths of ancient Greece. They are tales of gods and heroes, great loves, wars, daring adventures, and fabulous beasts. Some of them are told here. To the Greeks of long ago, the myths and the gods who appeared in them were very real.

## THE GREEK GODS

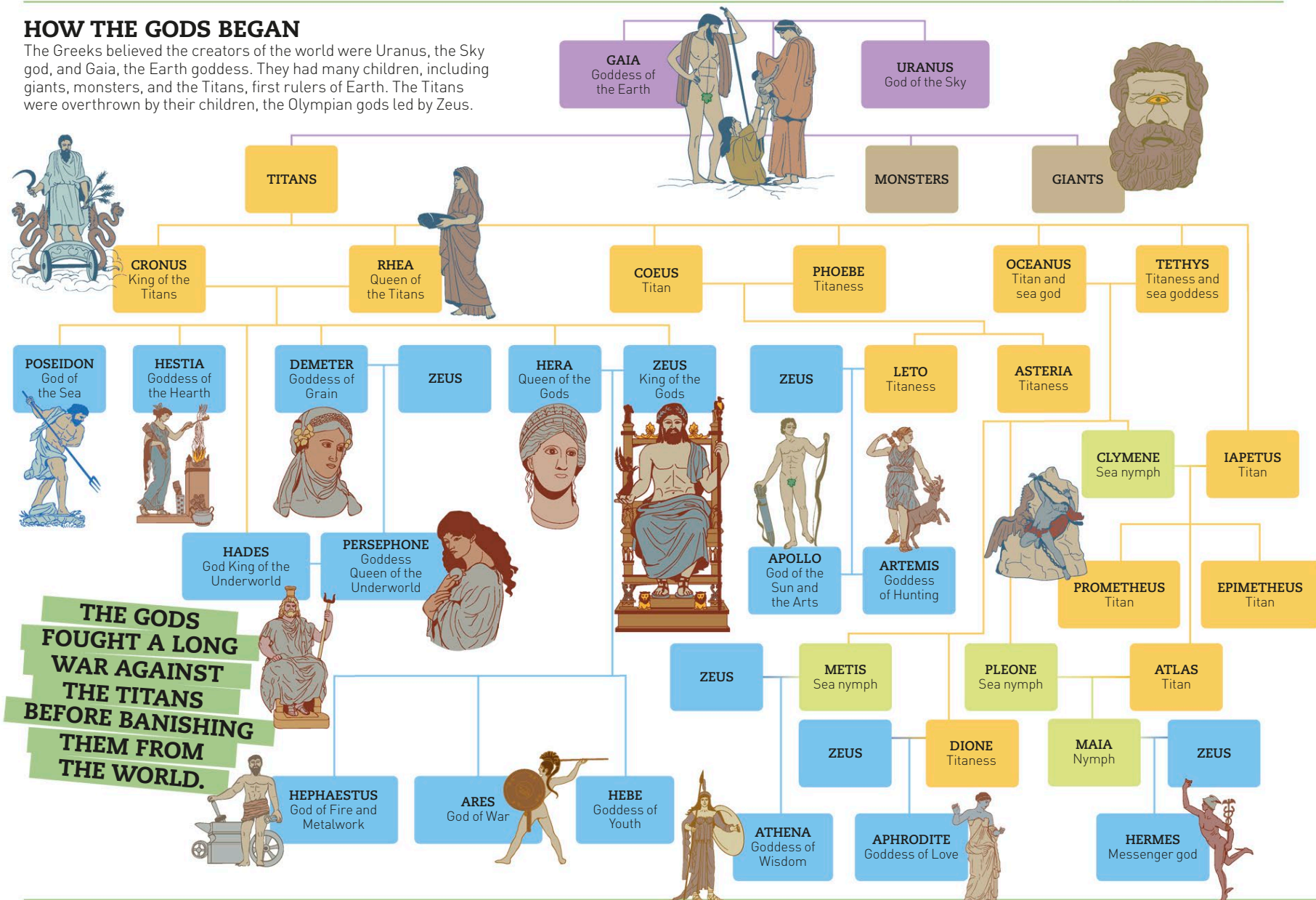
In Greek mythology, the gods were powerful supernatural beings who could make anything and everything happen. There were 12 major gods and goddesses, of whom Zeus was king. The gods lived in their palaces on the top of snow-capped Mount Olympus, the highest mountain in Greece.

MOUNT OLYMPUS



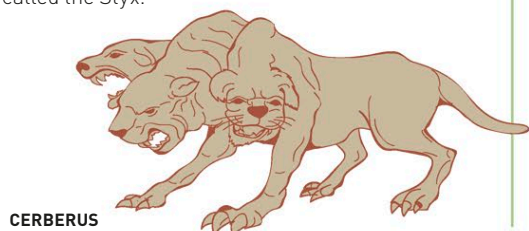
## HOW THE GODS BEGAN

The Greeks believed the creators of the world were Uranus, the Sky god, and Gaia, the Earth goddess. They had many children, including giants, monsters, and the Titans, first rulers of Earth. The Titans were overthrown by their children, the Olympian gods led by Zeus.



## THE UNDERWORLD

In the myths of ancient Greece, the realm of the dead was known as the Underworld, a shadowy kingdom ruled by the god Hades. There were demons and monsters there. One of the most frightening was the three-headed dog Cerberus, who stood guard at the gates. The souls of those who had died were ferried to the Underworld in a boat across an ink-black river called the Styx.



CERBERUS

## PUNISHMENTS FROM THE GODS

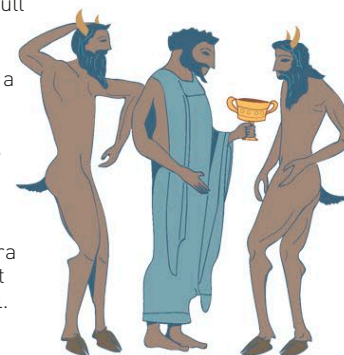
Many people were condemned to perpetual punishment in the Underworld because they had offended the gods. For example, Sisyphus, who had tried to become immortal, was made to push a huge rock uphill forever. Tantalus, who insulted the gods, felt hungry and thirsty all the time, with food and drink just out of his reach.



TANTALUS

## MYTHICAL BEINGS

Ancient Greek tales were full of weird creatures. There were beings called satyrs that had the upper body of a man but a lower half like a hairy goat, with hooves instead of feet. More noble were the wise centaurs, who were half man, half horse. A fire-breathing monster called the Chimera was part lion and part goat and had a serpent for a tail.



SATYRS



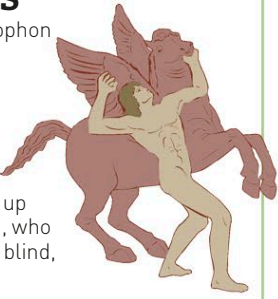
## KING MIDAS

In return for helping one of the gods, King Midas was granted a wish. Greedily, he asked that everything he touched be turned to gold. When his food, drink, and even his daughter turned to gold, Midas begged for the gift to be taken away.



## BELLEROPHON AND PEGASUS

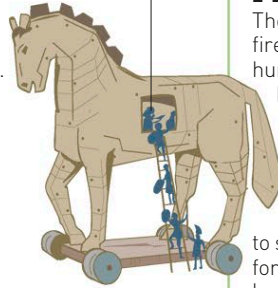
The young hero Bellerophon rode a magical winged horse called Pegasus. Too bold and proud, he tried to fly up to the home of the gods. This so angered Zeus, he made Pegasus rear up and throw Bellerophon, who was injured. Lame and blind, he became a beggar.



## THE TROJAN HORSE

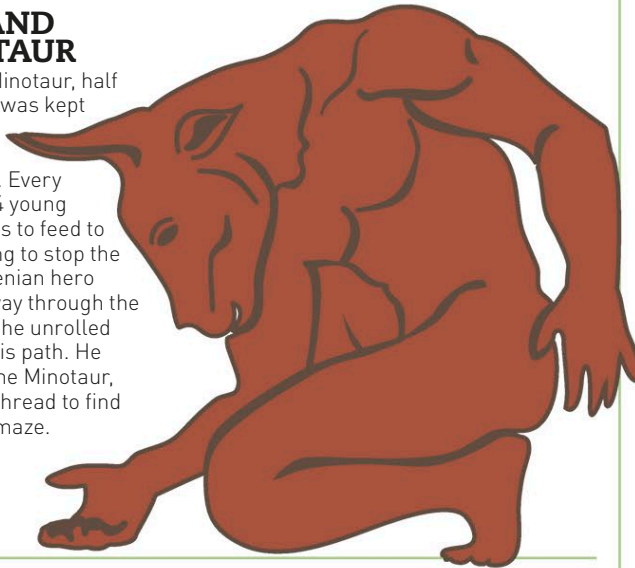
The Greeks defeated their Trojan enemies by trickery. Outside the city of Troy, they left a huge wooden horse, which the Trojans seized. At night, men hidden inside the horse crept out to open the city gates for the Greek army.

Greek warriors inside horse



## THESEUS AND THE MINOTAUR

The flesh-eating Minotaur, half man and half bull, was kept by King Minos of Crete in a winding labyrinth, or maze. Every year, Minos took 14 young people from Athens to feed to his monster. Vowing to stop the slaughter, the Athenian hero Theseus found a way through the maze. As he went, he unrolled a thread to mark his path. He fought and killed the Minotaur, then followed the thread to find his way out of the maze.



## DEMETER AND PERSEPHONE

Demeter, the goddess of grain, had her daughter Persephone stolen by Hades, king of the Underworld. While she grieved, the crops all died. Hades agreed to send Persephone back every spring and summer so that the corn and flowers could flourish. In winter, when she went back to Hades, nothing grew.



DEMETER



PERSEPHONE

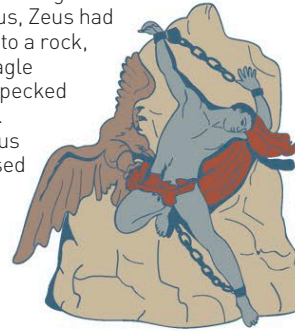
## MEDUSA

The Gorgon Medusa, a monster with snakes for hair, could turn people to stone with one look. Perseus, a son of Zeus, killed her. He avoided her gaze by aiming at her reflection in a shiny shield lent to him by the goddess Athena.



## PROMETHEUS

The Titan Prometheus stole fire from the gods to give to humans. Furious, Zeus had him chained to a rock, where an eagle constantly pecked at his liver. Prometheus was supposed to stay chained forever, but the hero Hercules rescued him.



## JASON AND THE GOLDEN FLEECE

Jason was heir to a kingdom that had been taken from him in childhood. To earn his throne, he had to steal the fleece of a magical golden ram. Jason found the fleece, but it was guarded by a terrible serpent. He asked the hero Orpheus to charm the serpent to sleep with music. Jason seized the fleece and returned home to claim his throne.



## PANDORA'S BOX

Zeus made a beautiful woman out of clay. He brought her to life and called her Pandora. When she married, he gave her the gift of a sealed jar (or box), telling her not to open it. Pandora's curiosity got the better of her, and she opened the lid. All the evil things in the world, such as hatred, disease, and war, flew out. Then one last tiny thing came out of the jar—hope for the future.



## THE 12 LABORS OF HERCULES

When the hero Hercules went mad and killed his family, he was punished by being given 12 seemingly impossible tasks.

### 1 THE NEMEAN LION

The lion had such tough skin that no spear could pierce it. Hercules managed to strangle the beast.

### 2 SLAYING THE HYDRA

The Hydra was a many-headed monster. Every time Hercules cut off one of its heads, two new ones appeared. By sealing each wound, he stopped more heads from growing.

### 3 THE KERYNEIAN HIND

After a long and grueling chase, Hercules caught a golden-horned deer belonging to the goddess Artemis.



### 4 THE ERYMANTHIAN BOAR

Hercules defeated this ferocious boar by trapping it in a snowdrift.

### 5 THE AUGEAN STABLES

The filthy stables of King Augeas had never been cleaned. Hercules changed the course of two rivers to wash all the dirt away.

### 6 THE STYMPHALIAN BIRDS

To get rid of some monstrous birds, Hercules frightened them into the air by playing castanets, then shot them.

### 7 THE BULL OF KING MINOS

Hercules captured a huge and dangerous bull belonging to the king of Crete.



### 8 THE MAN-EATING MARES

Hercules tamed a herd of dangerous meat-eating horses by feeding their owner to them.

### 9 THE BELT OF HIPPOLYTA

Hippolyta was queen of the Amazon women and terrifying in battle. Hercules dared to steal her valuable belt.

### 10 THE CATTLE OF GERYON

Sent to the edge of the world, Hercules stole the cattle belonging to a giant herdsman.

### 11 GOLDEN APPLES OF HESPERIDES

In yet another theft, Hercules took the precious apples belonging to the daughters of Atlas, the giant who carried the world on his shoulders.

### 12 VISITING THE UNDERWORLD

In his final task, Hercules went to the Underworld and captured the three-headed dog, Cerberus, that guarded the gates. The hero was finally forgiven for his crime.

## THE ODYSSEY

Among the most commonly told myths are the adventures of the hero Odysseus. After fighting in the Greek war against the Trojans, Odysseus spent many years on a dangerous sea voyage trying to get back home. The journey of Odysseus and his sailors is described in the story known as *The Odyssey*.

Odysseus's ships visit the lotus-eaters. These lazy people offer the sailors fruit that will make them forget the past.



Poseidon, the sea god, sends terrible storms to send the ships off course.

Circe, an enchantress, turns Odysseus's men into pigs and then back to men again.



Odysseus sails past the Sirens, who try to lure ships into dangerous waters with their song.

The sailors kill cattle on an island belonging to Helios, the Sun god. Zeus strikes their ship with a thunderbolt, killing everyone but Odysseus.

Now the only survivor, Odysseus washes up on the island of the goddess Calypso, where he stays for seven years.

## THE VOYAGE HOME



One-eyed giants called the Cyclopes keep the men captive and eat some of them. Odysseus blinds one of the giants and the crew escapes.

The giant Laestrygonians eat one of the sailors and throw rocks at the ships, sinking all but one.



Odysseus visits the Underworld to find out his future. He has a vision of his homeland being invaded by enemies.

The ship sails through the narrow channel between Scylla, a monster, and Charybdis, a whirlpool.



Odysseus finally returns home. He finds many men hoping to marry his wife, Penelope, and take his lands. Odysseus kills all the suitors and keeps his wife.



# Ancient Rome

The Roman Empire was one of the greatest empires the world has ever known. At its peak, Rome's armies were almost unchallenged, and its emperors ruled a huge area—from Spain to the borders of Persia and from North Africa to Scotland.

## EXPANSION

Rome began as a humble hill-top settlement in central Italy, but before long, it had conquered Italy. It then took over the northern Mediterranean before expanding into much of northern Europe, North Africa, and the Middle East.



**1 240 BCE** After conquering Italy, Rome seized the island of Sicily by defeating the city of Carthage in the First Punic War.



**2 120 BCE** In the Second Punic War, Rome took parts of Spain and North Africa. Victories against Macedonia gave it Greece.



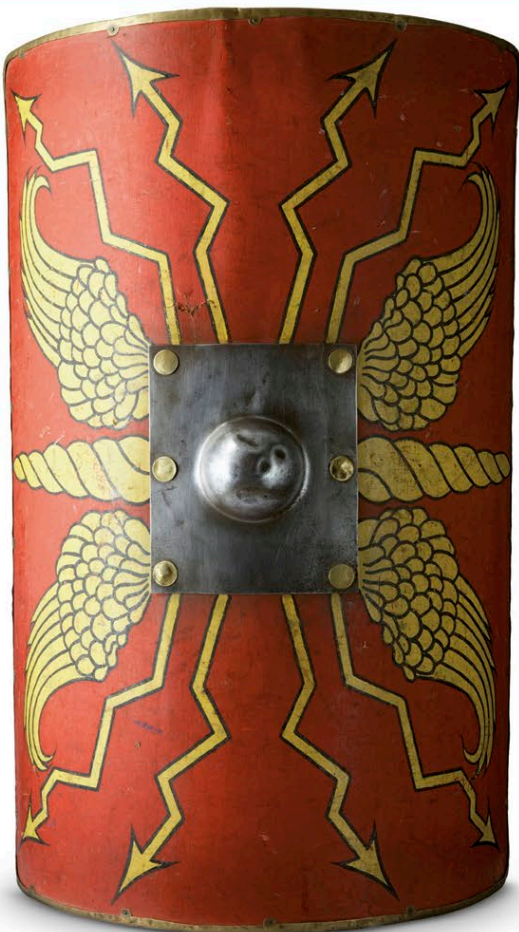
**3 14 CE** By the end of the reign of Emperor Augustus, Roman armies had advanced into Egypt, Syria, and much of Europe.

## ARMY

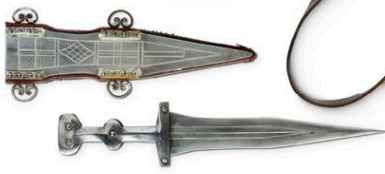
The Roman army was the ancient world's most effective fighting force. Professionally trained and armed, it had around 30 legions of 5,000 citizen-soldiers, each of whom served for 25 years.



**BACKPACK**  
Roman soldiers carried cooking implements and tools to build a camp each night.



**SHIELD**  
The legionary shield protected the whole body. Its edge could also be used to strike opponents.



**PUGIO**  
The Roman legionary dagger, or pugio, was around 8 in (20 cm) long. It was worn on the left hip.

**GLADIUS**  
The Roman legionary sword, or gladius, was about 20 in (50 cm) long.



**HELMET**  
Roman helmets had a metal bowl to protect the head, often with cheek pieces, and a horse-hair crest across the top.

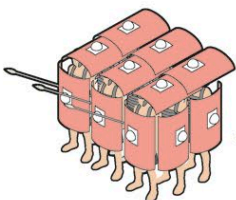
**ARMOR**  
Body armor was usually formed of rectangular metal or leather strips.

**KNEE GUARDS**  
Greaves protected their knees from sword blows.

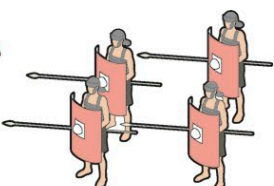
**SANDALS**  
Soldiers wore leather sandals with nails hammered into the soles.

## TACTICS AND FORMATIONS

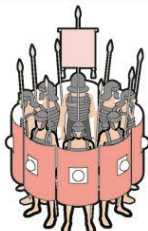
The Romans were very effective foot soldiers (infantry). Normally the legion would send a volley of arrows and javelins before charging and fighting at close quarters. Very few enemies could defend themselves against them.



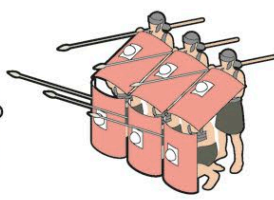
**TESTUDO**  
Raised shields in the testudo, or "tortoise," defended against missiles dropped from above.



**SKIRMISH**  
A skirmish formation was used for rapid advances or crossing difficult terrain.



**ORB**  
The circular orb formation was used by small groups when surrounded.

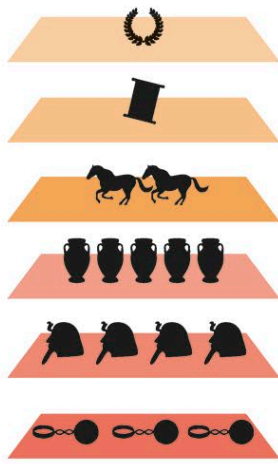


**CAVALRY DEFENSE**  
The front line held their javelins out at a 45-degree angle to defeat cavalry.



## SOCIAL STRUCTURE

The emperor ruled the empire. He held enormous power but depended on the support of rich aristocratic families. Below them were ordinary Roman citizens. However, women, slaves, and "foreigners" from places the Romans had conquered did not have citizenship and could not vote.



### EMPEROR

The emperor (or emperors) was the ultimate authority.

### SENATORS

Leading aristocrats served in the Senate.

### EQUESTRIANS

Below senators were the less wealthy officials.

### WORKING CLASS

Farmers, traders, urban workers, and merchants had little power.

### FOREIGNERS

Outside Italy, most men did not have Roman citizenship.

### SLAVES

Slaves had very few legal rights.

## DAILY LIFE

The family played a central role in Roman life. Each household was ruled by the eldest adult male. Women carried out domestic chores and performed rituals to household gods.



COLANDER

STONE GRINDER

GLASS BOTTLE

OIL FLASK

RING

### ROMAN KINGDOM

750–510 BCE

Romulus kills his twin to become the first king of Rome. Later, the city is ruled by six kings. Under them, the city grows slowly. The last king, Tarquinius Superbus, is overthrown.

### ROMAN REPUBLIC

509–27 BCE

Rome's kings are replaced by elected leaders. The republic lasts for nearly five centuries, until civil wars lead to its collapse.

### ROMAN EMPIRE

27 BCE–395 CE

The final victor in Rome's civil wars takes power as Emperor Augustus. For the next four centuries, Rome is ruled by a succession of emperors.

### EASTERN AND WESTERN EMPIRE

395–476 CE

As the Roman Empire faces new threats, a single emperor cannot defend it. It is divided between two emperors—one based in Rome and the other in Constantinople (Byzantium).

## TIMELINE

As their empire grew, the Romans' political system changed to meet the challenge of governing this vast area. They also fought many wars.

### 753 BCE

According to legend, the city of Rome is founded by Romulus and Remus, the twin sons of Mars, the god of war.



Statue of Romulus and Remus

### 509 BCE

Roman Republic is established after the overthrow of King Tarquinius.

### 264–241 BCE

Rome wins the First Punic War against the North African city of Carthage.



Soldiers in Carthage look at boats burning in the distance.

### 218–201 BCE

Carthaginian general Hannibal almost conquers Italy but is defeated in the Second Punic War.



Head of Hannibal on a coin

### 44 BCE

Julius Caesar, Roman general and dictator, is assassinated after his victory in the civil war against his rival Pompey.

### 27 BCE

Julius Caesar's adopted son Octavian defeats his last rivals in a new civil war. He becomes the first Roman emperor and takes the name Augustus.



Bust of Julius Caesar

### 80 BCE

One of the great examples of Roman engineering, the Colosseum is finished.

The largest amphitheater in the empire, it seats 50,000 spectators.



Colosseum

### 395 CE

The Empire is permanently split into eastern and western halves, each ruled by a separate emperor.



Goths attacking Rome

### 410 CE

The Goths led by Alaric sack Rome. It is the first time in 800 years the city has fallen to a foreign invader.

### 476 CE

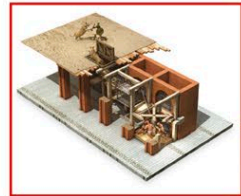
Romulus Augustulus, the last Roman emperor in the West, is overthrown. The eastern Roman Empire survives until 1453 CE.

## ENTERTAINMENT

Public entertainment was very important in Roman cities. Romans took part in religious festivals or went to the theater, public baths, and horse races. However, the most popular form of entertainment was gladiatorial contests in arenas such as the Colosseum in Rome.



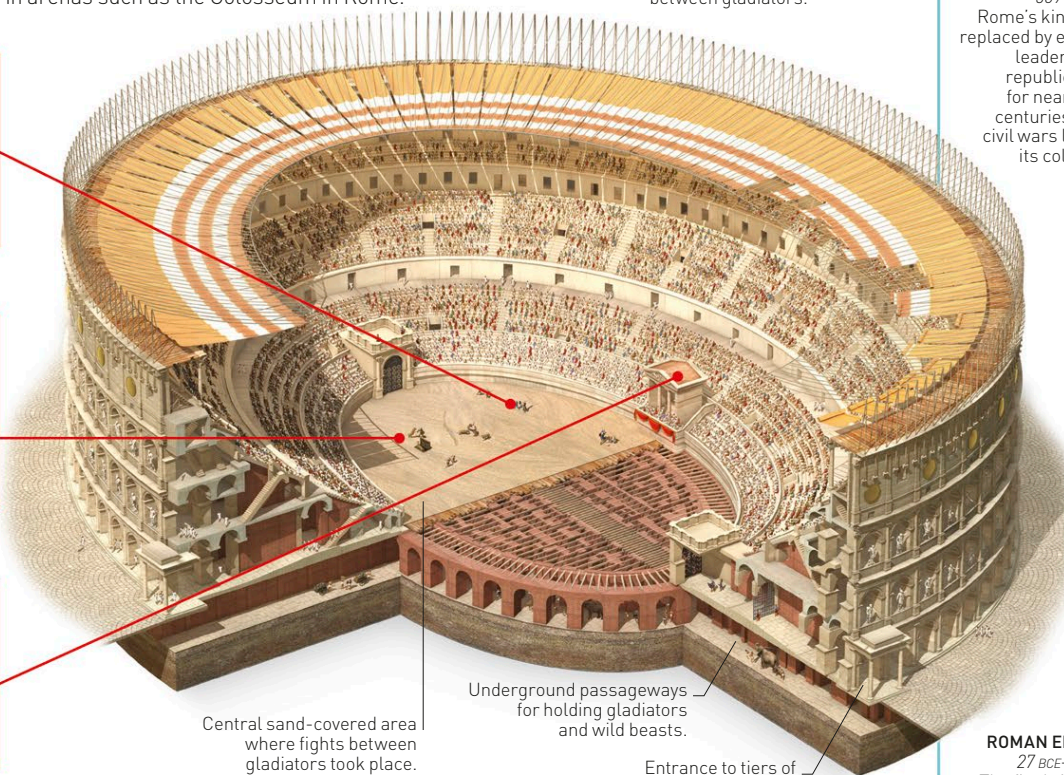
GLADIATORS



UNDERGROUND ELEVATOR



EMPEROR'S BOX



Central sand-covered area where fights between gladiators took place.

Underground passageways for holding gladiators and wild beasts.

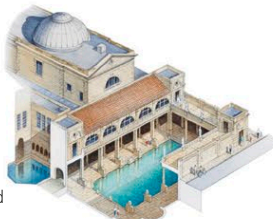
Entrance to tiers of seats for spectators.

## WHAT THE ROMANS DID FOR US

The Romans were brilliant engineers, builders, and scholars. Many essential things in our lives today were first introduced by the Romans.

### PUBLIC BATHS

The Romans built large complexes for public bathing. These baths were the forerunners of the hammams used today in Islamic countries.



THE GREAT BATH, ENGLAND

### ROADS

The Romans created a network of paved roads that linked towns and cities. We still use many of these roads today.

### AQUEDUCTS

Roman engineers built channels, or aqueducts, to carry water from rivers to the cities. They erected great arched structures to keep the channels straight through dips and valleys.



ROMAN AQUEDUCT

### CALENDAR

In their early calendars, the superstitious Romans avoided having months with even numbers of days because it was considered bad luck. Julius Caesar introduced a 12-month year with 365 days, which is close to the calendar we use today.

### LATIN

Many European languages, such as French, Italian and Spanish, are descended from Latin, the language of the Romans.

### ROMAN NUMBERS

The Romans had a numerical system that used letters to form numbers. We still use Roman numerals today on clocks and for important dates.

I 1	II 2	III 3	IV 4	V 5
VI 6	VII 7	VIII 8	IX 9	X 10
L 50	C 100	D 500	CM 900	M 1,000



# The Vikings

No one living between the 8th and 11th centuries welcomed a visit from the Vikings. These wild seafarers from Scandinavia caused widespread terror with lightning raids and looting. But as bold explorers, they traveled far and opened up a wider world.

## CLOTHING

Tunics and trousers for men and long dresses for women were usual Viking wear. Most clothes were made of wool or linen and animal skins. Only the rich could afford silks and fancy accessories. The women wove and sewed everything.



CHILD

MOTHER

MERCHANT

## RAIDING RECORD

The 300-year Viking history is marked by raids, voyaging, and the colonizing of new lands.



## TREASURE

Every self-respecting Viking family had their special treasures. Rich folk prized finely crafted gold and silver jewelry. A typical adventurer, whether raider or trader, picked up ornaments and trophies in other lands.



**JEWELS**  
Rock crystal beads set in silver.



**GOLDSMITH'S ART**  
Intricate brooch of twisted gold wires.



**GAMING PIECE**  
Amber figure used in a board game.



**HUNTING HORN**  
Made from the horn of an ox.



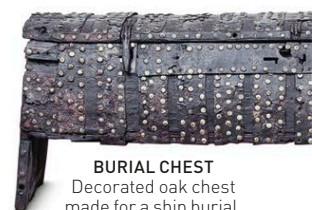
**"EASTER" EGG**  
Christian symbol of rebirth from Russia.



**ARM BAND**  
Solid silver arm ring with molded beading.



**BUCKLED UP**  
Patterned buckle plate.



**BURIAL CHEST**  
Decorated oak chest made for a ship burial.



**MINI CUP**  
Tiny silver cup with engraved pattern.



**LOKI**  
Shapeshifter and god of mischief.



**ASK**  
First man, created from an ash tree.



**ODIN**  
Norse god of wisdom and war.



**THOR**  
Hammer-wielding god of thunder.



**HEL**  
Goddess of the Underworld.

## NORSE MYTHS

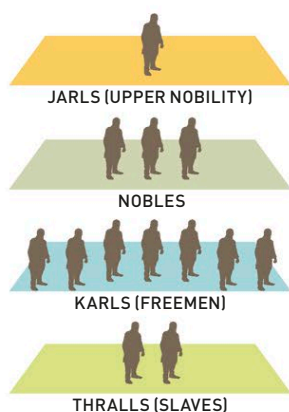
The ancient Norse myths explain how the world and the first people were created. The stories are full of dragons, magic, warring gods, and giants as wild as the Vikings themselves. According to Norse myth, there is a great battle still to come, which will end this world and start a new one.



RUNE ALPHABET

## VIKING SOCIETY

At the top of the Viking social scale were the nobility, the uppermost being the jarls. Then came the freemen, such as warriors, craftspeople, and farmers. Lowest on the scale were slaves, or thralls, many of them prisoners of war.



## RUNES

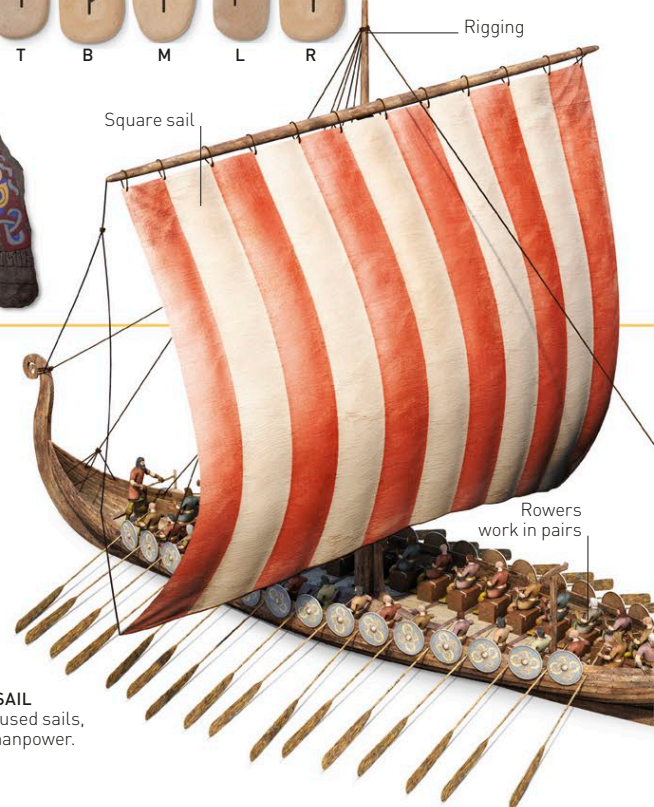
The Vikings used an alphabet of letters known as runes. These runes can be seen today carved into memorial stones, such as the famous Jelling Stones in Denmark, or as messages on pieces of wood and bone.

**JELLING STONES**  
A copy showing pictures and runes.



## FAR AND WIDE

The Vikings were skilled navigators. Sailing from what are now Denmark, Norway, and Sweden, they crossed open oceans in their small wooden boats. Their sea and land expeditions took them west to North America and east to Central Asia.



**FULL SAIL**  
A Viking ship used sails, as well as manpower.





SPINNER

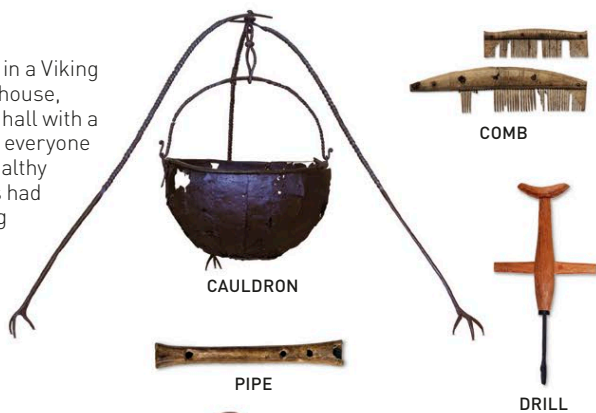
WARRIORS

HUNTER

ARCHER

## HOME LIFE

No one had any privacy in a Viking home, known as a longhouse, which had one room or hall with a central fireplace. Here, everyone lived, ate, and slept. Wealthy households sometimes had extra rooms for cooking and weaving. Outside, there were animal barns, grain stores, and workshops.



CAULDRON

COMB

PIPE

DRILL



**FANTASTIC BEAST**  
Gilded bronze fitting from a horse's bridle.



**HOLY CASKET**  
Container for Christian relics.

## ARMS AND ARMOR

An ax, a sword, and sometimes bow and arrows were Viking battle gear. An iron helmet and a wooden shield warded off enemy blows.



**SILVER WARRIOR**  
Figure of a horseman bearing a sword.



SHIELDS



HELMETS



DAGGERS



NORWEGIAN HELMET

Welded iron plates

Chain mail to protect neck

## ADVENTURERS

There are some famous heroes among the Vikings. Although their adventures took place more than 1,000 years ago, the legends of these chieftains live on.

### RAGNAR

A hero of his day, he invaded Paris in 845. Stories say that he was later imprisoned in northern England and left in a snake pit to die.

### BJÖRN IRONSIDE

One of the earliest known Viking explorers, he led raiding parties far and wide, attacking lands in Spain, France, Italy, and even North Africa.

### IVAR THE BONELESS

Despite the unexplained name, Ivar was a vicious and powerful warrior. He invaded East Anglia in England in 869.

### GUDRID THORBJARNARDÓTTIR

This Icelandic explorer arrived in America almost 500 years before Columbus. She also traveled to Greenland and Canada.

### ERIK THE RED

Originally Norwegian, he moved to Iceland from where he was banished for killings in 982. He founded the Norse colonies in Greenland.

### LEIF THE LUCKY

Son of Erik the Red, Leif Eriksson made it all the way to North America in about 1001. He landed in present-day Newfoundland.

LEIF THE LUCKY



VIKING KNIFE



ARROWS

LONGBOW



AXES



SWORDS



Unbleached linen

UNDERTUNIC AND LEGGINGS

IT IS A MYTH THAT VIKINGS WORE HORNED HELMETS.



THREE MAJOR CIVILIZATIONS

The Aztec civilization was based in what is now central Mexico. The Maya occupied southern Mexico, Guatemala, Belize, Honduras, and El Salvador. The Inca Empire stretched 2,485 miles (4,000 km) along the west coast of South America.



Ancient Americas

Three great civilizations of the Americas flourished in different parts of the continent: the Maya and Aztecs in central America (Mesoamerica) and the Inca in the south, centered in modern-day Peru. These cultures, although different in many ways, all left behind beautiful art and the remains of spectacular cities.



DIVERSE CULTURES

As well as the Maya, Aztec, and Inca civilizations, a rich mosaic of other peoples and cultures flourished in the region.

- MAYA (c.2000 BCE–1697 CE)**  
Excelled at astronomy and devised a way of writing using pictures. There are still millions of Maya in Central America today.
- OLMEC (1200–400 BCE)**  
One of the earliest civilizations of Mesoamerica, their culture was based mainly on farming and trade.
- ZAPOTEC (500 BCE–900 CE)**  
Based in southern Mexico. Ruled over 1,000 settlements in the region from its main city, Monte Albán.
- NAZCA (100 BCE–800 CE)**  
Best known for the massive pictures and shapes (geoglyphs), they etched on the ground in southern Peru.
- TEOTIHUACÁN (1–750 CE)**  
Built Teotihuacán, the largest and most impressive city in the ancient Americas.
- MOCHE (100–800 CE)**  
Built huge, mysterious pyramids from mud bricks that still dominate the countryside in northern Peru.
- TOLTEC (750–1170)**  
Expert Mesoamerican architects and craftspeople. Built giant pyramids and palaces in their capital, Tula.
- CHIMU (1000–1470)**  
Occupying a large area in the west of South America, they were skilled goldsmiths and architects. Eventually conquered by the Incas.
- INCA (1150–1532)**  
Became the most powerful people in the Andes mountain region when they conquered the city of Cuzco in 1438. They went on to take over many other states for their empire.
- AZTEC (1300s–1521)**  
Originally a wandering tribe, they founded the city of Tenochtitlán in 1325, which became the center of their mighty empire.

GREAT CITIES

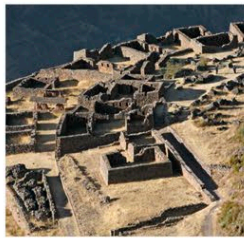
Cities were built in a variety of places. The surrounding landscape and the building materials available had an effect on the look of the buildings. Cities were often dominated by huge temples and other religious buildings.



**TIKAL**  
Major Maya city, inhabited from 600 BCE to around 900 CE.



**CHICHÉN ITZÁ**  
Maya city that was an important trading center.



**CUZCO**  
The religious and political capital of the Incas.



**TEOTIHUACÁN**  
City state that was destroyed mysteriously around 700 CE.



**AZTEC SUN STONE**  
Describes the Aztecs' beliefs about time and religion.

WRITING

Many of the different Mesoamerican cultures used picture-writing to keep records and write about their history. The Incas and their neighbors did not use writing, but recorded information on a *quipu*, an arrangement of knotted strings.

**MAYA WRITING**  
Made up of a system of symbols called glyphs.

SKY	PERSON	MOUNTAIN	SUN	JAGUAR	FIRE
BONE	SPIRIT	BOOK	WATER	LORD	CLOUD
WOMAN	TO GRAB	QUETZAL	SNAKE	HOLY	TO SCATTER
YEAR	BLUE	SHIELD	FLINT	HOUSE	TWENTY



## TIMELINE

The civilizations of the region lasted for 2,000 years, until European explorers and their armies wiped them out.

500 BCE

The Zapotecs build Monte Albán as their capital and religious center.

c. 900–1000 CE

Toltecs build their capital at Tula, Mexico.



Toltec pottery

1325

Aztec city of Tenochtitlán founded on an island in Lake Texcoco.



Tenochtitlán marketplace

1519–1521

Explorer and soldier Hernándo Cortés conquers the Aztecs for Spain.

Cortés meeting Aztec leader Moctezuma II



1542

The Spanish establish a capital at Merida and the Maya resistance comes to an end.

## 1400 BCE

1400 BCE

The Olmecs build temples and carve colossal sculptures in northern Mexico.



Tikal temple

350 BCE

First great Maya city of Tikal built in the rainforest of Guatemala.

Incas begin to expand their empire through the central Andes.



Cuzco, Inca capital

c. 1300

c. 1438

Inca chief Pachacuti takes power. City of Machu Picchu is built.



Machu Picchu

1471

Tupac becomes king of the Incas and pushes far south to expand the empire.

1502

Moctezuma II begins his reign over 10 million Aztecs. The empire is at its height.

1532

The Inca Empire ends when Spanish warrior Francisco Pizarro captures and kills the Inca emperor, Atahualpa.

## 1700 CE

1697

The very last Maya outpost, Tayasal, falls to the Spanish.

## GODS AND GODDESSES

The Mesoamericans and Incas worshipped many gods, most of them to do with nature or farming. People would ask the gods for good weather to make crops grow or for better health for themselves and their families.



CHALCHIUHTLICUE  
Aztec goddess of water and storms.



VIRACOCHA  
Most important god of the Incas.



XOLOTL  
Aztec god of death and lightning.



TZULTACAH  
A group of Maya thunder gods.



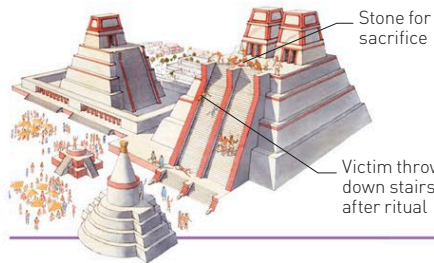
MAMA KILLA  
Inca goddess of the moon.



MAIZE GOD  
Unnamed, shaven-headed Maya god.

## RITUAL AND SACRIFICE

Sacrifice was a vital religious ritual. Animals and humans were offered up to feed the gods so that they would look after the earth.



## AZTEC WARRIORS

War was a way of life for the Aztecs. Apart from gaining new land, the main reason for going to war was to capture enemy warriors for sacrifice to the gods.

AT 17, YOUNG AZTEC MEN WERE SENT OFF TO CAPTURE THEIR FIRST PRISONER.



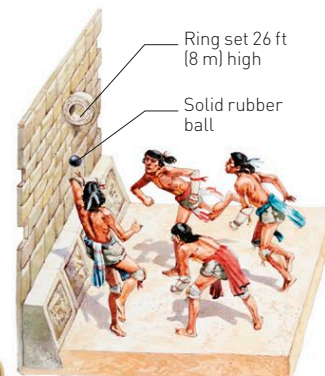
JAGUAR WARRIORS  
For taking captives, Aztec warriors were awarded distinctive costumes.



APPRENTICE WARRIOR  
Carrying wooden spear tipped with sharp stone.

## FUN AND GAMES

Ulama was a fast and furious ball game played by various cultures, including the Aztecs. We don't know the exact rules, but the aim was for two teams on a special court to try to put a ball through a ring set into a wall.



## ART AND CRAFTS

The pottery, carvings, ceramics, and metalware left behind by the Mesoamerican and ancient Peruvian cultures are a valuable source of information about the way they lived, their ideas about life, and how and who they worshipped.



JADEITE JAGUAR MASK  
Olmec, 900–300 BCE



JADE MASK  
Aztec, c. 1420–1519



CARVED FROG  
Aztec



JADEITE FIGURE  
Aztec, 1500–1530



MOTHER AND BABY  
Teotihuacán, c. 200 CE



CARVED JAGUAR BONES  
Maya, 400 CE



JADEITE CARVING  
Maya, 600–900 CE



PITCHER  
Inca, 1476–1550



STIRRUP POT  
Moche, 200–500 CE



MARBLE VASE  
Maya, 600–1000 CE



GOLD CUP  
Sicán (Andean culture)



FIGURE OF A WOMAN  
Inca, c. 1476–1550



GOLD LLAMA  
Inca



## KEY EVENTS

The Ottoman Empire expanded rapidly after it was formed, as the sultans set out to gain new territory for Islam, as well as wealth to reward their followers.

**1453**  
Mehmed II conquers Constantinople. The Byzantine Empire ceases to exist.

**1514**  
Selim I invades northern Iraq and takes over most of the Middle East.

**Selim I mosque, Istanbul**



**1571**  
Defeat at Battle of Lepanto stops Ottomans from expanding farther west.

**1914**  
Ottomans join World War I on the side of the Central Powers.

**1923**  
The Ottoman Empire is dissolved and the Republic of Turkey is formed.

**1300**

**1354**  
Ottoman armies cross into Europe at Gallipoli.

**1369**  
Ottomans capture Edirne, which becomes their capital.



**Edirne mosque**

**1529**  
Army of Suleiman I besieges the Austrian capital, Vienna, but fails to conquer it.

**1566**  
Suleiman I dies in Hungary. The Ottomans would advance no farther into Europe.

**1538**  
Ottoman navy wins control of the eastern Mediterranean at the Battle of Preveza.

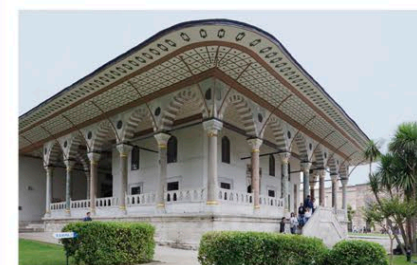
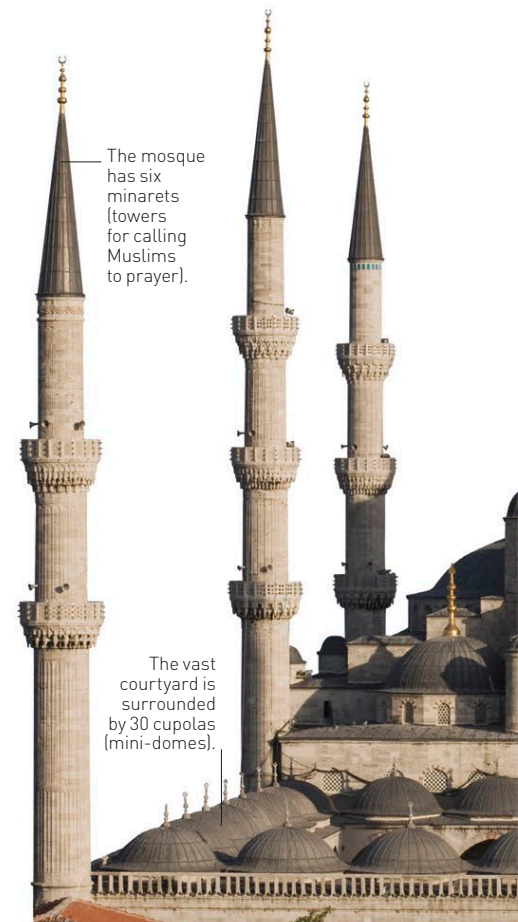
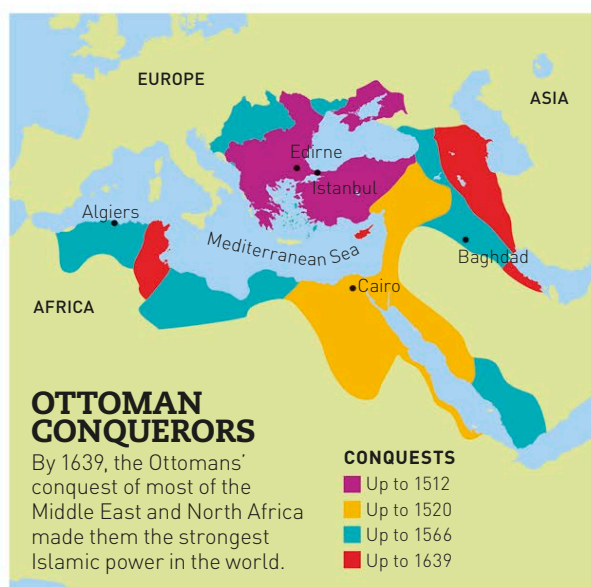
**1683**  
The Ottomans are defeated at the Battle of Vienna, starting the decline of the empire.



**Modern Turkish flag**

# The Ottoman Empire

The Ottoman Empire was one of the biggest and longest-lasting empires in history. It was founded in the 14th century by Osman, a Turkish *ghazi* (Islamic warrior). Two hundred years later, the empire stretched over three continents: Africa, Asia, and Europe. It was ruled over by a series of powerful sultans, with the help of armies of slave-soldiers.



**TOPKAPI PALACE**  
Built in 1460 for Mehmed II, Topkapi was the main palace of the sultans for 400 years.

## POWERFUL SULTANS

The Ottoman Empire was ruled by descendants of the same family for 600 years. The sultans formed strong governments, and life under Ottoman rule was mostly peaceful and safe for ordinary citizens.

- OSMAN I (GAZI) (c.1258–1326)**  
The founder and first sultan of the Ottoman Empire. A successful military general who extended Ottoman territory throughout his 27-year reign.
- MEHMED II (THE CONQUEROR) (1432–1481)**  
A great military leader, he captured Constantinople and conquered territories in Anatolia and the Balkans.
- SELIM I (THE GRIM) (1470–1520)**  
Selim came to power after a civil war. He killed his brothers and others who might have had a claim to the throne after his death so that his chosen son, Suleiman, could become sultan.
- SULEIMAN I (THE MAGNIFICENT) (1494–1566)**  
One of the greatest sultans. During his 46-year reign, the Ottoman Empire became a world power. Suleiman's reign was also a time of great achievements in literature, poetry, art, and architecture.
- ABDÜLMECID I (1823–1861)**  
Responsible for an ambitious reform of the army, schools, and other institutions. Abdülmecid hoped this reform would make the declining empire competitive with other European countries.

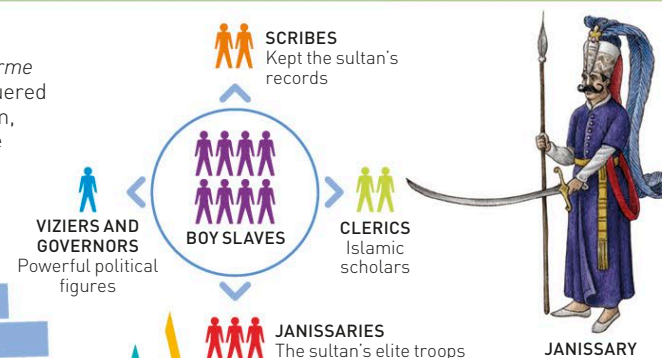


**SULEIMAN I THE MAGNIFICENT**

## THE SULTAN'S LOYAL MEN

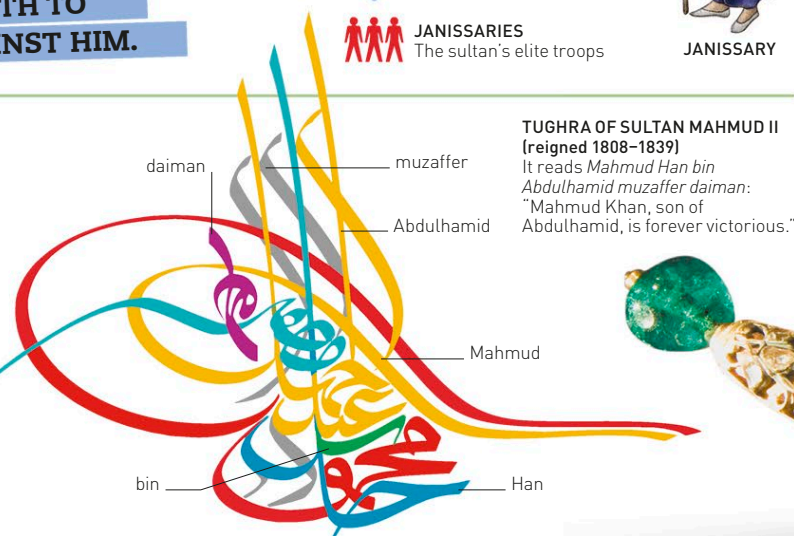
The Ottomans operated a system called *devshirme* (gathering), in which Christian boys from conquered countries were made slaves, converted to Islam, and taught total loyalty to the sultan. They were then trained to do important jobs within the sultan's household and army.

**WHEN SULTAN MEHMED II TOOK POWER, HE PUT ALL HIS BROTHERS TO DEATH TO PREVENT PLOTS AGAINST HIM.**



## MARK OF THE SULTAN

The *tughra* was the personal seal of the Ottoman emperors. All important documents, coins, and letters from the sultan carried a symbol, which was different for every ruler. The *tughra* was based on Arabic calligraphy. It was designed at the beginning of the sultan's reign and drawn by the *nişancı* (court calligrapher) on to court papers.

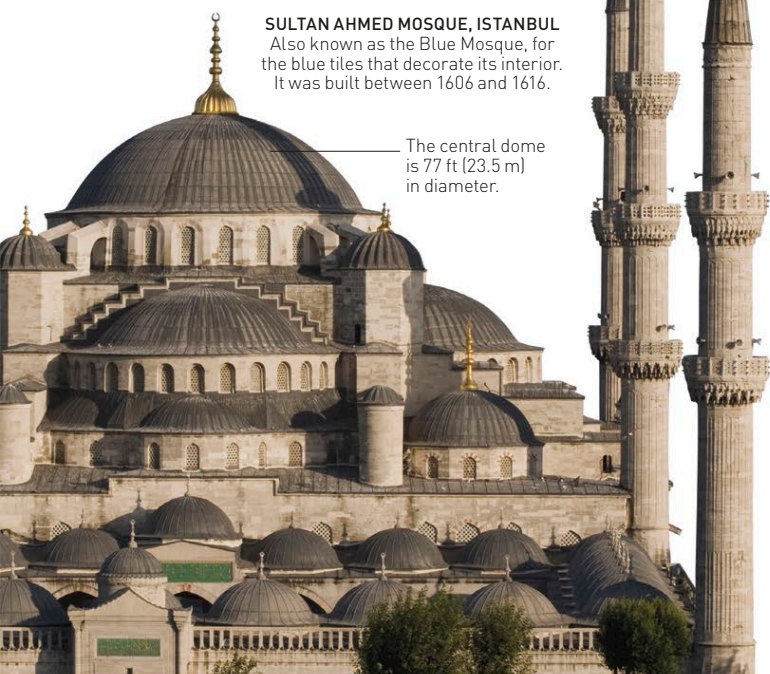


**TUGHRA OF SULTAN MAHMUD II (reigned 1808–1839)**  
It reads *Mahmud Han bin Abdulhamid muzaffer daiman*: "Mahmud Khan, son of Abdulhamid, is forever victorious."



## MASTER BUILDERS

Ottoman rulers commissioned many magnificent palaces and mosques as symbols of their great power, as well as to show their devotion to Islam. Ottoman architects were inspired by both Islamic and European art, and their buildings are a lively mix of both traditions.

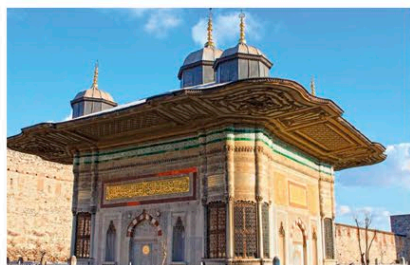


**SULTAN AHMED MOSQUE, ISTANBUL**  
Also known as the Blue Mosque, for the blue tiles that decorate its interior. It was built between 1606 and 1616.

The central dome is 77 ft (23.5 m) in diameter.



**DOLMABAHÇE PALACE**  
Home to six sultans until the deposition of the last sultan in 1922.



**AHMET FOUNTAIN**  
Public drinking fountain built by Ahmed III in 1728. The water is supplied from a pool inside the kiosk.

## ART AND DECORATION

As the Ottoman Empire grew richer and more powerful, artists and craftspeople were in great demand to produce art and objects for the sultan's palaces. The town of Iznik was particularly famous for beautiful ceramic tiles and pottery, which were decorated with flowers and intricate plant motifs and Arabic script, mainly in vivid shades of blue and green.



IZNIK PLATE



IZNIK CERAMIC TILES

Sheath is decorated with more than 50 diamonds.

Enamel flower motif



## WEAPONS AND ARMOR

During the reign of Suleiman I, the Ottoman army was the largest and most successful in Europe. The sultan's troops were highly trained, well disciplined, and equipped with the latest weapons and armor.



HIDE AND COPPER  
CHICHAK (HELMET)



CUIRASS (BODY ARMOR)



STEEL  
HELMET



MACE, DAGGER,  
AND SWORD



BREASTPLATE



CAVALRY BOOTS



CHAIN-MAIL ARMOR



KALKAN (SHIELD)

## JEWELS AND FINERY

The Ottomans' taste was influenced by the variety of cultures across their vast empire. Jewelry was ornate and generally mixed different metals and gems in one piece. Emeralds and jade were popular because green was associated with the prophet Muhammad.



Hilt is decorated with three Colombian emeralds.

Five pieces of different shapes are engraved with sacred verses from the Qur'an.

**TOPKAPI DAGGER**  
Made as a gift from Sultan Mahmud I to the ruler of Persia, Nadir Shah, in 1747.

**SPOONMAKER'S DIAMOND**  
86-carat, pear-shaped diamond in gold and 49-diamond setting.

**NECKLACE**  
1875–1925



# The Mughal Empire

The Mughal Empire was founded by Babur, a Muslim prince and descendant of the Mongol conqueror Genghis Khan. The Mughals' enormous wealth and power can still be seen today in the many great monuments they left behind.

- 1504** Babur captures the city of Kabul and becomes ruler of Afghanistan.
- 1526** Babur conquers Delhi in northern India. The Mughal age begins.
- 1540** Humayun, Babur's son, loses power to a rival Afghan dynasty but seizes it back in 1555.
- 1556** Babur's grandson, Akbar, becomes emperor.
- 1563** Akbar begins to pass laws granting Hindus religious and political freedom.
- 1605** Jahangir becomes emperor on Akbar's death.
- 1613** British East India Company allowed to build a warehouse in Surat, Gujarat.
- 1627** Jahangir dies at the age of 58.
- 1632** Emperor Shah Jahan begins building the Taj Mahal as a memorial to his wife Mumtaz Mahal.
- 1657** Shah Jahan falls ill; a year later, his son Aurangzeb defeats his brothers and takes power.
- 1686** The East India Company starts a war with Emperor Aurangzeb over trading territory. After three years, the company admits defeat.
- 1707** Emperor Aurangzeb dies, triggering a period of rebellions.
- 1739** Nadir, Shah of Persia, captures Delhi. The Mughal Empire starts to decline.
- 1857** The last Mughal emperor, Bahadur Shah II, is deposed by the British for supporting the Indian Mutiny.



Akbar and his Hindu bride



Tomb of Mumtaz Mahal

## TIMELINE OF THE MUGHALS

The Mughals originally came from Central Asia. At their height, they ruled all of what is now northern India, Pakistan, Afghanistan, and Bangladesh. Eventually they lost nearly all their territory.



Indian Mutiny, 1857



## MIGHTY MUGHALS

Babur and the strong rulers who came after him ensured that their empire grew steadily richer and more powerful.

### BABUR (1483–1530)

A brilliant general, and also passionate about poetry and gardening. He wrote his own life story in the form of a diary, the *Baburnama*.

### AKBAR (1542–1605)

Won the support of his people by setting fair taxes and promoting religious tolerance.

### JAHANGIR (1569–1627)

An enthusiastic patron of the arts. His wife, Noor Jahan, was one of the most powerful women in Mughal history.

### SHAH JAHAN (1592–1666)

Famed for the magnificence of his court, he built a new city, Shahjahanabad (now Old Delhi), as his capital.

### AURANGZEB (1618–1707)

Expanded the empire by a quarter, but the cost of military campaigns drained his treasury.



AKBAR'S TOMB

## ARMOR AND WEAPONS

Mughal warriors fought mostly on horseback, but they also used elephants that were specially trained to charge and trample the enemy during battle.



KULAH KHUD (CONICAL HELMET)



CHAIN-MAIL HELMET



MAIL GAUNTLET



IVORY GUNPOWDER HORN



DAGGERS AND SCABBARD



ARM GUARD



MACE



TABAR (BATTLE AX)



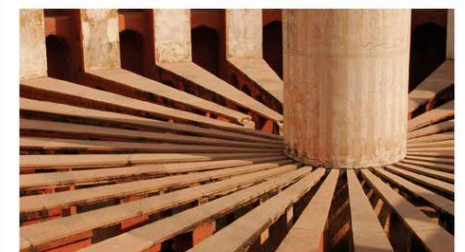
SWORDS



TONGI (POLE AX)

## ASTRONOMY

Many Mughal emperors took a keen interest in science, mathematics, and especially astronomy. They built observatories and employed astronomers to produce detailed *zijes* (astronomical tables) and calendars.



JANTAR MANTAR OBSERVATORY, NEW DELHI (1724)  
Built by order of the Emperor Muhammad Shah to help create new astronomical tables.



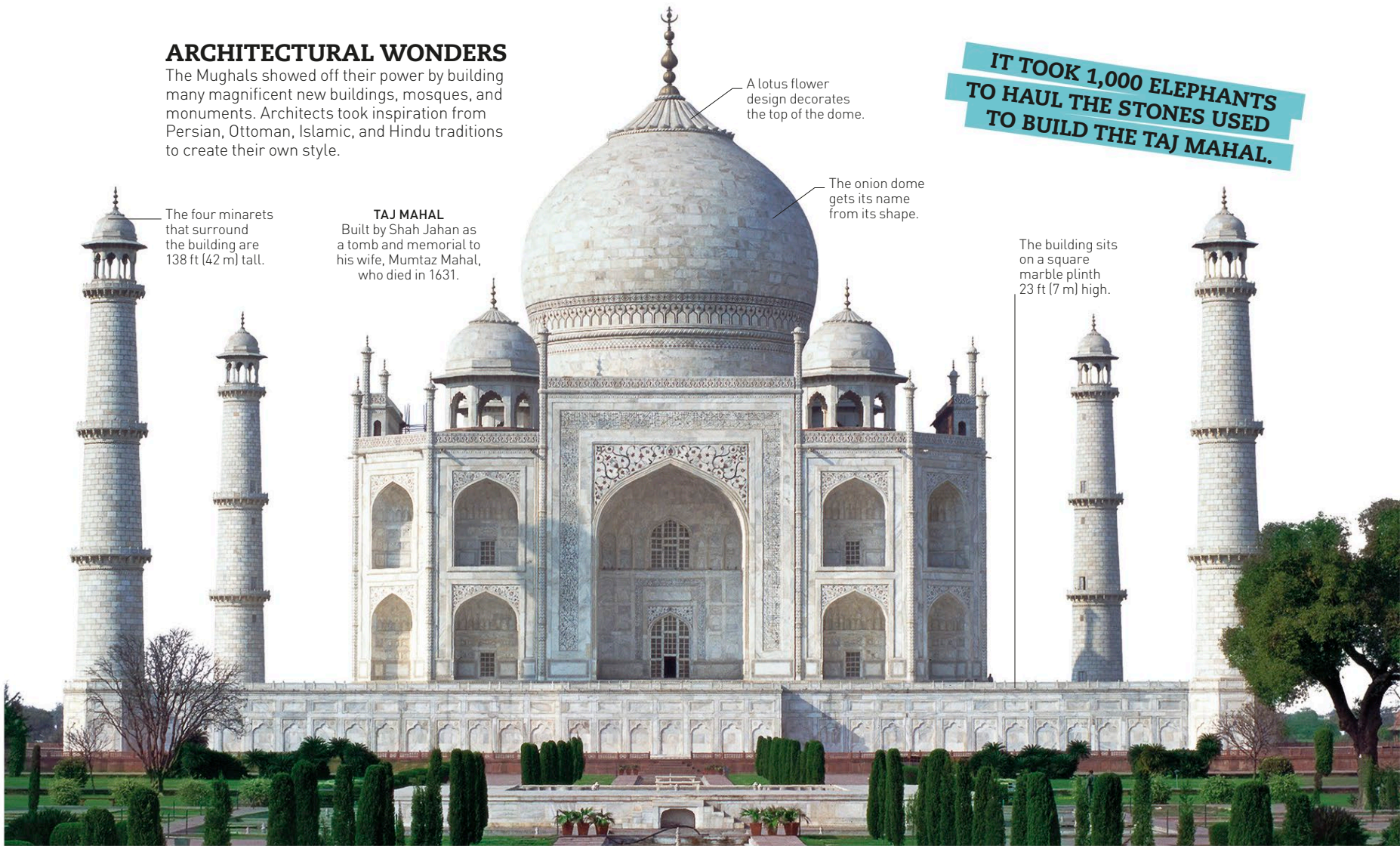
BRASS CELESTIAL GLOBE (1790–1791)  
Shows the position of the stars and their constellations.



## ARCHITECTURAL WONDERS

The Mughals showed off their power by building many magnificent new buildings, mosques, and monuments. Architects took inspiration from Persian, Ottoman, Islamic, and Hindu traditions to create their own style.

**IT TOOK 1,000 ELEPHANTS TO HAUL THE STONES USED TO BUILD THE TAJ MAHAL.**



The four minarets that surround the building are 138 ft (42 m) tall.

**TAJ MAHAL**  
Built by Shah Jahan as a tomb and memorial to his wife, Mumtaz Mahal, who died in 1631.

A lotus flower design decorates the top of the dome.

The onion dome gets its name from its shape.

The building sits on a square marble plinth 23 ft (7 m) high.



**FATEHPUR SIKRI (CITY OF VICTORY)**  
Founded in 1571 by Akbar to celebrate his military victories at Chittor and Ranthambore.



**TOMB OF HUMAYUN**  
Built in Old Delhi in 1572, this magnificent garden tomb was the first major building of the Mughal period.



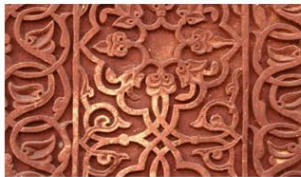
**MOTI MASJID (PEARL MOSQUE)**  
Built in Old Delhi by Emperor Aurangzeb in 1659–1660, the mosque is part of the Red Fort complex of buildings.



**TOMB OF SAFDARJUNG**  
Completed in 1754 in New Delhi, this is one of the last great buildings of the Mughal Empire.

## MUSLIM ART

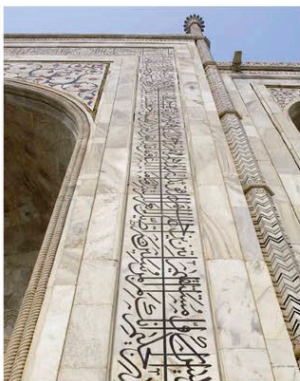
Muslims were against showing people or animals in religious art, so sacred buildings were decorated with geometric patterns, plant and flower motifs, and decorative writing (calligraphy).



LEAF GEOMETRIC DESIGN



FLOWER DESIGN MARBLE INLAY



CALLIGRAPHY ON BUILDING ENTRANCE



OCTAGON AND SQUARE PATTERN

## DAZZLING CRAFTWORK

Art was greatly valued by the Mughals. The most skilled painters, craftworkers, jewelers, and textile designers from all over the empire were commissioned to produce exquisite works to adorn the emperor's palaces.

Richly decorated borders were a tradition borrowed from Persian miniatures.



JADE BOWL



ENAMELED KNIFE HILT



JEWEL-INLAID PENDANT



JADE JUG



MINIATURE PAINTING

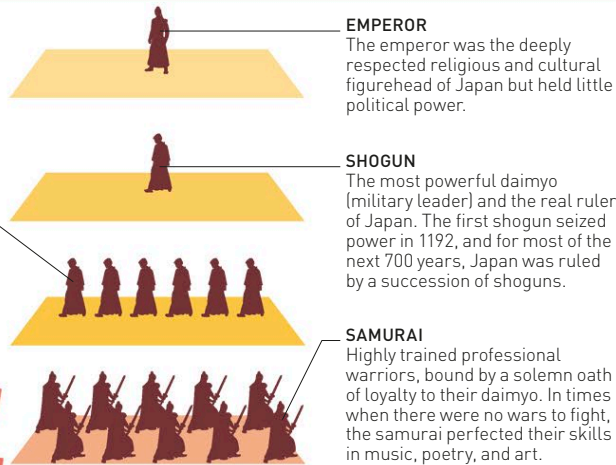


# Imperial Japan

The story of Japan's Imperial Age is filled with feuding clans and warlike samurai, constantly battling for wealth and power. But it was also a place where art and culture flourished and where honor was respected above all.

## RULE OF THE SHOGUNS

Although the ruler of Japan was the emperor, the country was really governed by the shogun. He was the most powerful of a group of wealthy, influential military generals called daimyo.



**THE FULL TITLE  
SEII TAISHOGUN MEANS  
"GREAT GENERAL SUBDUING  
THE BARBARIANS."**

## FEARSOME WARRIORS

Japan's history was shaped by the military men who battled on behalf of warring clans.

- **MINAMOTO YORITOMO (1147–1199)**  
After fierce struggles with rival clans and his own family, he finally became shogun in 1192. At his death seven years later, his son took over as ruler.
- **SASAKI TAKATSUNA (1160–1214)**  
Commander in the war between the Minamoto and Taira clans, he saved Yoritomo's life at the Battle of Ishibashiyama.
- **NITTA YOSHISADA (1301–1338)**  
Resistance leader and general. At his final battle, he was surrounded by his enemies and, rather than be captured, he cut off his own head.
- **TOKUGAWA IEYASU (1543–1616)**  
After civil war, Tokugawa Ieyasu united Japan under his control. His descendants ruled for the next 260 years.
- **KATO KIYOMASA (1561–1611)**  
A formidable military leader and devout Buddhist, he led a brutal campaign to rid Japan of Christianity.



SASAKI TAKATSUNA



KATO KIYOMASA



NITTA YOSHISADA

## MAGNIFICENT CASTLES

In the 16th century, noble families, who were often at war with their neighbors, built mighty fortresses to protect their land and armies. These magnificent castles also served as symbols of the clans' power and wealth.



HIMEJI CASTLE

Also called the Castle of the White Heron, because its delicate, curved roofs resemble birds' wings.

## FAITH AND WORSHIP

Most people followed a faith called Shinto—"the way of the gods"—a belief that all living things possess a divine spirit called *kami*. Worshipers held rituals and left offerings to the *kami* at specially built shrines all over Japan.



SHRINE ENTRANCE AT MIYAJIMA, SOUTHERN JAPAN  
The gateway to a Shinto shrine is called a *torii*.

## SAMURAI WARRIORS

Samurai were men of noble birth who were trained in all aspects of fighting and war. They were the only people allowed to carry a *katana* and a *wakizashi* (a pair of swords known collectively as *daisho*) in public.



The *Kabuto* (helmet) often featured a decorative crest.

The *Mempo* was an iron mask used for protection and to scare enemies.

Cheek and neck protector

Light armor, made from metal scales, allowed for easy movement.

SAMURAI SUIT OF ARMOR, 19TH CENTURY



## SAMURAI CODE

Loyalty and honor were essential to the samurai. They lived by a strict, seven-point code called *Bushido*, which means "the way of the warrior."

<b>GI</b>	Integrity	<b>JIN</b>	Kindness
<b>REI</b>	Respect	<b>MAKOTO</b>	Sincerity
<b>YU</b>	Bravery	<b>CHUGI</b>	Loyalty
<b>MEIYO</b>	Honor		

## WEAPONS AND ARMOR

The samurais' favorite form of fighting was hand-to-hand combat with knives and swords. They were also expected to be skilled with bow and arrow; spears; and, later, guns.



**MEMPO**  
(FACE PROTECTOR)



**THROWING KNIFE**



**KOGATANA**  
(SMALL KNIFE)



**KATANA**  
(SWORD)



**NAGINATA**  
(GLAIVE)

**SPEAR**

## ART AND CRAFTS

In 1603, the city of Edo (now Tokyo) became the capital of Japan. In the 260 years of peace that followed, art and culture flourished as never before. Edo artists and craftspeople produced beautiful work, from delicate ivory carvings to bold, colorful paintings and prints showing city life.



**WOODBLOCK PRINT OF EDO**  
BY UTAGAWA HIROSHIGE 1857



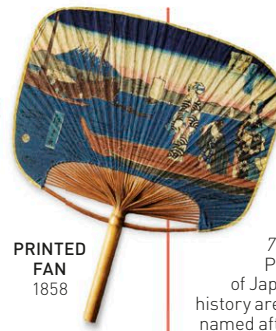
**BRASS LANTERN**  
18th century



**WRESTLER'S NETSUKE** 1800–1850



**CERAMIC INCENSE BURNER**  
1600–1650



**PRINTED FAN**  
1858



**TEA KETTLE**  
Edo period



**PORCELAIN TEA BOWL**  
1700–1750

## MUSIC AND THEATER

Going to the theater and listening to music were popular pastimes for the wealthy. Noh theater was a solemn form of storytelling, performed by actors in masks. Kabuki plays were much livelier and more dramatic.



**KOTSUZIMI DRUM**



**NOTCH FLUTE**



**BAMBOO FLUTE**



**KABUKI ACTOR, EDO PERIOD**



**KOTO**



**SHAMISEN**

## ERAS AND EVENTS

Japan's Imperial Age began around 700 CE. Before then, the area was made of several smaller chiefdoms. The age effectively ended in 1868, when the modern era began. Japanese history is split into periods. A new period began at the start of the reign of a new emperor or with a similar major event.

**1156** Civil war between several clans.



**Woodblock print of Minamoto Tametomo fighting in the civil war.**

**1192** After 30 years of civil war, Minamoto Yoritomo becomes shogun. The emperor's power is taken from him and he is reduced to a figurehead.

**1281** Mongols attempting to invade Japan are forced back by a typhoon that the Japanese name *kamikaze*, or "divine wind."



**The invading Mongols are forced back by a typhoon.**

**1568** Oda Nobunaga seizes power in Kyoto. His army is equipped with muskets acquired from Portuguese traders.

**c.1600** Art and culture flourish in the Edo period—beautiful objects are created by master craftspeople.



**Folding war fan**

**1603** Shogun Ieyasu sets up his capital in a fishing town called Edo, which will become Tokyo.

**1639** Foreigners are forced to leave, beginning a 220-year period of complete isolation for Japan.

700

2025

**NARA**  
710–794  
Periods of Japanese history are often named after the capital cities used by rulers of that period. The city of Nara is Japan's first permanent capital.

**HEIAN**  
794–1185  
Heian (now Kyoto) replaces Nara as Japan's capital in 794.

**KAMAKURA**  
1185–1333  
This period sees a huge rise in power of the daimyo and the samurai who serve them.

**KENMU**  
1333–1336  
Brief restoration of rule by an emperor.

**MUROMACHI**  
1336–1568  
Also known as the Warring State period, this is a time of rebellion and unrest.

**AZUCHI/MOMOYAMA**  
1568–1600  
This period sees an end to the damaging internal conflicts the country has suffered.

**EDO/TOKUGAWA**  
1600–1868  
A long period of peace, during which Japan effectively cuts itself off from the rest of the world.

**MEIJI**  
1868–1912

**TAISHO**  
1912–1926

**SHOWA**  
1926–1989

**HEISEI**  
1989–2019

**REIWA**  
2019–



# Imperial China

China is one of the world's oldest civilizations, having lasted more than 4,000 years. It was an empire from 221 BCE until 1912, making it the longest-lasting empire in history.

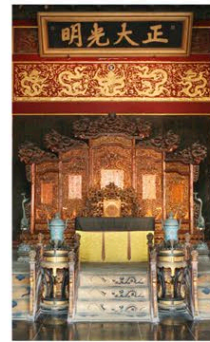
## THE GREAT WALL

The final version of the Wall, built during the Ming Dynasty to keep China's northern enemies out, was around 5,500 miles (8,850 km) long.



## ANCIENT WONDERS

The empire, with its vast wealth, technological skills, and unlimited manpower, created some of the biggest and most magnificent works of engineering and architecture ever made.



**FORBIDDEN CITY**  
Enormous palace and fortress built in Beijing in 1406–1421.



**TERRACOTTA ARMY**  
8,000 life-size statues, buried along with Emperor Qin Shi Huang.

## GREAT EMPERORS

Some strong emperors had long reigns, but many emperors were deposed or assassinated. At times, China was split among warring emperors.

- **QIN SHI HUANG (QIN DYNASTY, 259–210 BCE)**  
He conquered neighboring states to become the first emperor of a unified China and founder of the Qin Dynasty.
- **HAN WUDI (HAN DYNASTY, 156–87 BCE)**  
Seventh emperor of the Han, he ruled for 54 years. During his reign, China's wealth and territory increased.
- **WU ZETIAN (TANG DYNASTY, 624–705 CE)**  
China's only female emperor. She was the wife of Emperor Gaozong and took over from him when he became ill. Eventually, she declared herself China's sole ruler.
- **YONGLE (MING DYNASTY, 1360–1424)**  
The third Ming emperor, known for his ruthlessness and cruelty. He moved the Chinese capital from Nanjing to Beijing and built the Forbidden City.
- **KANGXI (QING DYNASTY, 1654–1722)**  
The longest-reigning emperor, he took the throne at the age of 8. His 61-year rule was a time of peace and prosperity for China.

EMPEROR YONGLE



## GREAT INVENTIONS

Some of the world's greatest inventions and discoveries came from Imperial China, and many of those inventions are still in use today. Scientists and engineers were highly valued by the emperors.



**SILK**  
c. 4000 BCE



**KITE**  
c. 500 BCE

## WRITING

Writing by hand was considered an art form in China. It took calligraphers [professional hand-writers] years to learn how to make the 40,000 characters they needed to write the language.



CALLIGRAPHY SET

INK

## THE DEVELOPMENT OF WRITING

Chinese characters have been simplified over their 4,000 years of use.

	HUMAN	WOMAN	HORSE	MOUNTAIN
<b>ORACLE BONE</b> 14th–11th century BCE	人	女	馬	山
<b>CLERICAL SCRIPT (LISHU)</b> c. 300 BCE	人	女	馬	山
<b>MODERN SIMPLIFIED SCRIPT</b> 1956	人	女	马	山

## RULING DYNASTIES

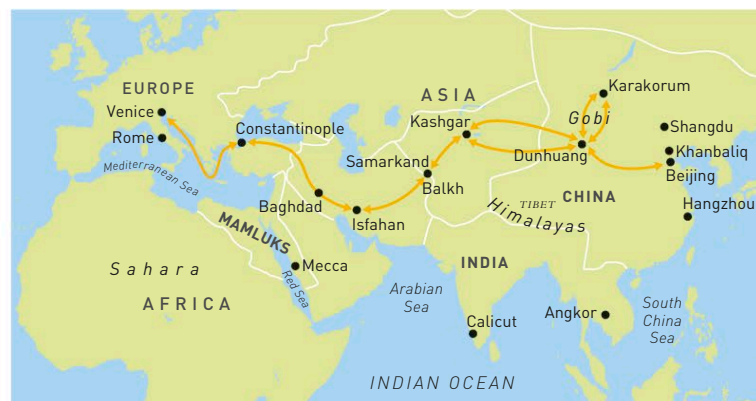
China was ruled by a series of dynasties, or families. Emperors were sometimes overthrown by rival clans or foreign invaders. When this happened, a new ruler took the throne and a new dynasty began.

- 1650 BCE**  
**SHANG**  
c. 1650–1046 BCE  
China's first great ruling dynasty.
- c. 1500 BCE**  
Craftspeople learn large-scale production of bronze weapons and tools.
- c. 1250 BCE**  
Earliest evidence of writing in China.
- c. 1046 BCE**  
The last Shang ruler is defeated at the Battle of Muye.
- Bronze wine beaker, Shang Dynasty**
- 771 BCE**  
King You is killed and Haojing, the capital, is overrun by invaders. The Zhou court flees east.
- Rice pot, Zhou Dynasty**
- 551 BCE**  
Philosopher Confucius is born.
- 221 BCE**  
Warrior Zheng declares himself Emperor Shi Huang, ruler of all China.
- 214 BCE**  
Construction begins on the Great Wall.
- Building the Great Wall**
- c. 68 CE**  
Buddhism is practiced in China.
- 105 CE**  
An imperial court official reports the invention of paper.
- PERIOD OF DISUNITY**  
221–589  
China is invaded and divides into separate states.
- SUI**  
581–618  
China is reunified.
- TANG**  
618–906  
China expands to become a great world power.
- Horse figure, Tang Dynasty**
- FIVE DYNASTIES AND TEN KINGDOMS**  
907–960  
China is once again divided into north and south.
- 1100**  
China's population grows to about 100 million.
- Porcelain vase, Song Dynasty**
- SONG**  
960–1279  
Advances in technology bring wealth and prosperity.
- 1279**  
Mongol invaders, led by Kublai Khan, conquer China.
- Mongol warrior**
- YUAN**  
1279–1368  
The conquering Mongols establish their own dynasty.
- 1420**  
Beijing is named as the new capital of China.
- 1839–1860**  
In the Opium Wars, China and Western nations battle over trade.
- Plate, Ming Dynasty**
- 1912**  
2,000 years of imperial rule come to an end when the 6-year-old emperor, Puyi, is deposed.





**THE MORTAR USED TO BIND THE BRICKS OF THE GREAT WALL WAS PARTLY MADE FROM RICE FLOUR.**



## THE SILK ROAD

The Silk Road was a route that ran from China across Asia toward Europe. It was protected by the Chinese so that traders from all over the world could use it safely. Chinese merchants became very rich by exporting goods such as silk, tea, porcelain, and spices.

KEY

— Silk Road

## TAICHU CALENDAR

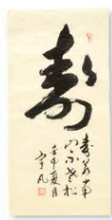
The traditional Chinese calendar dates back thousands of years. It was first officially recorded in 104 BCE, during the rule of Han Wudi.



**ANIMAL YEARS**  
Each year is named after an animal. Every 12 years, the cycle starts over again.



**SHIP'S RUDDER**  
c.100 CE



**PAPER**  
105 CE



**EARTHQUAKE DETECTOR**  
132 CE



**GUNPOWDER**  
c.850 CE

## MYTHS AND LEGENDS

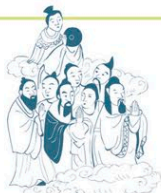
Chinese mythology was a rich mix of traditional folk tales, legends based on real people, and stories adapted from Buddhist and Daoist teaching.



**THREE SOVEREIGNS**  
According to legend, the first rulers of China.



**SUN WUKONG**  
Monkey king with superpowers.



**EIGHT IMMORTALS**  
Able to bestow life and destroy evil.

## ART AND CRAFTS

The exquisite creations of Chinese artisans were always in demand, both at home and abroad. Craftspeople enjoyed high status in society, above the merchants who sold their work.



**BOTTLE**  
1736–1795



**PEWTER TEA CADDY**  
18th century



**GLAZED CAMEL**  
618–906 CE



**GLASS BOWL**  
1825–1875



**IVORY PUZZLE BOX**  
1800–1900



**PORCELAIN TEAPOT**  
1662–1772

## THE THREE WAYS

Imperial China was generally tolerant of different religions. People were free to choose which of the three popular belief systems they wished to follow.



**CONFUCIANISM**  
Followed the rules of Chinese thinker Confucius.



**BUDDHISM**  
A philosophy begun by Buddha, a north Indian prince.



**DAOISM**  
Daoists followed legendary Chinese philosopher Lao Zi.

## DRESSING UP

Rich people wore splendid robes made of the finest silk. Peasants wore loose clothes made of hemp, a rough, scratchy fabric made from plant fibers.



**JADE PENDANTS**



**IVORY FAN**



**CIVIL SERVANT'S HAT**



**SILK ROBE**



**EMBROIDERED SHOES**  
Many women's feet were tightly bound to make them as small as possible.



# Medieval Europe

A thousand years of European history, from around the 5th to the 15th century, are known as the medieval era, or Middle Ages. This is often imagined as a colorful time of jousting knights and moated castles, but for most people, life was hard.

## WHAT THEY WORE

Most people dressed in wool and linen. The style and quality of their clothes told everyone whether they were rich or poor. Rich people wore bright colors, as well as expensive materials and furs.



LONG, POINTY "CLOWN" SHOES WERE VERY POPULAR IN LATE MEDIEVAL EUROPE.

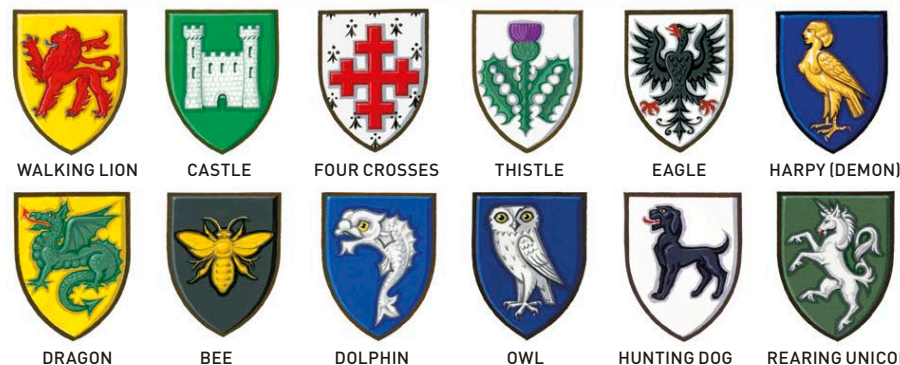
## BUILT TO LAST

Medieval architecture changed styles many times over the centuries. Some of the biggest and most impressive buildings from this period—such as castles, churches, and abbeys—are still standing.



## MAKING MUSIC

In medieval Europe, people of all classes enjoyed music, both as entertainment and in religious ceremonies. Many of their musical instruments developed into the ones we play and listen to today.



## COATS OF ARMS

A knight carried a set of symbols, or coat of arms, on his shield so that people could recognize him in full armor. The symbols were arranged under a system called heraldry. There were strict rules about colors and designs and who was allowed to use them.





## RELIGION

Medieval people had very firm religious beliefs. Europe was mostly Christian, but there were some Jews, and the Middle East was mainly Muslim.



**RELIGIOUS IMAGE**

This 13th-century stained-glass window was made for a French royal chapel.



## THE CRUSADES

In a long-running series of wars called the Crusades, Christian European armies tried to drive Muslim rulers out of the Holy Land. They captured Jerusalem, only to lose the city again later.

### ROUTES BY LAND AND SEA

- 1st Crusade, 1096-1099
- 2nd Crusade, 1147-1149
- 3rd Crusade, 1189-1192
- 4th Crusade, 1202-1204

## TIMELINE

There is no clear beginning or end to the medieval period. Generally, it is dated from around the late 5th century to the middle of the 15th century.



**Symbol of Islam**

**570**  
Muhammad, Islam's most important prophet, is born.

**793**  
Vikings from Denmark, Norway, and Sweden begin their raids in northern Europe.



**French fortress built for William the Conqueror**

**1066**  
William the Conqueror of Normandy conquers the English at Hastings and becomes king of England.



**Church inside Crusader fortress**

**1206**  
The Mongol Empire is founded by Genghis Khan.

**1431**  
French heroine Joan of Arc is executed by the English and their French allies at the age of 19.

**1453**  
The Turks take Constantinople, last outpost of the Eastern Roman Empire. This marks the approximate end of the Middle Ages.

**450**

**476**  
The Roman Empire in Western Europe ends. This is the approximate start of the medieval era also known as the Middle Ages.

**732**  
At the Battle of Tours, European armies defeat Muslim invaders.



**12th-century statue of Charlemagne**

**800**  
Charlemagne crowns himself emperor of Western Europe and builds a vast empire.

**878**  
Alfred the Great defeats the Vikings, saving England from invasion.



**Jewel with portrait of Alfred the Great**

**1096**  
Christian Crusaders start a long period of religious wars in the Holy Land.

**1191**  
Richard I (the "Lionheart"), king of England, defeats Saladin, great ruler of Egypt and Syria.



**Richard the Lionheart**

**1347**  
The disease called the Black Death begins and will kill about half the people in Europe.

**c.1440**  
German craftsman Johannes Gutenberg invents the printing press.

**1500**

## JOUSTING

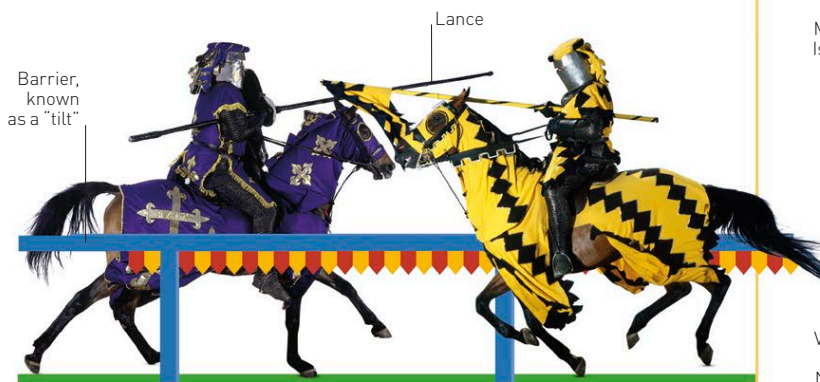
A mock one-to-one fight on horseback, jousting was a dangerous sport. Two knights charged at one another, each trying to unseat the other with his lance.



**JOUSTING HELMET**

**VAMPLATE (HAND GUARD)**

**LOCKING-GAUNTLET**



## ARMOR AND WEAPONS

In the 12th century, knights wore chain-mail armor made from linked iron rings. By the 15th century, battledress was more often a suit of steel plates. Men fought with swords and long-handled weapons such as pikes and axes.



**CUIRASSIER**

**ARMET**

**BURGONET**

**BASINET**

**MAIL HELMET**

**MAIL JACKET**

**HORSE HEAD ARMOR**

**BATTLE AX**

**POLE AX**

**DAGGERS**

**WAR HAMMER**

**PICK**

**HAND CANNON**

## CRIME AND PUNISHMENT

The law in medieval times was very brutal. Cruel instruments of torture were used both as punishments and to force people to admit guilt or divulge information. Many castles had a torture chamber hidden in their lower depths.



**NECK SPIKER**

**THUMBSCREWS**

**IRON MASK**

**MOUTH SCREW**

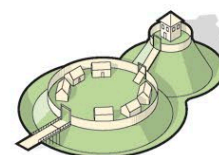


# Castles

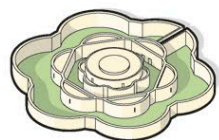
A castle was the imposing residence of a lord, built as a fortress to withstand enemy attack. It was also a community where the lord and his family, his garrison of soldiers, and his many servants lived and worked.

## TYPES OF CASTLE

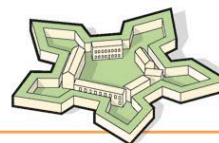
The design of castles changed as weapons of attack developed. The earliest castles were built from earth and timber. Then, during the 12th century, lords began to build castles from stone. Although they took longer to build and more skill, they were much stronger and did not burn like wood.



**MOTTE AND BAILEY**  
11th–12th century.  
A wooden castle is built on a motte (mound), surrounded by a fortified enclosure.



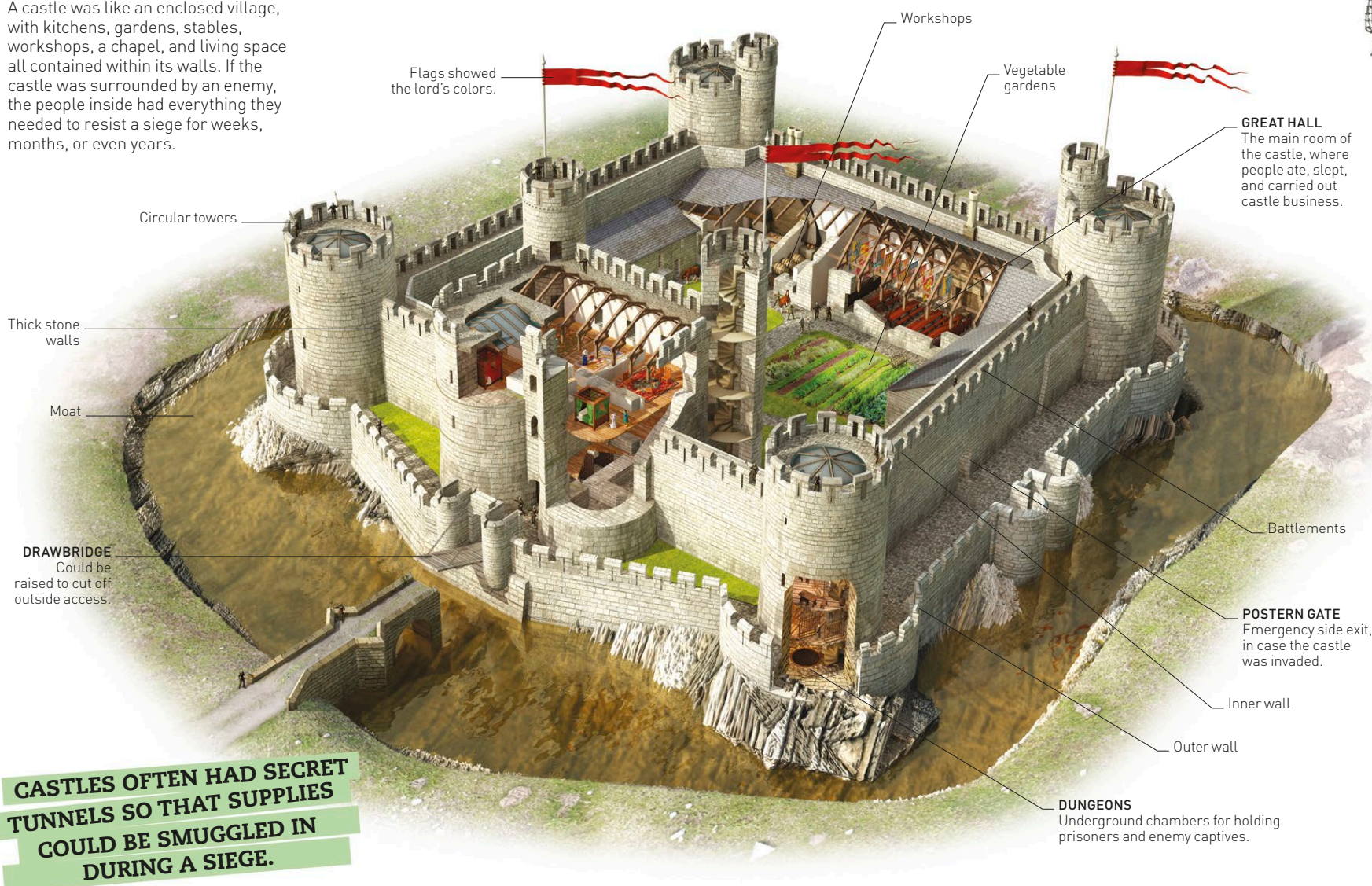
**CONCENTRIC**  
12th–15th century.  
A central fortress is surrounded by layers of stone walls.



**STAR FORT**  
15th–20th century.  
Shape deflects cannon fire and allows defenders to fire from several angles.

## INSIDE A CASTLE

A castle was like an enclosed village, with kitchens, gardens, stables, workshops, a chapel, and living space all contained within its walls. If the castle was surrounded by an enemy, the people inside had everything they needed to resist a siege for weeks, months, or even years.



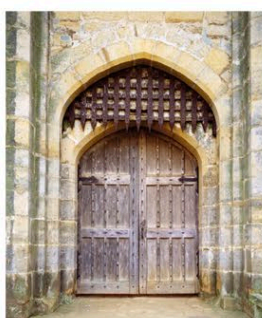
## BUILT FOR DEFENSE

Many castles had features to make it as difficult as possible for attackers to get inside. Towers were built on either side of the vulnerable gatehouse so that defenders could rain missiles or boiling water down on uninvited visitors. Often the lord chose to place his castle on a hillside or clifftop so that he and his men had a good view of anyone approaching.



**MOAT**

A wide, steep-walled ditch around the castle, usually filled with water.



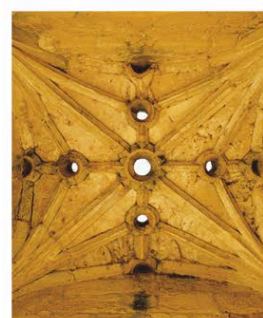
**GATEHOUSE**

The main entrance was often fortified by a movable iron grate called a portcullis.



**ARROW AND GUN LOOPS**

The thick walls had narrow slits through which a soldier could fire missiles at attackers.



**GATEHOUSE CEILING HOLES**

Boiling water or other harmful liquids could be dropped on to intruders.



**SPIRAL STAIRCASE**

Narrow spiral staircases meant that invaders could not easily use swords while climbing.



## BUILDING A CASTLE

A master mason would be employed to plan and build a castle. The work could take years and provided jobs for many local people, from quarry workers and stone-porters to carpenters and well-diggers.



### RECREATING A CASTLE

Using 13th-century techniques, this castle in Treigny, France, is being constructed in an archaeology project.

## SIEGE WEAPONS

There were two ways for attackers to overcome the defenses of a castle. Either they could take it by force by battering down the gate, climbing the walls, or tunneling under the defenses. Or they could surround the castle and starve those inside until they surrendered or died, which might take a long time.



### TREBUCHET

Used to hurl heavy stones at castle walls.



### LONGBOW

Used to shoot arrows at long range.



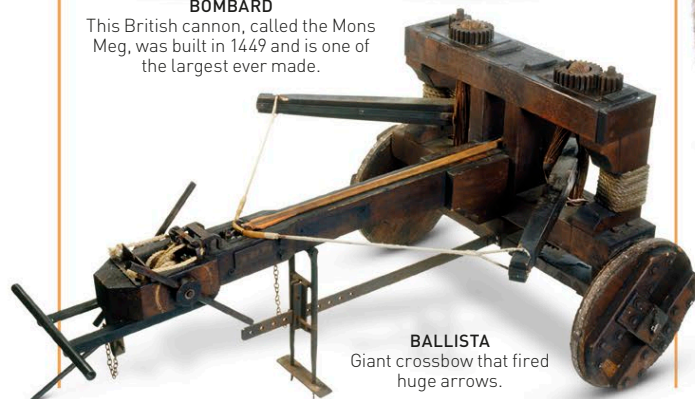
### BOMBARD (CANNON)

Blasted walls with large stone balls.



### BOMBARD

This British cannon, called the Mons Meg, was built in 1449 and is one of the largest ever made.



### BALLISTA

Giant crossbow that fired huge arrows.

## WHO'S WHO IN THE CASTLE

The household of a great castle in medieval Europe could easily contain 400 people. It was a busy place as servants, craftspeople, soldiers, and entertainers went about their various jobs.



### THE LORD AND HIS FAMILY



### GARRISON

The armed troops who were stationed in the castle to defend it.



### CHAPLAIN

Led worship in the castle's chapel.



### CONSTABLE

The lord's second-in-command, also called a castellan.



### GONG FARMER

Dug and cleaned out the castle's toilets.



### HUNTSMAN, FALCONER, DOG-KEEPER

Outside servants, each with a specific purpose on the lord's estate.



### SEAMSTRESS

One of the many domestic servants who looked after the lord and his family.

## PAGES, SQUIRES, AND KNIGHTS

Knights led the force that defended a lord's castle and lands. They were noblemen who pledged to fight for the lord whenever he needed them. In return, knights were paid well and granted lands of their own.

### PAGE

A knight started his career at the age of 7, as a page. A page would serve meals and carry messages, as well as learning good manners and how to hold a weapon.



### PAGE

### SQUIRE

At the age of 15, the page became a squire. He would clean his knight's armor and weapons and accompany the knight to the battlefield. Squires were taught horsemanship and fighting skills.



### SQUIRE

### KNIGHT

At the age of about 21, a squire would be made a knight at the ceremony of dubbing. Another knight, usually the squire's master, tapped the new knight on the shoulder with the flat of a sword and announced him as a knight.



### KNIGHT

## CASTLE LIVESTOCK

The castle kept a variety of animals to provide food for the community. Chickens and geese lived in the courtyard, while larger animals grazed in the fields and were brought inside the castle walls at night to keep them safe.



### COTSWOLD SHEEP



### CHICKENS



### LONGHORN COW



### GOOSE



### BRITISH PRIMITIVE GOAT



### BOAR

## CASTLES AROUND THE WORLD

The size, shape, and location of a castle were influenced by natural features such as mountains or lakes, the climate, what building materials were available, and how permanent the castle was intended to be.



HOHENZOLLERN CASTLE, GERMANY (19TH CENTURY)



BELMONTE CASTLE, SPAIN (15TH CENTURY)



KRAK DES CHEVALIERS, SYRIA (11TH-12TH CENTURY)



KASTELHOLM CASTLE, FINLAND (14TH CENTURY)



QATRANA CASTLE, JORDAN (16TH CENTURY)



OKAYAMA CASTLE, JAPAN (16TH CENTURY)



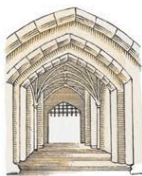
## THE REBIRTH OF EUROPE

The Renaissance began in northern Italy toward the end of the 14th century. Two hundred years later, its influence had spread all over the world.

c.1420

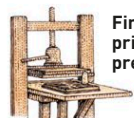
Architect Filippo Brunelleschi rediscovers perspective, meaning that objects can be drawn to look as if they are near or far away.

Arches drawn using perspective



c.1440

Johannes Gutenberg invents the printing press in Germany.



First printing press

1469

Lorenzo de Medici becomes head of the city-state of Florence.

Statue of Lorenzo de Medici



1472

Artist Leonardo da Vinci, aged only 20, is invited to join the Painters' Guild of Florence.

1486

Botticelli paints his masterpiece *The Birth of Venus*.

1498

Leonardo paints the mural *The Last Supper* for a convent in Milan.

1503

Pope Julius II commissions many artists, including Michelangelo and Raphael, to create work for him in Rome.



Statue on the tomb of Pope Julius II

1504

Michelangelo's statue of David is displayed in Florence.

1509

Dutch scholar Erasmus publishes his book *Praise of Folly*, which pokes fun at superstition.

1511

Raphael completes the fresco *The School of Athens* to decorate a wall in the Vatican, the Pope's palace.

1527

Rome is sacked by the army of Charles V, the Holy Roman Emperor.

1543

Doctor Andreas Vesalius publishes the first textbook about the human body and how it works.



Woodcut portrait of Andreas Vesalius

1546

Michelangelo is appointed chief architect at St. Peter's Basilica, Rome.

1550

Giorgio Vasari publishes a massive history of Renaissance art: *The Lives of the Artists*.

# The Renaissance

The Renaissance is the name given to a time of huge cultural change in Europe, beginning in the late 14th century. Scholars rediscovered the writings of the ancient Greeks and Romans, and this led to an explosion of new ideas about science, art, and politics.

## WHERE IT BEGAN

The Renaissance began in the richest parts of Europe. The city-states of northern Italy were full of wealthy noblemen, bankers, and merchants who were eager to show off their wealth and power by supporting artists and inventors. In northern Europe, scholarship and new ideas flourished in the prosperous wool-trading regions of what are now Belgium, Germany, and the Netherlands.

### KEY

• Major Renaissance cities



## POWERFUL PATRONS

The Medici family were rich bankers. From 1434, they ruled the city of Florence and commissioned artists such as Leonardo da Vinci and Michelangelo to produce many great buildings and works of art.



MEDICI COAT OF ARMS

LEONARDO DESIGNED RECOGNIZABLE VERSIONS OF THE MODERN BICYCLE, HELICOPTER, AND PARACHUTE.

## SCIENCE AND DISCOVERY

A new method of approaching science began to take hold during the Renaissance, in which conducting experiments and gathering evidence were seen as the best ways to gain knowledge. This approach led to great progress in the sciences and to many new inventions.



### PRINTED BOOK

Printing meant that scholars could publish their work more widely and exchange ideas with each other.



### THEODOLITE

An instrument to help architects and builders measure angles.



### ASTROLABE

An ancient navigation aid redesigned and widely used by Renaissance explorers.

### FLYING MACHINE

Leonardo da Vinci's design for the ornithopter, a human-powered aircraft.



### MATCHLOCK MUSKET

The matchlock was a new way of firing a gun so that it could be operated by a single person.



### WHEELLOCK PISTOL

A method for firing the gun mechanically rather than by a lit wick, it was safer and more portable than the matchlock weapon.

## RENAISSANCE MEN

During the Renaissance, many of the most influential people did not focus solely on one subject, but became experts in a range of disciplines.

### LEONARDO DA VINCI (1452–1519)

A truly well-rounded person, Leonardo was a brilliant painter, inventor, sculptor, architect, and scientist. His *Mona Lisa* is probably the best-known painting in history.

### MARTIN LUTHER (1483–1546)

German monk and university professor. He attacked corruption in the Roman Catholic Church, was excommunicated, and became a key figure in the Protestant Reformation.

### PARACELSUS (1493–1541)

Swiss scientist who studied medicine and found that many doctors made patients worse rather than healing them. He used his knowledge of chemistry to develop new drugs and medicines.

### MICHELANGELO (1475–1564)

Artist, architect, and sculptor who painted the ceiling of the Sistine Chapel, part of the Vatican in Rome. The ceiling contains more than 400 life-size figures and took four years to complete.

### NICCOLÒ MACHIAVELLI (1469–1527)

A diplomat and writer from Florence. His book *The Prince* gave advice to ambitious politicians on how to succeed. The word "machievellian" is still used today to describe ruthless or cunning behavior.

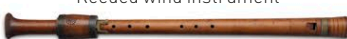


## MUSICAL INSTRUMENTS

Music was the main form of entertainment in Renaissance Europe. Composers experimented with new instruments and different ways of singing in harmony.



**RAUSCHPFEIFE**  
Reeded wind instrument



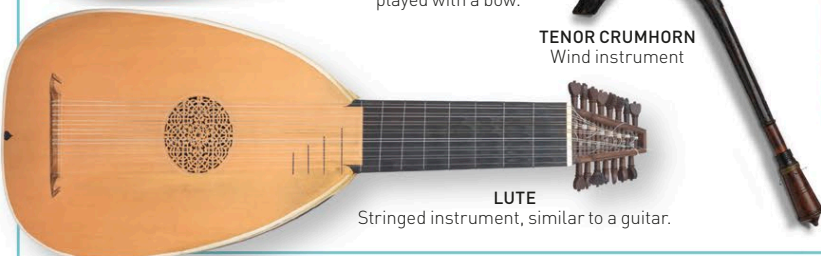
**BASS RECORDER**  
Wind instrument



**RACKETT**  
Wind instrument



**REBEC**  
Stringed instrument  
played with a bow.

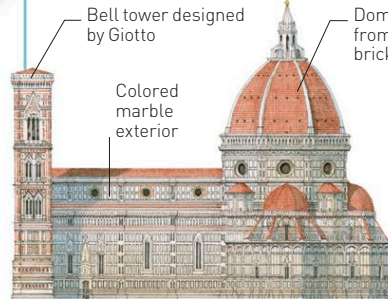


**TENOR CRUMHORN**  
Wind instrument

**LUTE**  
Stringed instrument, similar to a guitar.

## GOLDEN AGE OF ARCHITECTURE

Architects were inspired by the ruins of ancient Roman and Greek buildings. They studied ancient writings on geometry and proportion in order to make buildings that were both beautiful to look at and suited to their purpose.



**DUOMO, FLORENCE**  
Completed in 1436, the *duomo* (cathedral) is topped by a huge, octagonal dome designed by sculptor and architect Filippo Brunelleschi.



**RIALTO BRIDGE, VENICE**  
A late Renaissance masterpiece of architecture and engineering, completed in 1591.



**ST. PETER'S BASILICA, ROME**  
Over a 120-year period, many of Italy's finest architects worked on the building. It was completed in 1626.

**THE INTERIOR OF ST. PETER'S BASILICA WAS DESIGNED TO HOLD UP TO 60,000 PEOPLE.**

Dome designed by Michelangelo

Bell tower designed by Giotto

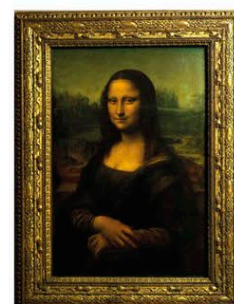
Colored marble exterior

Dome built from 4 million bricks

Single stone arch supports two arcades of shops.

## A REVOLUTION IN ART

A way of thinking called humanism became popular during the Renaissance. Humanism's focus on the experiences and achievements of real human beings had a huge influence on artists. They started to portray people, including religious figures, as realistically as possible and to place them in more everyday situations.



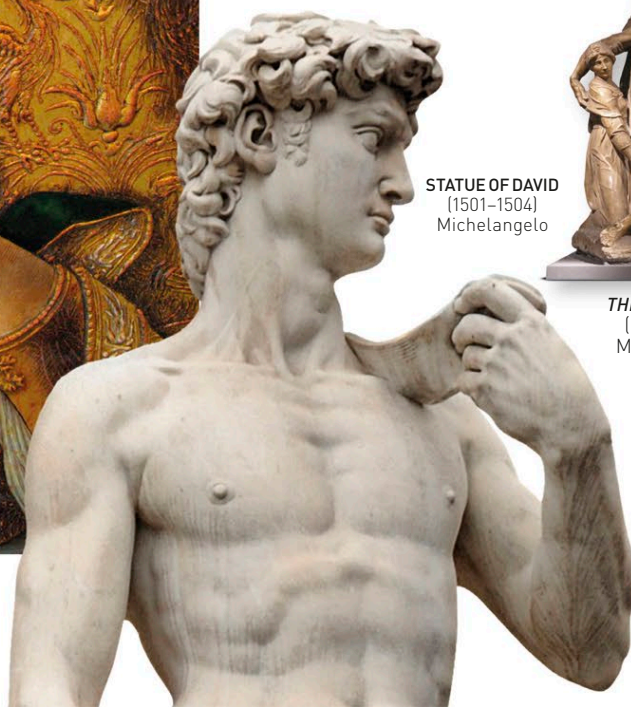
**MONA LISA** (1503–1506)  
Leonardo da Vinci



**FRESCO (WALL PAINTING) OF THE QUEEN OF SHEBA** (1466)  
Piero della Francesca



**VIRGIN AND CHILD** (c.1480)  
Carlo Crivelli



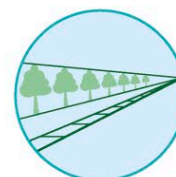
**STATUE OF DAVID** (1501–1504)  
Michelangelo



**THE DEPOSITION** (1547–1555)  
Michelangelo

## NEW ARTISTIC TECHNIQUES

Renaissance artists wanted their work to look realistic. They rediscovered ancient techniques and developed new ones to make their subjects and backgrounds look as much like those in the real world as possible.



### LINEAR PERSPECTIVE

Perspective was used to give an artwork a sense of depth. For instance, if an artist drew a line of trees, he would make them smaller and closer together as they got farther away from the foreground (front) of the drawing.



### AERIAL PERSPECTIVE

Also called atmospheric perspective. It was a way of creating depth and distance, especially in a landscape, by making features paler and less detailed the farther away they got from the foreground.



### HARMONY AND PROPORTION

Drawing objects so that they are precisely the right size when compared to each other. Artists rediscovered ancient Greek and Roman writings, which set out how mathematics could be used to work out ideal proportions. A work of art created in this way would have perfect balance and harmony, they believed.



2750 BCE

c. 2700 BCE

Egyptians build wooden ships capable of sea voyages. They begin trading with nearby countries.

334 BCE

Alexander the Great invades the Persian Empire, then continues east and north as far as what is now Pakistan and India.

1001 CE

Viking Leif Ericsson reaches North America and makes a settlement in Newfoundland, Canada.

1488

Bartholomeu Dias of Portugal sails from the Iberian Peninsula to southern Africa.

1497

Vasco da Gama sails around the Cape of Good Hope to India.

1519–1521

Portuguese Ferdinand Magellan is the first European to sail from the Atlantic Ocean to the Pacific Ocean.



Portuguese caravel (sailing ship)

1769

Captain James Cook discovers New Zealand.



Statue of Captain James Cook

1943

Jacques Cousteau invents the aqualung, an automatic air supply for divers.

1961

Yuri Gagarin becomes the first human in space.

2012

James Cameron reaches the bottom of the Mariana Trench, the deepest undersea location in the world.

2015

## ADVENTURERS AND EXPLORERS

From the first sailing expeditions to rocket-propelled space travel, humans have always gone beyond the limits of their known world to see what else is out there.

1500–500 BCE

Phoenicians (from what is now Israel and Lebanon) explore the Mediterranean, then as far as west Africa and Britain, looking for new trading partners.



Phoenician traders

1271

Marco Polo begins his exploration of China and Asia.



Marco Polo's China and Asia expedition

1492

Christopher Columbus lands in America and claims it for Spain.



Christopher Columbus's coat of arms

1577–1580

Englishman Sir Francis Drake circumnavigates the globe (sails around the world).



Statue of Sir Francis Drake

1642

Abel Tasman explores Van Diemen's Land (now Tasmania).



Deep-sea diving helmet

1839

Augustus Siebe invents a helmet that enables divers to work at a depth of 197 ft (60 m).



Antarctic explorer's reindeer skin sleeping bag

1858

John Hanning Speke discovers Lake Victoria, Africa.

1911

Norwegian Roald Amundsen and his team reach the South Pole.



Amundsen arriving at the South Pole

1969

Neil Armstrong, commander of US's Apollo 11 mission, sets foot on the Moon.



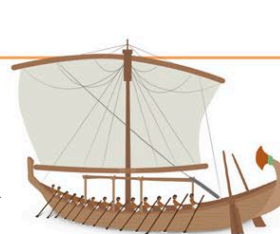
Apollo 11 commemoration badge

# Exploration

The first explorers set sail in search of new places to buy and sell goods. Later, people led expeditions to get rich, to claim territory for their country or religion, to make scientific discoveries, or simply for the thrill of adventure.

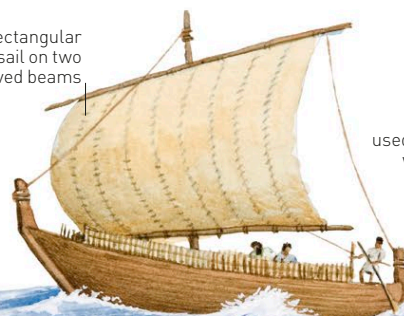
## EXPLORERS OF THE ANCIENT WORLD

The earliest explorers were the Phoenicians and the Egyptians, who wanted to find markets to trade their goods. Later cultures, such as the Romans and Vikings, also wanted to conquer new territories to expand their empires.



EGYPTIAN TRADING SHIP

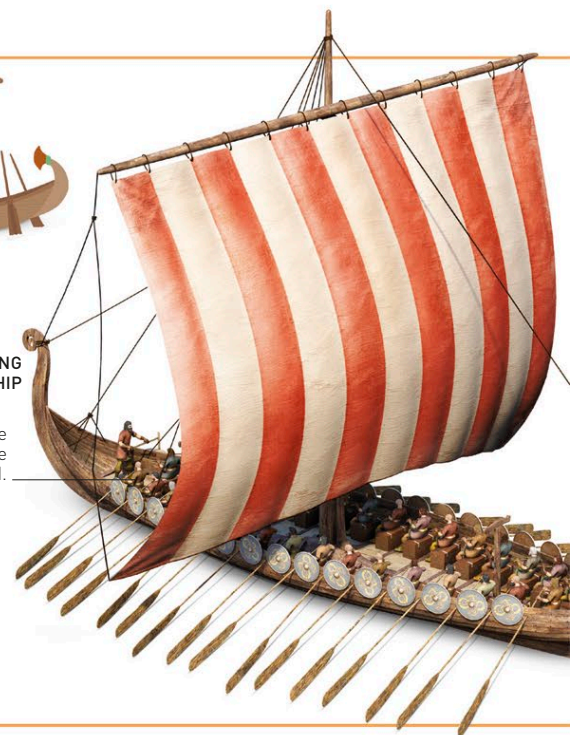
Rectangular sail on two curved beams



PHOENICIAN TRADING SHIP

VIKING LONGSHIP

Oars were used when there was no wind.



## THE AGE OF EXPLORATION

In the early 15th century, Portuguese sailors set out to find a sea route to Asia. This triggered a wave of exploration, as rival countries found new trading routes and established colonies all over the world.

### KEY

- Magellan's route
- Other Spanish missions
- Portuguese expeditions
- English expeditions
- French expeditions
- Dutch expeditions

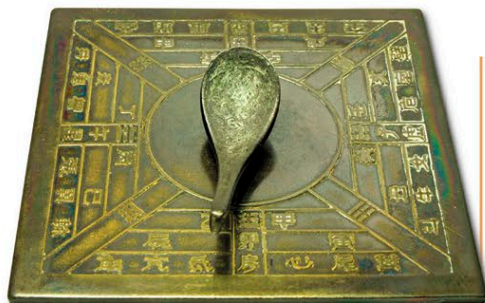


**SOME EXPEDITIONS TOOK MANY YEARS, AS THE SHIPS COULD ONLY COVER ABOUT 100 MILES (160 KM) IN A DAY.**



## NAVIGATION TOOLS

Sailors exploring new territories had no maps to guide them, so they had to find their way by other methods. Navigators used a compass to find the right direction, and they calculated their position by observing stars and planets.



**LODESTONE SPOON**  
An early type of magnetic compass.



**TELESCOPE**  
Used to identify landmarks from a distance.



**MAGNETIC COMPASS**  
18th century, England.



**GLOBE**  
For calculating routes and bearings.



**ASTROLABE**  
Allowed sailors to use the stars to navigate.



**EARLY AIRCRAFT INSTRUMENT PANEL**  
Showed aircraft's height and speed.

## SCIENTIFIC JOURNEYS

In the 19th century, the thirst for knowledge was so great that scientists and naturalists such as Charles Darwin embarked on long and dangerous trips to search out new species of animals or plants.



**MICROSCOPE**  
Used by Charles Darwin in the 1830s.



**BEETLE SPECIMENS**  
Collected by Charles Darwin.



**INSECT DRAWINGS**  
Sketched by naturalist Henry Bates.



**SNOUTFISH**  
Collected by explorer Mary Kingsley.

## ADVENTURERS OF THE GOLDEN AGE

Exploration was a risky business, but the rewards were potentially huge. Successful explorers could expect fame, wealth, and personal favors from a grateful monarch.

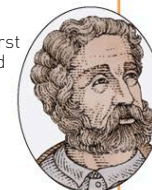
- CHRISTOPHER COLUMBUS (1451-1506)** Italian sailor Columbus was paid by King Ferdinand and Queen Isabella of Spain to find a sea route to China. Instead, in 1492, he found America and called it the New World.



**VASCO DA GAMA**

- VASCO DA GAMA (c.1460-1524)** A Portuguese explorer, he led the first expedition to sail around the Cape of Good Hope, at the tip of Africa, to India.

- FERDINAND MAGELLAN (1480-1521)** Magellan led the first expedition to sail all the way around the world. Unfortunately, Magellan himself did not make it home alive: he was killed in a battle between local tribes in the Philippines.



**FERDINAND MAGELLAN**

- HERNÁN CORTÉS (1485-1547)** A Spanish conquistador (soldier), Cortés first traveled to Mexico to set up a trading colony for Spain but ended up destroying the entire Aztec Empire in Central America.



**SIR WALTER RALEIGH**

- SIR WALTER RALEIGH (c.1552-1618)** An English adventurer who tried unsuccessfully to set up colonies in the New World but who is best remembered for bringing tobacco back to Europe from the Americas.



## POLAR PIONEERS

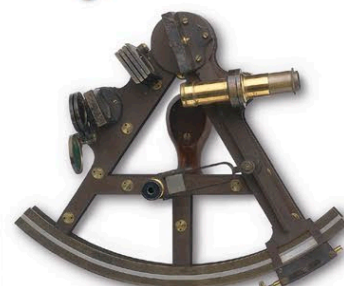
In the 19th century, the cold, hostile regions of the Arctic and Antarctic were largely undiscovered. Explorers from many different countries joined the race to be the first to conquer the North and South Poles.



**CHEMISTRY SET**  
Used by Captain Robert Scott's team for experiments in their second South Pole expedition, 1910-1912.



**WINDPROOF HOOD**  
Worn by Sir Ernest Shackleton on his South Pole attempt of 1907-1908.



**CLASP KNIFE AND SEXTANT**  
Used by Captain Scott on his South Pole expedition of 1912.



**CROSS-COUNTRY SKIS**  
Used by Captain Scott on his first South Pole expedition, 1901-1904.



**POLAR SLED**  
Wooden sled loaded with scientific equipment, food, and medical supplies from a polar expedition, 1934-1937.



# Great leaders

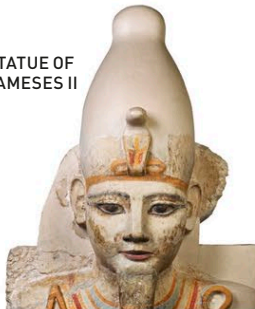
Ever since humans started to live together in communities, leaders have inspired and influenced people. From war victories and political revolutions to social changes and business breakthroughs, they have directed the course of history and shaped our societies. Many leaders have left a lasting mark on our lives.

◀ c.1302–1213 BCE

## RAMESES II

One of Egypt's greatest pharaohs, Ramses II ruled for almost 70 years. He used a combination of smart military strategy and skillful diplomacy to bring prosperity to his kingdom. The temples at Abu Simbel and Karnak were built during his reign.

STATUE OF RAMESES II



▶ 356–323 BCE

## ALEXANDER THE GREAT

This ambitious king of Macedon (a kingdom in northern Greece) created a vast empire stretching from Egypt to northwest India. By conquering many peoples, he helped to spread ancient Greek culture across the known world.

STATUE OF ALEXANDER THE GREAT



▶ 304–232 BCE

**ASHOKA'S  
"LION CAPITAL"  
SCULPTURE IS INDIA'S  
NATIONAL EMBLEM.**

## ASHOKA

Emperor Ashoka of India's Maurya Dynasty (322–185 BCE) began his reign as a ruthless warrior. Under his rule, his empire extended from modern-day Afghanistan in the west to Bangladesh in the east. He later became an advocate of peace and nonviolence when he converted to Buddhism.

◀ c.1822–1913

## HARRIET TUBMAN

Tubman was an African American enslaved woman who escaped her owners in 1849. Despite a large bounty on her head, she led countless other enslaved people to freedom via the "Underground Railroad," a secret network of shelters. During the Civil War, she fought for the abolition of slavery.



▶ 1809–1865

## ABRAHAM LINCOLN

Lincoln was a natural leader who rose to power from a humble background. This self-trained lawyer became president and led the US through the Civil War (1861–1865), abolishing slavery and helping heal deep divisions in the country.



MEDALLION DEPICTING ABRAHAM LINCOLN

◀ 1783–1830

**"When tyranny becomes law, rebellion is a right."**

## SIMÓN BOLÍVAR

Venezuelan general Simón Bolívar was inspired by revolutionary ideas popular in Europe in the 19th century. He helped end 300 years of Spanish rule in six South American countries: Venezuela, Bolivia, Peru, Ecuador, Colombia, and Panama.

◀ 1769–1821

## NAPOLEON BONAPARTE

Born in Corsica, Napoleon led the French Army to many victories before declaring himself Emperor of France in 1804. He introduced the Napoleonic code—a set of civil laws that treated all men as equal and was adopted across much of Europe.



◀ 1729–1796



IVORY CARVING OF CATHERINE THE GREAT

## CATHERINE THE GREAT

Credited with starting the Russian school system, Catherine II, empress of Russia, turned her nation into a major European power. A patron of learning and the arts, she remodeled the Winter Palace in St. Petersburg.

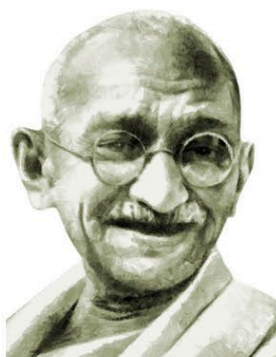
▶ 1858–1928

## EMMELINE PANKHURST

A British activist, Pankhurst fought for the right of women to vote. She founded the Women's Social and Political Union in 1903. Its members, called suffragettes, included her three daughters, and campaigned by organizing marches, chaining themselves to railings, or smashing windows.



▶ 1869–1948



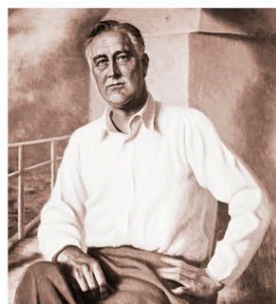
## MAHATMA GANDHI

Mohandas Karamchand Gandhi's peaceful, nonviolent protest against British rule in India was vital to India's struggle for independence. He led the resistance until India became independent in 1947.

▶ 1882–1945

## FRANKLIN D. ROOSEVELT

The only US president to serve four consecutive terms, Roosevelt was first elected during the Great Depression (1929–1939). He brought the US out of the economic slump through a series of reforms, provided much-needed aid to Britain during WWII (1939–1945), and helped plan the creation of the United Nations.



▶ 1898–1978



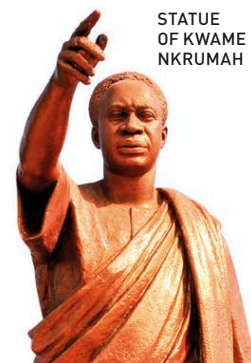
## GOLDA MEIR

A teacher and stateswoman, Meir was a signatory of Israel's declaration of independence in 1948. She was elected prime minister in 1969 and led Israel through the Yom Kippur War against Egyptian and Syrian forces in 1973.

▶ 1909–1972

## KWAME NKRUMAH

A revolutionary and politician, Nkrumah led Ghana to independence from British rule in 1957. His encouragement of activists across the continent led to the African Independence movement.



STATUE OF KWAME NKRUMAH



▶ 100–44 BCE

ROMAN COIN  
DEPICTING CAESAR**JULIUS CAESAR**

A skilled speaker and powerful Roman general, Gaius Julius Caesar declared himself dictator for life after winning the Great Roman Civil War (49–45 BCE). He played a major role in transforming the Roman Republic into a vast empire.

▶ c.69–30 BCE

**CLEOPATRA VII**

The last Egyptian pharaoh, Cleopatra VII was renowned for her military prowess and beauty. Despite alliances with Roman generals, she was unable to preserve Egypt's independence from the mighty Roman Empire.



BUST OF CLEOPATRA VII

▶ 624–705 CE

**WU ZETIAN**

Empress Wu Zetian was the first and only female emperor of China to rule in her own name. A skillful ruler, she introduced many reforms to promote education and help the poor. She believed women should have the same rights and opportunities as men.

▶ 1137–1193

**SALADIN**

This Muslim Sultan (king) of Egypt and Syria was capable in diplomacy and warfare. He was a generous and brave ruler whose capture of Jerusalem from the Crusaders in 1187 ended Christian rule in the Holy Land forever.

▶ 1412–1431

**JOAN OF ARC**

This French teenager was only 17 when she declared that she had been chosen by God to fight in the Hundred Years' War (1337–1453) between France and England. She led her army to victory in the city of Orléans but was killed at 19.

STATUE OF  
JOAN OF ARC

◀ 1717–1780

**MARIA THERESA**

Maria Theresa was only 23 when she became the Empress of the Austrian Habsburg Dynasty. She reformed the government and the military, and used diplomacy to solve her kingdom's international problems. She also introduced compulsory education for all in 1774.

SILVER COIN SHOWING  
MARIA THERESA, 1780

◀ 1672–1725

**"I have conquered an empire, but I have not been able to conquer myself."**

**PETER THE GREAT**

When Peter I became the Czar (king) of Russia, he pushed back against the country's conservative aristocracy to focus on military, social, and religious reforms.

◀ 1543–1616

**TOKUGAWA IYASU**

A fierce warrior and politician, Tokugawa Iyasu established the Tokugawa Shogunate (1600–1868) in Japan, starting an era of prosperity that lasted for nearly three centuries.

STATUE OF  
TOKUGAWA  
IYASU

◀ 1542–1605

**AKBAR**

Known as Akbar the Great, Akbar extended the Mughal Empire across most of India through war and diplomacy. Tolerant of all faiths, and a lover of the arts, Akbar's court was a center of culture.



◀ 1418–1471

STATUE OF  
PACHACUTI  
INCA**PACHACUTI INCA**

Pachacuti was the ninth ruler of the Incas. He expanded his control beyond the small city of Cuzco (in modern-day Peru, South America), establishing the first Incan Empire. He founded the city of Machu Picchu.

▶ 1918–2013

**NELSON MANDELA**

Apartheid was a law that forced the black and white populations of South Africa to stay separated. Nelson Mandela opposed this passionately. He was arrested and jailed for 27 years. South Africa finally ended apartheid after international pressure. Mandela was released in 1991 and elected President in 1994.

▶ 1929–1968

**MARTIN LUTHER KING JR.**

The leader of the civil rights movement in the US, King organized large-scale peace marches and strikes and rallied the people against the discrimination and inequality faced by African Americans in the country.



▶ 1930–1978

**"Rights are won only by those who make their voices heard."**

**HARVEY MILK**

American gay-rights activist and politician, Milk made history in 1977, when he became one of the first openly gay government officials in US history. He succeeded in pushing through a law that banned discrimination against gay people looking for housing and employment.

▶ 1954–

**ANGELA MERKEL**

Merkel is the first female chancellor of Germany. The leader of Europe's strongest economy, she served for four consecutive terms between 2005 and 2021. Her belief in universal human rights to asylum led to Germany opening its doors to refugees from many war-torn countries.



▶ 2003–

**GRETA THUNBERG**

As a teenager, this Swedish environmental activist sparked a global movement against the climate crisis. In 2019, young people across the world joined Thunberg in protesting against world leaders' inaction on climate change.

**INSPIRED BY  
GRETA THUNBERG,  
PEOPLE IN 185 COUNTRIES  
PARTICIPATED IN THE  
GLOBAL CLIMATE  
STRIKE OF 2019.**



# Revolutions

Political revolutions have occurred throughout history and can completely change society. Often violent, they typically occur when angry citizens rebel against their rulers to demand a fairer society—and frequently a different leadership. Revolutions can change existing power structures very quickly. However, their causes have usually been building over many years.

► 1566–1648

## DUTCH REVOLT

In 1566–1568, Dutch Protestants rose up against Catholic Spain, which had ruled the Netherlands since 1555, and declared independence. The revolt led to a long and bloody war with Spain that ended with Dutch independence in 1648.



MEDAL COMMEMORATING  
ENGLISH SUPPORT FOR  
THE DUTCH

► 1640–1660



ENGLISH CIVIL WAR  
TROOPER'S HELMET

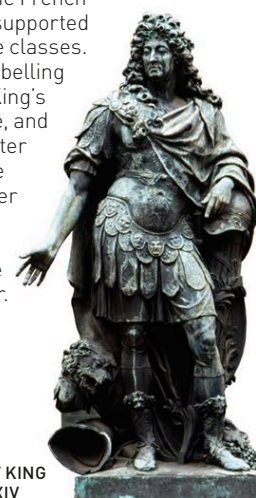
## ENGLISH CIVIL WAR

This period of intense political activity started when Parliament wished to restrict the authority of King Charles I. Civil war broke out and ended with the execution of the king in 1649. For 10 years, England was a republic, ruled from 1653 by Lord Protector Oliver Cromwell and his son.

► 1648–1653

## THE FRONDE

A series of uprisings called the Fronde took place in France, initiated by the French nobility and supported by the middle classes. They were rebelling against the King's absolute rule, and discontent later spread to the masses. After the Fronde failed, the King became even stronger.



STATUE OF KING  
LOUIS XIV

◀ 1945



HO CHI MINH:  
LEADER OF THE VIET MINH

## AUGUST REVOLUTION

In 1945, Ho Chi Minh and his mainly communist force, the Viet Minh, set out to liberate Vietnam from French rule. They seized Hanoi and declared independence, but French forces retaliated. This led to the First Indochina War and the start of bitter conflict in the region.

◀ 1936–1939

## SPANISH CIVIL WAR

This revolt against the Spanish government led to civil war. The nationalists were led by General Francisco Franco, backed by Nazi Germany and Fascist Italy. They fought Republicans: Communists, socialists, and anarchists, who were backed by the Soviet Union.



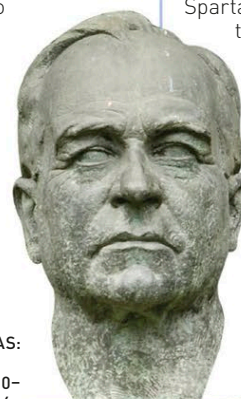
GENERAL FRANCO: DICTATOR  
OF SPAIN 1939–1975

◀ 1930

## BRAZILIAN REVOLUTION

Economic hardship, powerful landlords, and demands for workers' rights led to revolution in Brazil in 1930. A provincial governor named Getúlio Vargas seized power. A dictator at first, he introduced reforms that modernized Brazil and earned him the nickname "Father of the Poor."

GETÚLIO VARGAS:  
BRAZILIAN  
PRESIDENT 1930–  
1945, 1951–1954



◀ 1918–1923

## GERMAN REVOLUTION

A series of revolutions shook Germany immediately after World War I (1914–1918). Communists Rosa Luxemburg and Karl Liebknecht led the Spartacists' uprising against the government, but it was brutally quashed. Later, extreme nationalists, led by Wolfgang Kapp, tried to seize power, blaming the Weimar Republic for betraying the German Empire.

◀ 1917

STATUE OF LENIN,  
BOLSHEVIK LEADER

## OCTOBER REVOLUTION

Two revolutions happened in Russia in 1917. The first, in March, removed the czar (ruler) and set up a provisional government. In the second, in October, the Bolshevik party, led by Vladimir Ilyich Ulyanov (Lenin), called for "peace, land, and bread." They seized power and in 1922 set up the Soviet Union, the world's first Communist state.



► 1946–1949

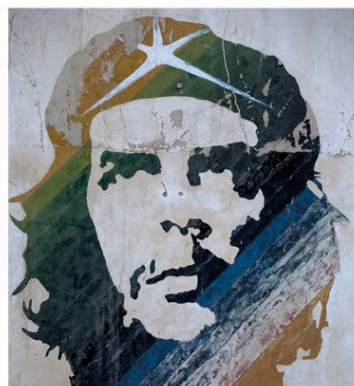
## CHINESE REVOLUTION

From the 1920s onward, there was a struggle for control of China between the Kuomintang, or nationalists, led by Chiang kai-shek, and Communists under Mao Zedong. Civil war broke out in 1945, ending with a Communist victory in 1949.



MAO ZEDONG

► 1953–1959



REVOLUTIONARY CHE GUEVARA  
BECAME A WORLDWIDE HERO

## CUBAN REVOLUTION

An armed revolution led by Fidel Castro and Che Guevara overthrew the US-backed dictatorship of President Fulgencio Batista. Cuba became a revolutionary socialist state and later a Communist country.

► 1956

## HUNGARIAN REVOLUTION

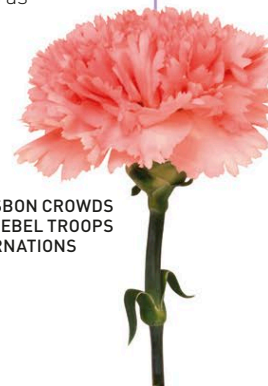
After World War II (1939–1945), Hungary became a Communist state under the influence of the Soviet Union. In 1953, Imre Nagy, a moderate socialist, became leader, and in October 1956, he called for Hungary to become independent in an anti-Soviet uprising. The Soviet troops invaded Hungary and put down the uprising with great brutality.

► 1974

## CARNATION REVOLUTION

On April 25, 1974, army rebel tanks rolled into Lisbon, Portugal, and seized control of the city's communications. They overthrew the government of Prime Minister Marcello Caetano, ending 50 years of dictatorship. The revolt was called the "carnation revolution" because the people gave carnations to the troops as they entered the city.

GRATEFUL LISBON CROWDS  
PRESENTED REBEL TROOPS  
WITH CARNATIONS



► 1974–1977

## ETHIOPIAN REVOLUTION

In September 1974, Mengistu Haile Mariam led an alliance of radical armed forces and police (the Derg) to depose the emperor, Haile Selassie. They executed the emperor and set up a Communist state. The coup was followed by years of bloodshed and civil war.



▶ 1775–1783

## AMERICAN REVOLUTION

In the mid-1770s, American colonists revolted against British rule and “taxation without representation.” They issued a Declaration of Independence. War broke out in 1775, ending in 1783 with the colonists winning independence and creating the United States of America.



THE US CONSTITUTION, DRAWN UP IN 1787

▶ 1789–1799



THE STORMING OF THE BASTILLE, A PRISON IN PARIS, JULY 14, 1789

## FRENCH REVOLUTION

This rebellion was against poverty, the nobility, and the royal family. In Paris, revolutionaries demanding political change stormed the Bastille. A National Assembly was formed and the Declaration of the Rights of Man called for liberty, equality, and fraternity (brotherhood). King Louis XVI and his wife Marie Antoinette were executed, and France became a republic.

▶ 1791–1804

## HAITIAN REVOLUTION

In the French colony of Saint-Domingue, former slave Toussaint L'Ouverture led slaves in a rebellion against slavery, burning plantations and killing their owners. Slavery was abolished on the island, which became independent Haiti.



L'OUVERTURE LEADING REVOLT AGAINST FRENCH PLANTATION OWNERS

▶ 1806–1826

## LATIN-AMERICAN REVOLUTIONS

Influenced by the American, French, and Haitian revolutions, Latin-American revolutionaries led by men such as Venezuelan Simón Bolívar and Argentinian José de San Martín rose up against Spanish colonial rule. By 1825, most of Latin America had gained independence.



SIMÓN BOLÍVAR, KNOWN AS “THE LIBERATOR”

◀ 1911

## XINHA REVOLUTION

During the Xinhai Revolution, nationalists overthrew the Manchu Dynasty in China, ending 2,000 years of imperial rule. They set up a republic under Sun Yat-sen, although real power stayed in the hands of provincial warlords.

SUN YAT-SEN



◀ 1910–1920

## MEXICAN REVOLUTION

The Mexican Revolution started as a protest against the dictatorship of President Porfirio Díaz but soon spiraled into an armed revolution that lasted around 10 years. Led by Emiliano Zapata, Pascual Orozco, and Pancho Villa, the rebels fought to reform society.

“IT IS BETTER TO DIE ON YOUR FEET THAN TO LIVE ON YOUR KNEES.”

EMILIANO ZAPATA, REVOLUTIONARY LEADER

◀ 1868



EMPEROR MEIJI RULED 1867–1912

## MEIJI RESTORATION

Led mainly by young samurai, this revolution in Japan overthrew the Tokugawa shogunate (hereditary military rulers) and restored imperial rule under Emperor Meiji. The revolution led to reforms that modernized Japan.

◀ 1848

## EUROPEAN REVOLUTIONS

Often called “the year of revolutions,” 1848 saw more than 50 uprisings break out across Europe. Although these revolutions happened independently, people across the continent were banding together to demand political and social change and an end to monarchies. Thousands were killed as the uprisings were put down.



THE HUNGARIAN TRICOLOR FLAG, A SYMBOL OF THE 1848 REVOLUTION

▶ 1979

## NICARAGUA

In the 1970s, there were extremes of rich and poor in Nicaragua. Supported by peasants, urban workers, and the middle classes, the guerrilla troops of the Sandinista National Liberation Front (FSLN) threw out wealthy dictator Anastasio Somoza and introduced new socialist reforms. Later, rebel groups called the Contras fought back against the Sandinistas, who lost power in 1990.

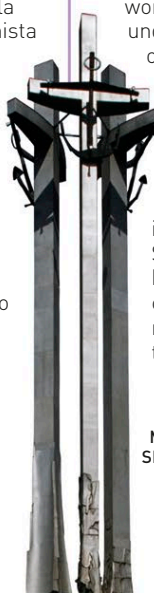
▶ 1980–1981

## SOLIDARITY IN POLAND

Revolution broke out in Poland when the independent trade union Solidarity organized workers' strikes, under the leadership of Lech Wałęsa.

They wanted liberation from Soviet control, and their actions forced the Polish government to introduce reforms. Solidarity was banned but continued their resistance until they took power in 1990.

MONUMENT TO THE SHIPYARD WORKERS, GDANSK, POLAND



▶ 1986



YELLOW RIBBON

## YELLOW REVOLUTION

The Yellow Revolution was a series of mass popular protests in the Philippines against the corrupt regime of President Ferdinand Marcos. In this nonviolent revolution, more than 2 million Filipinos demonstrated for greater democracy, displaying yellow ribbons as a symbol of protest. Marcos departed and was replaced by Corazón Aquino.

▶ 1988–1991

## EASTERN EUROPE

By the late 1980s, protests were spreading through the Soviet satellite states of Eastern Europe, demanding greater democracy. In Berlin, demonstrators pulled down the hated Berlin Wall that divided East and West Germany, and by 1989, Communism had collapsed throughout Eastern and Central Europe.



FRAGMENT OF THE BERLIN WALL

▶ 2004–2005

## ORANGE REVOLUTION

Taking its name from the orange banners and clothes of demonstrators, the Orange Revolution in Ukraine was made up of mass protests against the undemocratic election of a Russian-backed president. The election was repeated and anticorruption candidate Viktor Yushchenko was elected.

▶ 2010–2012

## ARAB SPRING

Starting in 2010, a wave of pro-democracy uprisings took place in the Middle East and North Africa—in Tunisia, Egypt, Libya, Yemen, and Syria, among others—that challenged authoritarian governments. Protesters were met with violence. Regimes in Tunisia and Egypt were toppled, but Libya, Syria, and Yemen descended into civil war.

EACH DAY, 5,500 TONS OF OATMEAL AND 10,000 LOAVES WERE SUPPLIED TO ORANGE REVOLUTION PROTESTERS IN UKRAINE.



# US Presidents

Since the office was created in 1789, there have been 44 different presidents of the United States, all men. To be eligible, a person has to be at least 35 years old and born either in the US or overseas to US-citizen parents. As well as being Head of State, the president is Commander-in-Chief of the country's armed forces.



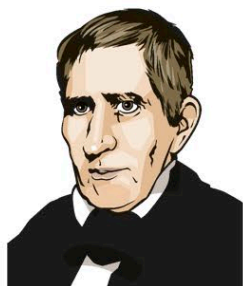
**GEORGE WASHINGTON**

**1789–1797**  
Led army against the British in the American Revolution, then became the first president. Unanimously elected.



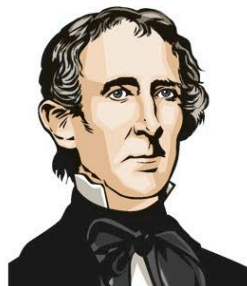
**JOHN ADAMS**

**1797–1801**  
Helped draft the Declaration of Independence. Established the naval department, so he is remembered as the "Father of the Navy."



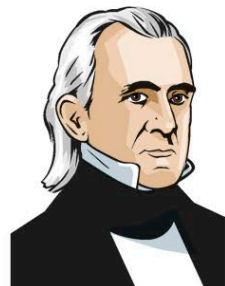
**WILLIAM HENRY HARRISON**

**1841**  
The first president to die in office. He died of pneumonia only a month after he became president.



**JOHN TYLER**

**1841–1845**  
Vice president who took the presidency on the death of William Henry Harrison, making him the first president to serve without being elected to office.



**JAMES K. POLK**

**1845–1849**  
Greatly expanded the territory of the US, adding Texas, Wisconsin, and Iowa as states and taking over land in the west that would become New Mexico and California.



**ZACHARY TAYLOR**

**1849–1850**  
Successful military general who commanded US forces in the war against Mexico (1846–1848). Died of cholera a year after taking office.



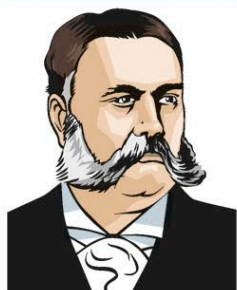
**MILLARD FILLMORE**

**1850–1853**  
Tried to make a compromise between the anti-slavery states and the slave-owning states in the south, but the peace was short-lived.



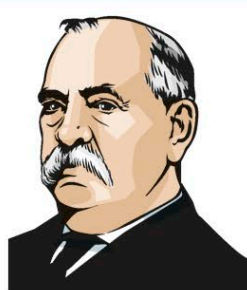
**FRANKLIN PIERCE**

**1853–1857**  
Allowed new states to decide for themselves whether to allow slavery, which angered many and edged the US closer to civil war.



**CHESTER A. ARTHUR**

**1881–1885**  
Brought in a law that meant that civil servants were hired purely for their ability rather than because of their political connections.



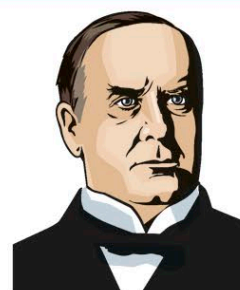
**GROVER CLEVELAND**

**1885–1889; 1893–1897**  
The only president ever to serve two nonconsecutive terms—he lost an election, then was voted back in again four years later.



**BENJAMIN HARRISON**

**1889–1893**  
Grandson of President William Harrison. During his term, the country expanded and six new states were admitted to the Union.



**WILLIAM MCKINLEY**

**1897–1901**  
Oversaw expansion of US territories, including Hawaii and Puerto Rico. Six months into his second term, he was assassinated.



**THEODORE ROOSEVELT**

**1901–1909**  
The youngest person to become president, at 42. Won the Nobel Peace Prize in 1906 for negotiating peace between Russia and Japan.



**WILLIAM H. TAFT**

**1909–1913**  
A lawyer by profession, he set up the postal savings bank and passed a law allowing the collection of federal income tax.



**DWIGHT D. EISENHOWER**

**1953–1961**  
Led the Allied armed forces in World War II. During his two terms of office, the US economy thrived.



**JOHN F. KENNEDY**

**1961–1963**  
His work to reform civil rights and promote racial equality was cut short when he was shot dead in Texas.



**LYNDON B. JOHNSON**

**1963–1969**  
Brought in the Civil Rights Act, but faced opposition for sending more troops into the war in Vietnam.



**RICHARD NIXON**

**1969–1974**  
Ended the Vietnam War and improved relations with the USSR. His term ended in disgrace after political corruption was uncovered.



**GERALD FORD**

**1974–1977**  
Unexpectedly became vice president, then president, during an era of scandals. His honesty helped restore the image of the presidency.



**JIMMY CARTER**

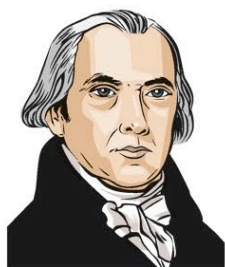
**1977–1981**  
President during a difficult period for the US, both at home and abroad. After his term in office, he became a respected statesman.





**THOMAS JEFFERSON**

**1801–1809**  
The main author of the Declaration of Independence, which stated that the colonies would no longer accept British rule.



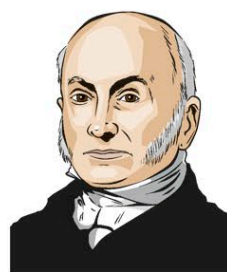
**JAMES MADISON**

**1809–1817**  
Helped draw up the US Constitution, which set out America's laws and guaranteed certain rights for its citizens.



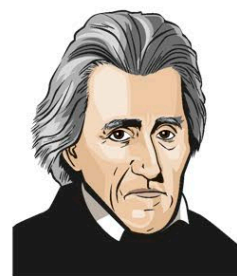
**JAMES MONROE**

**1817–1825**  
Remembered for the Monroe Doctrine, which declared that the US would resist attempts by other countries to establish colonies in the Americas.



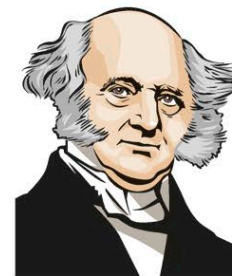
**JOHN QUINCY ADAMS**

**1825–1829**  
Son of a previous president, John Adams. After his presidency, he became a strong campaigner against slavery.



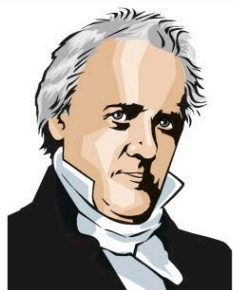
**ANDREW JACKSON**

**1829–1837**  
Before he took office, he became a national hero for leading the army that defeated the British at the Battle of New Orleans.



**MARTIN VAN BUREN**

**1837–1841**  
After financial panic and a stock market crash led to economic depression, Van Buren became unpopular and was not reelected.



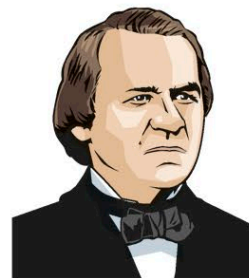
**JAMES BUCHANAN**

**1857–1861**  
Like previous presidents, he tried to make peace between states on the slavery issue, but by the end of his term, civil war was looming.



**ABRAHAM LINCOLN**

**1861–1865**  
Opposed to slavery, he led the country during four years of civil war. Days after the war ended, he was shot dead by John Wilkes Booth.



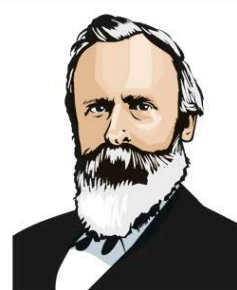
**ANDREW JOHNSON**

**1865–1869**  
Put on trial by the Senate for violating the Tenure of Office Act, he escaped being removed from office by a single vote.



**ULYSSES S. GRANT**

**1869–1877**  
A hero of the Civil War, he was an inexperienced politician whose presidency was overshadowed by scandal and corruption.



**RUTHERFORD B. HAYES**

**1877–1881**  
After winning one of the closest presidential elections ever, he fought to end corruption in politics and public life.



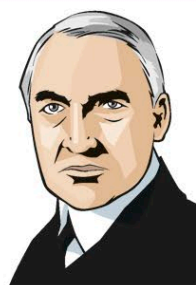
**JAMES A. GARFIELD**

**1881**  
Shot dead after only 200 days in office before he could carry out his promise to reform the civil service and other public bodies.



**WOODROW WILSON**

**1913–1921**  
Took the US into World War I in 1917. After the war, he proposed the formation of the League of Nations to try to prevent future conflict.



**WARREN G. HARDING**

**1921–1923**  
An unpopular president who was dogged by rumors of financial wrongdoing. He died suddenly before an investigation could begin.



**CALVIN COOLIDGE**

**1923–1929**  
Honest, hard-working, and modest, he was fondly nicknamed "Silent Cal." Under his presidency, the US economy boomed.



**HERBERT HOOVER**

**1929–1933**  
Shortly after his election, the US began an era of serious economic depression. Hoover was blamed and did not win a second term.



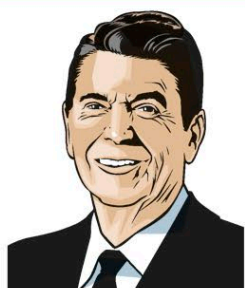
**FRANKLIN D. ROOSEVELT**

**1933–1945**  
Led the US through the Great Depression and World War II. He funded a plan to revive the US economy and help people out of poverty.



**HARRY S. TRUMAN**

**1945–1953**  
Authorized the dropping of two nuclear bombs on Japan, which ended World War II. Took the US to war with Korea.



**RONALD REAGAN**

**1981–1989**  
An ex-Hollywood star, he helped end the Cold War. He was shot by a would-be assassin but recovered.



**GEORGE H. W. BUSH**

**1989–1993**  
An oil tycoon and ex-head of the CIA, he took the US and its allies into the first Gulf War with Iraq (1990–1991).



**BILL CLINTON**

**1993–2001**  
Presided over a time of peace and prosperity, but his reputation was damaged by a scandal over a relationship with a White House worker.



**GEORGE W. BUSH**

**2001–2009**  
After the terrorist attacks of 9/11, he ordered the invasion of Afghanistan and declared the War on Terror.



**BARACK OBAMA**

**2009–2017**  
The first African American president. His healthcare reforms were disliked by opponents and led to stalemate in government.



**DONALD TRUMP**

**2017–**  
Former businessman and TV celebrity. During his presidency, he courted controversy on issues such as the building of a border wall with Mexico.



# US Civil War

In the early 1860s, the US, then known as the Union, was torn apart by war. The northern states had made slavery illegal and believed it should be abolished in the rest of the country. The southern states disagreed. Their landowners relied on African slaves to farm their tobacco and cotton. Some southern states felt so strongly, they left the Union.

## EVENTS AND BATTLES

Less than a century after gaining its independence, the US was in danger of breaking up. More than 50 major battles and 5,000 minor ones were fought before the Unionists finally won the war.

1860



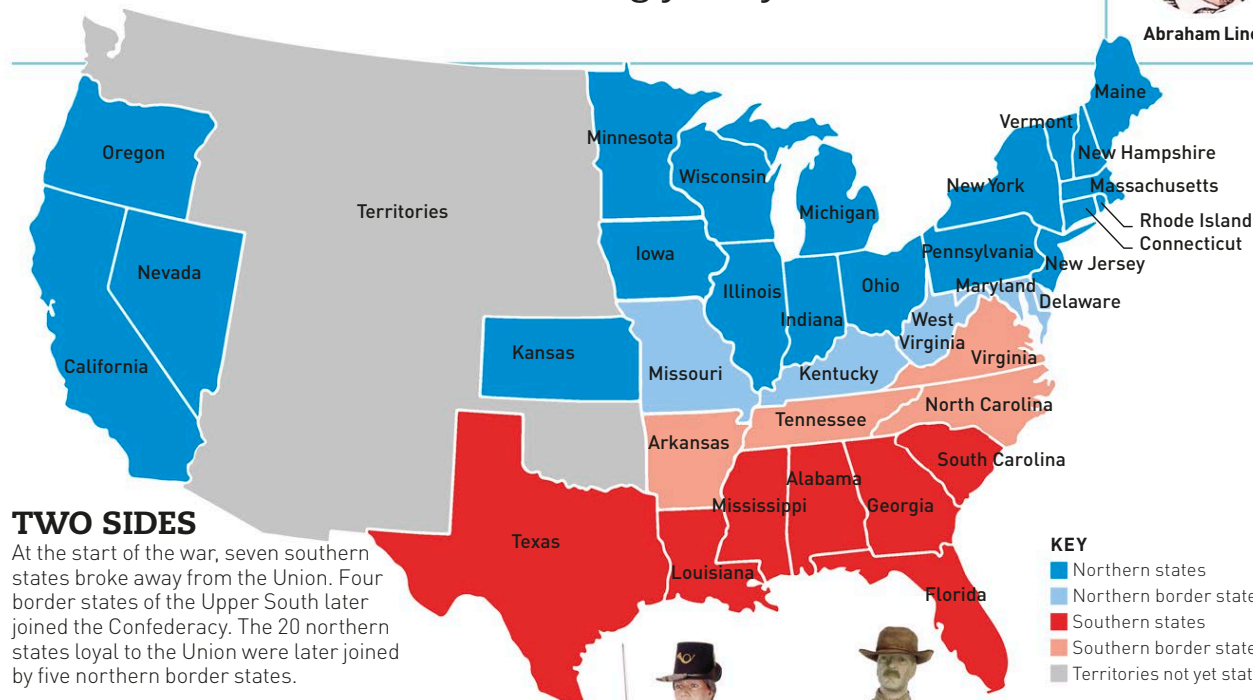
Abraham Lincoln

**NOVEMBER 6, 1860**  
Abraham Lincoln is elected the 16th US president. He promises to abolish slavery.

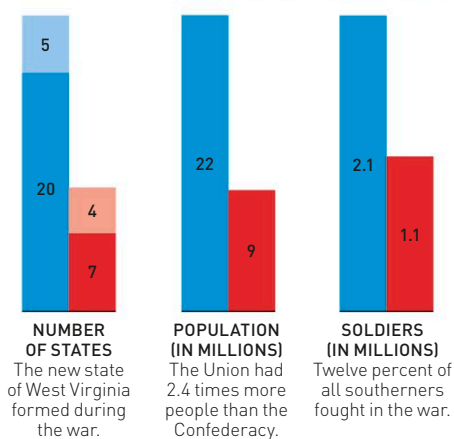
**DECEMBER 20, 1860**  
South Carolina withdraws from the Union. Six states follow by February 1861.



Confederate flag



**ONE IN FOUR SOLDIERS WHO WENT TO WAR NEVER CAME HOME—MANY WENT MISSING.**



## UNIFORMS AND GEAR

The Union side wore blue and the Confederates wore gray. Soldiers carried their food, water, toiletries, ammunition, and personal belongings in a knapsack. Union soldiers were better equipped because the North had more factories to make supplies and railways to transport them.



UNION SOLDIER'S LAP DESK



TOOTHBRUSH



CANDLE IN TIN



UNION INFANTRY UNIFORM



CONFEDERATE INFANTRY UNIFORM



WATER CANTEEN



TIN MUG



KNIFE



RAZOR



KNIFE AND FORK



SOAP



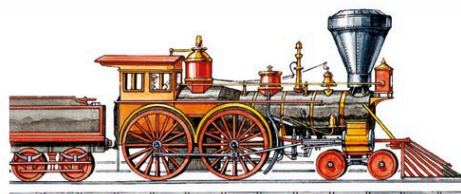
KNAPSACK



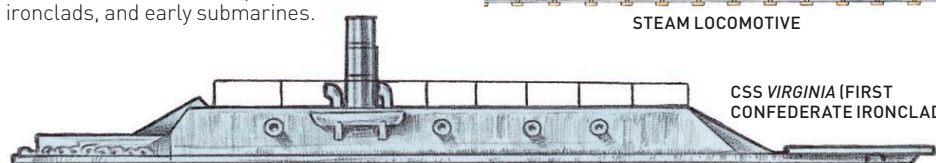
CARTRIDGE BOX

## TRANSPORT INNOVATIONS

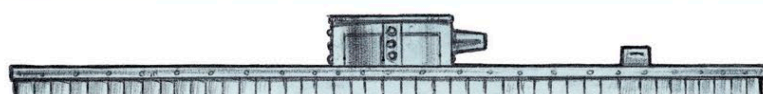
The 1830s had seen the birth of the railways. Both sides relied on steam trains to transport troops and supplies, but the North had more than twice as much track as the South. Other advances included the appearance of armored steam warships, called ironclads, and early submarines.



STEAM LOCOMOTIVE



CSS VIRGINIA (FIRST CONFEDERATE IRONCLAD)



USS MONITOR (FIRST UNION IRONCLAD)

## WEAPONS AND CONFLICT

The Civil War was the first in which large numbers of infantrymen were armed with rifles instead of muskets. Rifles shot farther and with greater accuracy. The repeating rifle, introduced in 1863, was even better—it could fire more than one bullet before it needed reloading.



BAYONET FOR SPRINGFIELD 1861



COLT ARMY MODEL 1860 REVOLVER



**APRIL 12-14, 1861**  
The first battle of the Civil War, fought at Fort Sumter, South Carolina, is a victory for the Confederates.



Union flag

**FEBRUARY 11-16, 1862**  
Ulysses S. Grant leads a Union victory at the Battle of Fort Donelson, Tennessee.



Ulysses S. Grant

**JULY 4, 1863**  
After a six-week siege, the Union army captures the city of Vicksburg, cutting off Arkansas, Louisiana, and Texas from the rest of the Confederacy.

**NOVEMBER 15-DECEMBER 21, 1864**  
Union General William T. Sherman sweeps through Georgia, ending victoriously at the port of Savannah.

**FEBRUARY 1, 1865**  
Lincoln signs the 13th Amendment, which formally abolishes slavery in the US.

**APRIL 9, 1865**  
Confederate General Lee surrenders to Union General Grant. The Civil War is over.

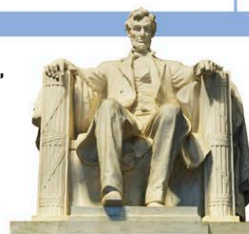
**JULY 21, 1861**  
The Union army is defeated at the first major battle of the war—the First Battle of Bull Run in Virginia. Almost 850 soldiers lose their lives (460 Union soldiers and 387 Confederates).

**MARCH 8-9, 1862**  
The Battle of Hampton Roads, off the coast of Virginia, sees the first combat between ironclad warships.

**SEPTEMBER 17, 1862**  
The Battle of Antietam takes place in Union territory near Sharpsburg, Maryland. With a total of 22,717 dead, wounded, or missing, it is the bloodiest single-day battle in US military history.

**JULY 1-3, 1863**  
The Union side halts the Confederates' advance at the Battle of Gettysburg, Pennsylvania.

**NOVEMBER 8, 1864**  
Lincoln is reelected US president for a second term of office.

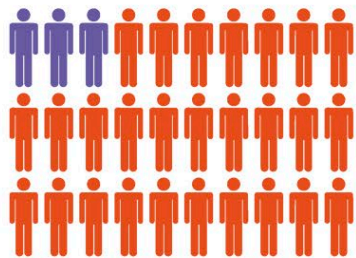


Lincoln Memorial

**APRIL 14, 1865**  
Lincoln is shot while at the theater by John Wilkes Booth. He dies a day later.

## AFRICAN AMERICAN SOLDIERS

Roughly a tenth of the Union army was made up of African American soldiers (179,000). There are no records of how many slaves were forced to fight for the South.



SOLDIERS IN THE UNION ARMY

### KEY

African American soldiers White soldiers

## UNION FIGURES

The people on this side were loyal to the United States of America. They were nicknamed "Yanks" or "Yankees."

### ABRAHAM LINCOLN (1809-1865)

As US president, Lincoln led his country through the war, abolished slavery, and saved the Union.

### ULYSSES S. GRANT (1822-1885)

General Grant led the Union army from 1862 onward. After the war, he served two terms as president.

### JOSHUA CHAMBERLAIN (1828-1914)

Chamberlain heroically led a crucial bayonet charge at Gettysburg.

### ROBERT SMALLS (1839-1915)

A southern slave, Smalls freed himself, took over a Confederate ship, then fought on the side of the Union.



UNION GENERAL

## CONFEDERATE FIGURES

People from the rebel states in the South broke away from the Union and formed a new country, the Confederacy.

### JEFFERSON DAVIS (1808-1889)

A soldier and senator, Davis was the president of the Confederate States of America.

### ROBERT E. LEE (1807-1870)

Virginia-born Lee became the supreme commander of all the Confederate forces.

### JOHN BROWN GORDON (1832-1904)

This fearless Confederate general was wounded so often that people said he must be invincible.

### BELLE BOYD (1844-1900)

A notorious spy, Maria "Belle" Boyd gathered information from Union soldiers.



CONFEDERATE GENERAL

## LIVES LOST

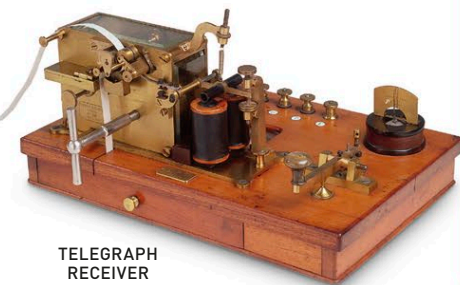
In total, an estimated 620,000 men lost their lives in the Civil War. Where possible, Union soldiers received a proper military funeral, but the military cemetery in Washington, DC, soon filled. Arlington, Virginia, the family estate of Confederate General Robert E. Lee's wife, Mary, was taken over for the new state cemetery.



ARLINGTON CEMETERY

## COMMUNICATION

Both Union and Confederate leaders made use of the newly invented electric telegraph. They could send messages to generals on the battlefield and receive updates on the fighting.



TELEGRAPH RECEIVER

## MEDICAL ADVANCES

Although basic hygiene was still poor, great strides were made in treating the wounded. Horse-drawn ambulances transported casualties between field hospitals. Women worked as nurses on the battlefield for the first time.



SET OF AMPUTATION KNIVES



BONE SAW



BOX OF INSTRUMENTS



LIGATURE NEEDLES

SAW

CRIMPER

FORCEPS



SPRINGFIELD 1861 RIFLE



CONFEDERATE COPY OF THE SPRINGFIELD 1861 RIFLE



SPENCER CARBINE (REPEATING RIFLE)

**THE SPENCER CARBINE COULD FIRE SEVEN SHOTS IN 30 SECONDS.**



CONFEDERATE DRUM

Those too young to carry a rifle enlisted as drummer boys. During battle, their drum calls communicated commands to the men.



## AGE OF IMPERIALISM

The growth of European empires spanned several hundred years and led to wars, revolutions, and rebellions by those who were unwilling to be controlled by foreign nations.

### 1500s

The Portuguese and Spanish start to explore widely, especially around South America.



Model of a Portuguese caravel

### 1565

The Spanish establish the first European colony in what is now the US. The first English colony is founded 20 years later in Roanoke.

### 1756–1763

The Seven Years War sees Britain become the world's largest colonial empire, gaining much of America and India in the global conflict.

### 1775–1781

The American states win independence from the British after the American Revolution.



The US constitution

### 1810–1826

Revolution in South America leads to most colonies freeing themselves from European rule.

### 1858–1947

British rule is imposed on India after the Indian rebellion of 1857 against the British East India Company.

### 1880–1914

European powers seek territory in Africa, invading and colonizing the continent in a "scramble for Africa."

### 1914–1918, 1939–1945

Two world wars end the Habsburg, Ottoman, Russian, German, Italian, and Japanese empires, and hasten the decline of others.

### 1947

The British make the first move to end colonialism by granting India independence after pressure from Mahatma Gandhi.



Statue of Mahatma Gandhi

### 1956

Disagreement over ownership of the Suez Canal in Egypt leads to the Suez Crisis. Britain and France lose their influence around the world.

### 1963

Independent African countries set up the Organization of African Unity to promote their economic, political, and cultural interests.



Flag of the Organization of African Unity

# European empires

AT ITS PEAK, THE  
BRITISH EMPIRE COVERED  
ONE-QUARTER OF THE  
WORLD'S LAND AREA.

As European explorers sailed around the world in the 16th century, they claimed new colonies for their home countries. Nations built empires overseas, and many became rich. However, the native people in these new empires were often treated very poorly.

## WHY BUILD AN EMPIRE?

Many European powers considered themselves to be superior to the rest of the world and thought they were the best people to govern, develop, and civilize other nations.



**EXPLORATION**  
People wanted to find new territories and trade routes.



**NATIONALISM**  
Nations wanted to demonstrate their power and compete with others.



**ECONOMY**  
There was a demand for new materials and new markets around the world.



**RELIGION AND IDEOLOGY**  
Religious groups wanted to convert more people to Christianity.

## BIGGEST EMPIRES

At their peak, some empires covered millions of square miles of land across the globe.

- 1 BRITISH EMPIRE**  
13 million sq miles (33.7 million sq km) in 1922.
- 2 SPANISH EMPIRE**  
7.5 million sq miles (19.4 million sq km) in 1740.
- 3 FRENCH EMPIRE**  
5 million sq miles (12.9 million sq km) in 1938.
- 4 PORTUGUESE EMPIRE**  
4 million sq miles (10.4 million sq km) in 1821.
- 5 ITALIAN EMPIRE**  
1.4 million sq miles (3.6 million sq km) in 1942.



### THE WORLD IN 1800

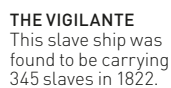
1800 saw the Spanish and Portuguese at their peak, as they occupied much of the Americas. Britain's empire around the world had also started to grow significantly.



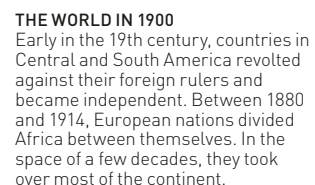
As Europeans claimed territories, they took advantage of the local resources, such as gold and spices, and traded them in markets around the world for profit.



Between 1500 and 1880, up to 12 million Africans were kidnapped from their homes and sold in the Americas as slaves. They were transported in slave ships, and many died of disease and lack of food or water.



People were chained together to prevent rebellion.



## THE WORLD IN 1900

Early in the 19th century, countries in Central and South America revolted against their foreign rulers and became independent. Between 1880 and 1914, European nations divided Africa between themselves. In the space of a few decades, they took over most of the continent.

## KEY

- |                           |   |   |                                       |
|---------------------------|---|---|---------------------------------------|
| ■ Ottoman Empire          | ■ Portugal and possessions                  | ■ Austrian Empire in 1850;<br>Austrian-Habsburg Empire<br>in 1800 | ■ Japan and possessions               |
| ■ Britain and possessions | ■ Swedish Empire                            |   | ■ Independent nations and other areas |
| ■ France and possessions  | ■ Netherlands and possessions               | ■ Italy and possessions in 1900                                   | ■ Qing Empire                         |
| ■ Denmark and possessions | ■ German Empire in 1900;<br>Prussia in 1800 | ■ Russian Empire and<br>possessions                               | ■ US and possessions                  |
| ■ Spain and possessions   |   |   |                                       |



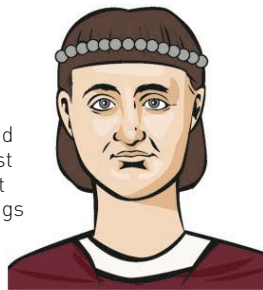
# British monarchs

The history of England, and later Britain, is tied together by a string of kings and queens. Early on, royals could start wars, break from the Church, and punish the country's leaders. Today, the Queen has little power but upholds long and popular traditions.

## 757-1066

### ANGLO-SAXONS

After the Romans left Britain in the 5th century CE, the land was attacked by invaders and split into warring kingdoms. Gradually, Mercia, Wessex, and Northumbria became the most powerful of these. Throughout the Saxon period, powerful kings fended off Viking raids, but England was ruled by Viking monarchs for over 25 years.



**OFFA**  
757-796  
The King of Mercia (central England) expanded his kingdom north and south and protected it by building a huge dyke along the Welsh border.



**EGBERT**  
802-839  
Originally King of Wessex, Egbert gradually increased the power and influence of his kingdom. His authority was recognized throughout most of England after he defeated Mercia and Northumbria.

757-796	OFFA	955-959	EADWIG
802-839	EGBERT	959-975	EDGAR
839-856	AETHELWULF	975-978	EDWARD II "THE MARTYR"
856-860	AETHELBALD	978-1013 AND 1014-1016	AETHELRED II "THE UNREADY"
860-866	AETHELBERT	1013-1014	SVEIN
866-871	AETHELRED I	1016	EDMUND II "IRONSIDE"
871-899	ALFRED "THE GREAT"	1016-1035	CANUTE
899-924	EDWARD "THE ELDER"	1035-1040	HAROLD I "HAREFOOT"
924-939	ATHELSTAN	1040-1042	HARDICANUTE
939-946	EDMUND I	1042-1066	EDWARD III "THE CONFESSOR"
946-955	EADRED	1066	HAROLD II

## 1485-1603

### TUDORS

The Tudors ruled with an iron fist and were not always popular, but they fostered national pride and parliament grew in strength. The manufacturing and merchant classes rose in status, and architecture, literature, and theater blossomed. Playwright William Shakespeare was a leading light.



**HENRY VIII**  
1509-1547  
Famous for his six wives (he divorced two and beheaded two), Henry VIII made himself head of the Church of England and bankrupted his country.

1485-1509	HENRY VII TUDOR
1509-1547	HENRY VIII
1547-1553	EDWARD VI
1553	LADY JANE GREY
1553-1558	MARY I
1558-1603	ELIZABETH I



**ELIZABETH I**  
1558-1603  
Strong-willed Elizabeth was a clever politician with loyal followers. Under her reign, trade, exploration, and prosperity increased.



**MARY I**  
1553-1558  
Nicknamed "Bloody Mary," Henry VIII's eldest daughter burned Protestants after she seized the throne and restored the Roman Catholic Church.

## 1461-1485

### YORKISTS

This branch of the House of Plantagenets had a strong claim to the throne. After Richard of York was killed in the Battle of Wakefield (1460), his son Edward became the first Yorkist king. William Caxton set up the first printing press in Britain in this period.

1461-1470	EDWARD IV
1471-1483	EDWARD IV
1483	EDWARD V
1483-1485	RICHARD III

**RICHARD III**  
1483-1485  
The last English king to die on a battlefield, Richard III may have had a role in the death of his two nephews, the princes, in the Tower of London.



1399-1413	HENRY IV
1413-1422	HENRY V
1422-1461	HENRY VI
1470-1471	HENRY VI



**HENRY VI**  
1422-61 AND 1470-71  
After losing his father's gains in France, mental ill health cost Henry VI the throne for a time. The War of Roses began in 1455.

## 1603-1649

### STUARTS

This dynasty was dominated by political battles between King and Parliament, which ended with a civil war and a beheading. Although the Stuarts believed they had a God-given right to rule, they were tolerant of Catholics and made peace with Spain. They were patrons of the arts and left a legacy of beautiful art and architecture.



**JAMES I**  
1603-1625  
Scotland and England were united when this Scottish king took the throne. He ruled for long periods without Parliament and was the target of Guy Fawkes's failed Gunpowder Plot.



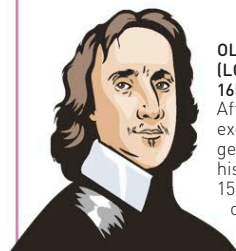
**CHARLES I**  
1625-1649  
This stubborn king believed in his divine right to rule and stamped on any opposition. Defeated by Oliver Cromwell in a civil war, he was tried and executed by Parliament.

## 1649-1659

### COMMONWEALTH

For the first and only time in its history, England was a Commonwealth (or republic) without a king or queen. Ruled by Puritan Oliver Cromwell and his parliament, the country took Jamaica from the Spanish and defeated the Dutch at sea.

1649-1653	REPUBLIC
1653-1658	OLIVER CROMWELL (LORD PROTECTOR)
1658-1659	RICHARD CROMWELL (LORD PROTECTOR)



**OLIVER CROMWELL**  
(LORD PROTECTOR)  
1653-1658  
After Charles I was executed, this leading general established his own council of 15 and a parliament of 400. He was followed by his son Richard.

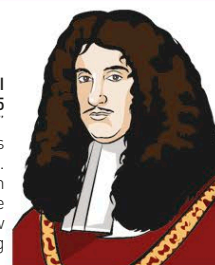
## 1660-1714

### STUARTS

After Charles II was restored to the throne, London suffered two disasters—a plague killed more than 100,000 people and a great fire destroyed most of the city. James II tried to restore Catholicism but fled when William of Orange was invited to invade and take power in the Glorious Revolution.

1660-1685	CHARLES II
1685-1688	JAMES II
1689-1694	WILLIAM III OF ORANGE AND MARY II (JOINTLY)
1694-1702	WILLIAM III
1702-1714	ANNE

**CHARLES II**  
1660-1685  
This "merry monarch" had many interests and many mistresses. He took a keen interest in architecture and science and introduced the new sport of yachting to England.



## 1714-1901

### HANOVERIANS

The Hanoverian dynasty saw many changes. Robert Walpole became Britain's first Prime Minister, to George I, and the country developed into an industrial society. By the end of Queen Victoria's reign, Britain's economic power was being challenged by other nations such as Germany and the United States.

1714-1727	GEORGE I
1727-1760	GEORGE II
1760-1820	GEORGE III
1820-1830	GEORGE IV
1830-1837	VICTORIA
1837-1901	VICTORIA

**GEORGE I**  
1714-1727  
This German-born king faced rebellion in Scotland, then scandal when a South Sea trading company went bust and ruined thousands of investors.

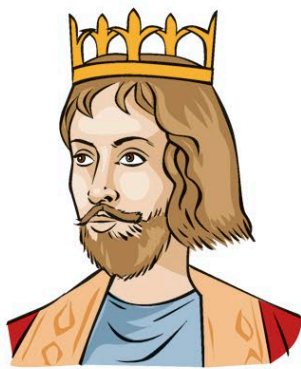






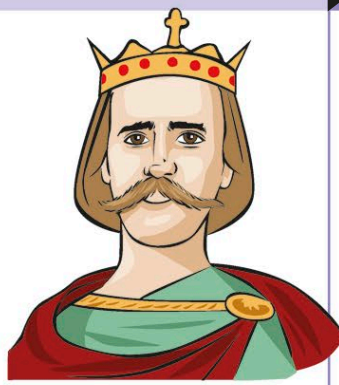
**ALFRED "THE GREAT"**  
871–899

The only English king to be known as "the Great," Alfred was almost overthrown by Viking raiders but fought back, captured London, and expanded his original Wessex kingdom.



**CANUTE**  
1016–1035

This Viking king treated Danes and Saxons fairly and the country prospered. There is an old story that he proved he was an ordinary man by trying and failing to make the tide go back.



**HAROLD II**  
1066

Harold II was appointed by his brother-in-law Edward the Confessor, but his reign was short-lived. He died after being shot in the eye in the Battle of Hastings, and William I took the throne.

## 1066–1154

### NORMANS

Originally Vikings who had settled in northwest France, the Normans were hungry for new land. William the Conqueror claimed the English throne after he defeated Harold II at the Battle of Hastings. The Normans built castles and brought with them a feudal system of lords, who held land, and peasants, who worked it.

1066–1087 **WILLIAM "THE CONQUEROR"**  
1087–1100 **WILLIAM II**  
1100–1135 **HENRY I**  
1135–1154 **STEPHEN**

**WILLIAM "THE CONQUEROR"**  
1066–1087

Called "the Conqueror" because he conquered England, William I was crowned king on Christmas Day 1066. He built the Tower of London and ordered a survey of land and people called the Domesday Book.



## 1399–1471

### LANCASTRIANS

These three kings reigned through almost continual warfare. French territory was recaptured and then lost, and in the War of the Roses, the royal houses of Lancaster and York fought over the throne for 30 years.



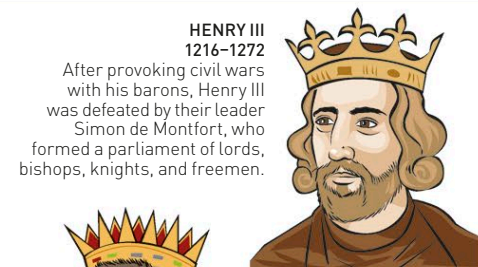
**HENRY V**  
1413–1422

Henry V reclaimed lost territories in France when he defeated the French at the Battle of Agincourt, losing only 400 English lives.



**HENRY IV**  
1399–1413

Returning from exile in France, Henry IV reclaimed the throne from Richard II. His reign was marked by many rebellions and revolts.



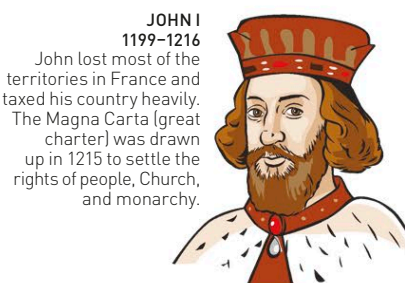
**HENRY III**  
1216–1272

After provoking civil wars with his barons, Henry III was defeated by their leader Simon de Montfort, who formed a parliament of lords, bishops, knights, and freemen.



**EDWARD I "LONGSHANKS"**  
1272–1307

This warrior king fought many battles to unite England and Scotland. A model parliament was formed during his reign.



**JOHN I**  
1199–1216

John lost most of the territories in France and taxed his country heavily. The Magna Carta (great charter) was drawn up in 1215 to settle the rights of people, Church, and monarchy.

## 1154–1399

### PLANTAGENETS

Originating in Anjou, France, this dynasty took its name from a yellow flower (*Planta genista*) an ancestor wore in his hat. During much of their rule, England was at war with France and Scotland, and Wales and Ireland came under English rule. The Plantagenets laid the foundation for law and government by creating justices of the peace and the first parliament. They put the royal seal on a charter of rights called the Magna Carta.

1154–1189 **HENRY II**  
1189–1199 **RICHARD I "THE LIONHEART"**  
1199–1216 **JOHN I**  
1216–1272 **HENRY III**  
1272–1307 **EDWARD I "LONGSHANKS"**  
1307–1327 **EDWARD II**  
1327–1377 **EDWARD III**  
1377–1399 **RICHARD II**



**RICHARD I "THE LIONHEART"**  
1189–1199

This crusading king spent most of his reign fighting for Christianity in the Holy Land. Imprisoned by the Emperor of Germany, he was returned for a huge ransom and was eventually killed in France.



**GEORGE III**  
1760–1820  
The Americans won independence and Britain fought France in the Napoleonic Wars during George's reign.



**WILLIAM IV**  
1830–1837

Many more people got the vote under William IV, and slavery was abolished throughout the British Empire.



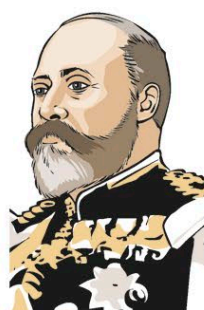
**VICTORIA**  
1837–1901

This much-loved queen ruled for 64 years. After her husband Prince Albert died, she went into mourning but was coaxed back to public life.

## 1901–1910

### SAXE-COBURG-GOTHA

This dynasty of just one king is named after Queen Victoria's husband Prince Albert, who was the son of the Duke of Saxe-Coburg and Gotha. Edward became king at the age of 59 and reigned during the first years of the 20th century, when new inventions such as the first automobile were taking Britain into the modern age.



**EDWARD VII**  
1901–1910

Edward was a social king who enjoyed sports, parties, and travel. He helped restore relations between France and England and built a new royal estate in Sandringham, Norfolk.

## 1910–

### WINDSORS

George V changed his surname to Windsor during World War I because of the strong anti-German feelings of his people. After Edward VIII gave up the throne to marry a divorced woman in 1936, his younger brother George VI was king through World War II. Queen Elizabeth II has reigned for more than 65 years.

1910–1936 **GEORGE V**  
1936 **EDWARD VIII**  
1936–1952 **GEORGE VI**  
1952– **ELIZABETH II**



**GEORGE VI**  
1936–1952

George VI was a good athlete and soldier, but this shy man with a stammer had not expected to be king. He managed to overcome his speech impediment and became popular during and after the war.



**ELIZABETH II**  
1952–

The queen remains head of the Commonwealth (former colonies) and is popular around the world. Her grandson Prince William leads a new generation of royals with his wife Catherine, Duchess of Cambridge, and their children.

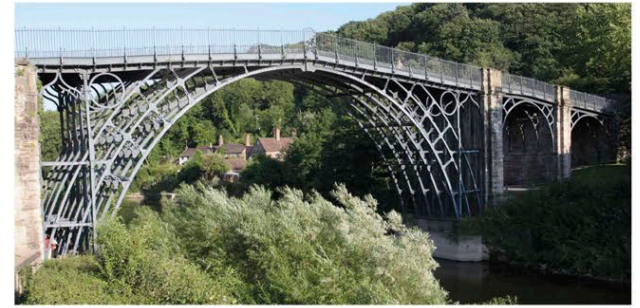


# The Industrial Revolution

In mid-18th-century Britain, a surge in new technology and inventions meant that fewer people were needed to farm the land. People moved from the countryside to towns to work in the newly built mills and factories. This change in the economy, from farming to manufacturing, is known as the Industrial Revolution.

## COAL AND IRON

For thousands of years, iron had been made by using charcoal from timber. But in 1709, Englishman Abraham Darby and his son developed a way of making iron using coal. Coal was easier to obtain than wood, so this discovery led to a huge growth in the production of iron to make tools and machinery and to the opening of more mines to provide the coal.



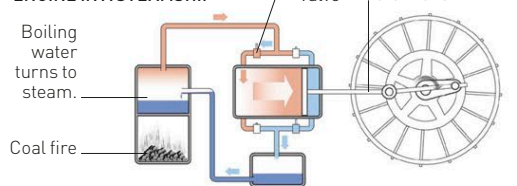
IRONBRIDGE, SHROPSHIRE

Site of the world's first iron bridge, built by Darby's grandson in 1781.

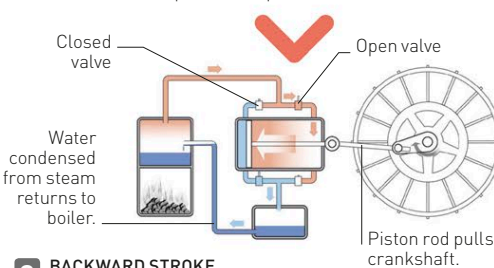
## STEAM POWER

The first steam engine was invented in 1712, to suck water from mines. Then, 60 years later, James Watt developed a way of using steam to drive factory machines. The age of steam had begun and would transform industry, travel, and home life, first in Britain and then all over the world.

### DOUBLE-ACTING ENGINE IN A STEAMSHIP



- 1 FORWARD STROKE**  
Steam enters the cylinder through the open valve on the left and pushes the piston forward.



- 2 BACKWARD STROKE**  
The steam now enters the cylinder through the valve on the right and pushes the piston back.

## CANALS

The growth in manufacturing meant there were more goods to be transported around the country, and canals were the answer—rivers made by people, deep enough to cope with large, heavy barges. In 1761, a British engineer named James Brindley built a canal 10 mile (16 km) long to carry coal direct from a mine in Lancashire to sell in Manchester. The venture made a fortune for the mine owner and sparked a boom in canal-building.



TRENT AND MERSEY CANAL

Originally called the Grand Trunk Canal, it cost £296,600 to build and opened in 1777.



CAEN HILL LOCKS

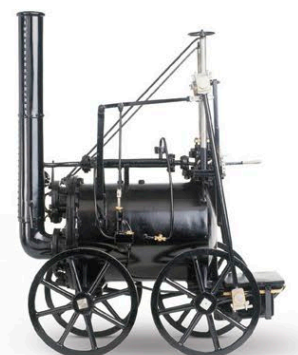
A series of 29 locks on the Kennet and Avon Canal in England was built in 1810 by John Rennie.

## BIRTH OF THE RAILWAYS

Factories needed a constant supply of raw materials coming in and finished goods going out, and the railway was the perfect solution. Trains were much quicker than canal barges and could carry much larger quantities of goods than road wagons. By the 1840s, fast and reliable steam engines were produced and became a symbol of the Industrial Revolution across Europe and America.

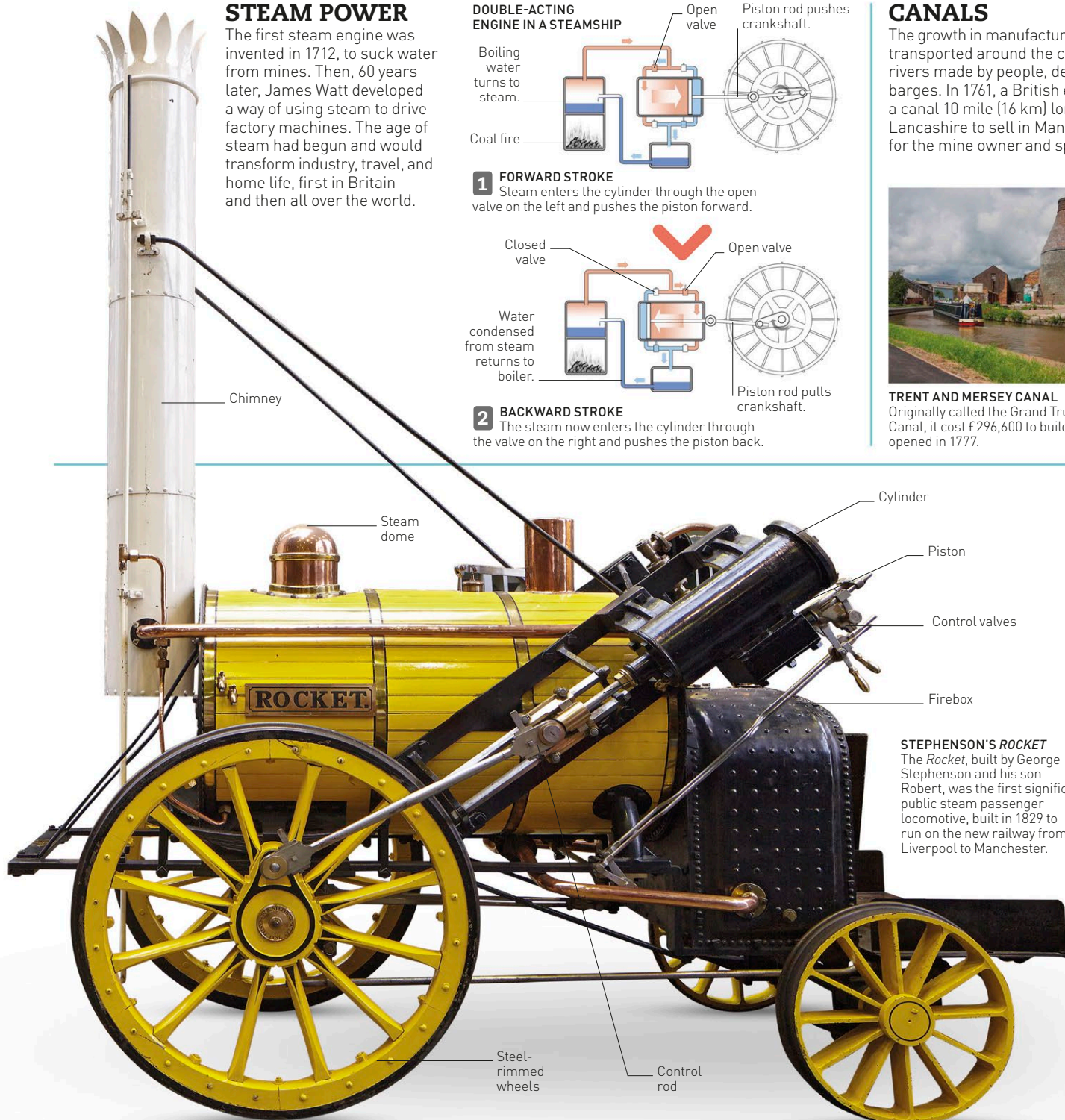
### STEPHENSON'S ROCKET

The *Rocket*, built by George Stephenson and his son Robert, was the first significant public steam passenger locomotive, built in 1829 to run on the new railway from Liverpool to Manchester.



TREVITHICK'S LOCOMOTIVE

In 1808, Richard Trevithick built a "rail circus" in London and charged a shilling for a ride on *Catch Me Who Can*.





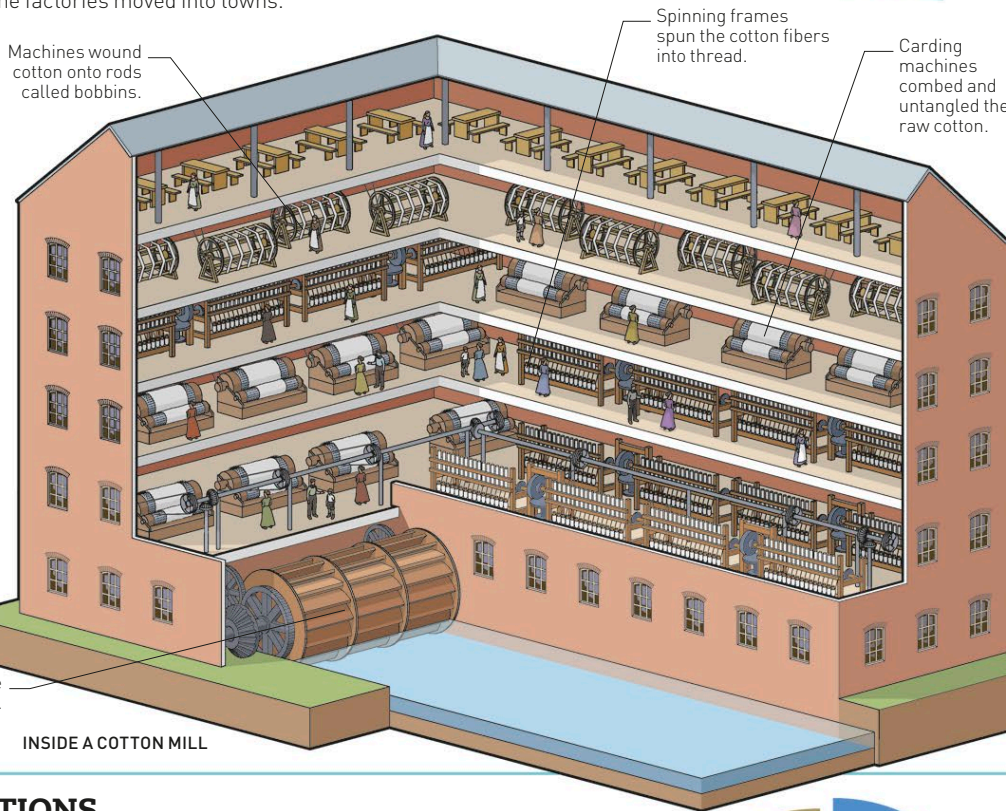
## THE FACTORY AGE

Traditional industries such as cotton and textiles were transformed by the Industrial Revolution. Machines were developed that could make raw cotton into thread in a fraction of the time it had taken craftworkers in the past. At first, the machines were powered by water, so mills and factories were built next to rivers. When steam replaced water power, the factories moved into towns.



**REGULATIONS**  
Factory life was harsh. Workers could be fined just for whistling or being five minutes late.

Flowing water turned the wheel to power the machines.



INSIDE A COTTON MILL

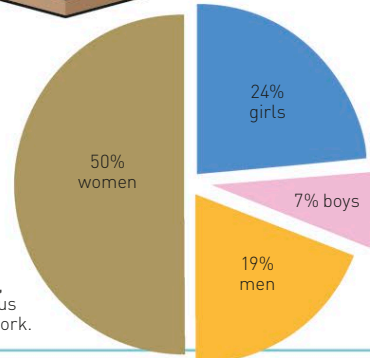
## WORK CONDITIONS

Factory workers worked more than 12 hours a day, six days a week. At the start of the Industrial Revolution, there were no laws to protect the health or safety of workers. Factories were hot and deafeningly noisy, and accidents and injuries were very common.



**PIT CHILDREN**  
Children worked deep underground in coal mines, pulling heavy wagons along tracks.

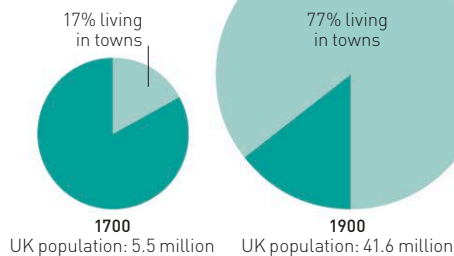
**WORKERS IN A COTTON MILL, 1859**  
A third of mill workers were children, aged as young as 5. They wriggled between machines to clear blockages, which was strenuous and dangerous work.



## RISE OF THE NEW TOWNS

As more and more factories were built, towns grew and housing, schools, and shops were built near where people worked. Small towns quickly became large, factory-dominated cities, which attracted even more people in search of work.

THE MOVE FROM COUNTRYSIDE TO TOWN IN THE UK



## FARM TECHNOLOGY

As the population grew, there was an increased demand for more food and more efficient, cheaper ways of growing it. Steam-powered plows and threshing machines appeared in the 1820s, then in 1831, American Cyrus McCormick invented a mechanical grain harvester.

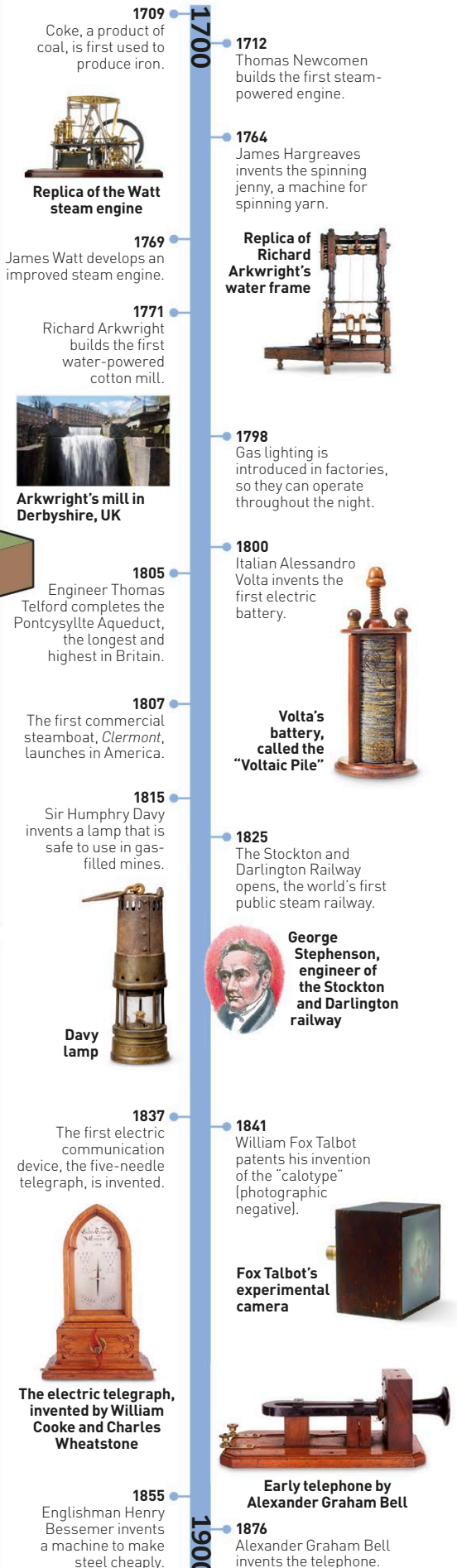


STEAM THRESHING MACHINE

**THE NEW SPINNING MACHINES PRODUCED COTTON 1,000 TIMES FASTER THAN A HUMAN WORKER COULD.**

## TIMELINE OF A REVOLUTION

The invention of steam power was a turning point in history. It also sparked major developments in other areas, including communications, transportation, and construction.



## INDUSTRIAL PIONEERS

The Industrial Revolution was driven by engineers and inventors, many of whose ideas paved the way for the age of high technology in the 20th century.

- RICHARD ARKWRIGHT (1732-1792)**  
Invented the water frame for spinning thread or yarn, then set up the first water-powered cotton mill in Britain.
- RICHARD TREVITHICK (1771-1833)**  
In 1804, this British engineer designed and built the world's first steam railway locomotive.
- ELI WHITNEY (1765-1825)**  
American who invented a machine called the cotton gin, which revolutionized the cotton industry in America.
- SIR HUMPHRY DAVY (1778-1829)**  
British chemist and inventor. He developed the Davy lamp, a light to help miners detect dangerous gases underground.
- ISAMBARD KINGDOM BRUNEL (1806-1859)**  
A British engineer who built bridges, tunnels, railways, and the world's biggest ship at the time, the *Great Eastern*.



RICHARD TREVITHICK

Davy lamp

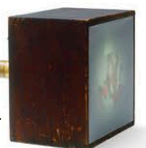


The electric telegraph, invented by William Cooke and Charles Wheatstone



George Stephenson, engineer of the Stockton and Darlington railway

Fox Talbot's experimental camera



Early telephone by Alexander Graham Bell



# World War I

In 1914, tensions that had been simmering in Europe came to a head. War broke out and quickly spread across the globe. Fought between two powerful groups of countries (the Allies and the Central Powers), it was the biggest war the world had ever seen.



GERMAN FOKKER Dr.I TRIPLANE

**JUNE 28, 1914**

Archduke Franz Ferdinand of Austria-Hungary is assassinated with his wife Sophie in Serbia. A month later, Austria-Hungary declares war on Serbia.

**AUGUST 12, 1914**

One by one, countries take sides until war has broken out over most of Europe.



Lifebelt from the RMS Lusitania

**MAY 7, 1915**

Germany sinks the RMS Lusitania, a luxury British passenger ship, killing more than 1,000 passengers.

**MAY 23, 1915**

Italy enters the war on the side of the Allies and prepares to invade its neighbor, Austria-Hungary.



Italian army ID tag

**JULY 1, 1916**

The Battle of the Somme begins in France. By the time it ends in November, more than 300,000 men will die.



Battlefield site, Somme, France

**DECEMBER 17, 1917**

Following a revolution in Russia, the new government makes peace with Germany and leaves the war.



Russian helmet plate

**NOVEMBER 3, 1918**

German sailors mutiny. Austria-Hungary makes peace with the Allies.

**JUNE 28, 1919**

The Treaty of Versailles is signed and the war officially ends.

## THE WAR TO END ALL WARS

When the war began, people believed it would be over quickly. In fact, it lasted for four years and more than 65 million men were called upon to fight.

**SEPTEMBER–OCTOBER 1914**

First trenches are dug along the Western Front in France and Belgium.

**DECEMBER 24, 1914**

British and German soldiers call an unofficial truce over Christmas.



Ottoman army medal

**APRIL 1915–JANUARY 1916**

The Allies fight Ottoman troops at Gallipoli, suffering disastrous casualties.

**FEBRUARY 21, 1916**

Battle of Verdun begins.



Fortified turret, Verdun, France

**MAY 31, 1916**

The Battle of Jutland starts—the only major sea battle of the war. Britain claims victory, despite suffering heavy losses.

**JANUARY 1917**

Britain attacks the Ottoman Empire again, this time by landing in Palestine and pushing north through the desert to the city of Damascus.

**APRIL 6, 1917**

President Woodrow Wilson leads the US into the war on the side of the Allies.

**JULY 15, 1918**

Second Battle of the Marne begins, near Paris.

**AUGUST 3, 1918**

The Allies win the Battle of the Marne. The German army collapses.

**NOVEMBER 11, 1918**

Germany agrees to an armistice and all fighting stops.



Memorial to the missing (near Thiepval, France), built 1932

## A CONTINENT AT WAR

The two main European arenas of the war were the Western Front, between Belgium and France, and the Eastern Front, which was mainly in Russia.

### KEY

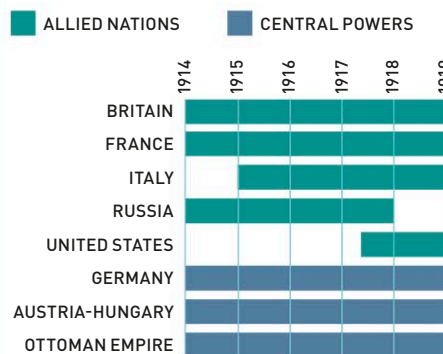
- Neutral
- Allied Nations
- Central Powers
- Western Front
- Eastern Front



EUROPE IN 1916

## TAKING SIDES

By the end of 1914, almost all of Europe had taken sides in the war. Only a few countries remained neutral.



## CASUALTIES OF WAR

The cost of the war in human lives was enormous. More than 30 million men were killed or injured, and some battles were so devastating that thousands died in a single day.



AMBULANCE CART

JULY 1–NOVEMBER 18, 1916	FEBRUARY 21–DECEMBER 18, 1916	JULY 11–NOVEMBER 10, 1917
Battle of the Somme	Battle of Verdun	Third Battle of Ypres (Passchendaele)
1,219,201	976,000	848,614

TOTAL CASUALTIES FROM THE BLOODIEST BATTLES OF WWI

## TRENCHES

Both sides built long trenches as a defense against long-range weapons. Soon, there was stalemate, with neither side able to advance into the other's territory. Life in the trenches was hard. Soldiers fought, ate, and slept there, sometimes for weeks on end.



CROSS-SECTION OF A TYPICAL WORLD WAR I BATTLEFIELD





BRITISH SOPWITH PUP



GERMAN ALBATROSS D.Va

## WAR IN THE AIR

Powered flight was barely 10 years old when war broke out but the technology developed quickly. Soon, both sides were building fast fighter planes and giant bombers capable of carrying huge bombs.



ALTIMETER



FRENCH PILOT'S GOGGLES AND HELMET



## WAR AT SEA

World War I was fought mainly on land, with very few major naval battles. The main role of the navies on each side was to protect merchant ships bringing in essential goods, as well as trying to stop the enemy from receiving supplies by sea.



HMS DREADNOUGHT



HMS SCOUT



GERMAN BATTLESHIP

**GERMANY'S GREATEST NAVAL WEAPONS WERE ITS SUBMARINES, KNOWN AS U-BOATS.**

## TANK WARFARE

The tank was one of the most important inventions of the war. Although early tanks were unreliable and dangerous for crews working in them, their ability to power through enemy lines meant an end to the stalemate of trench warfare.



BRITISH MARK V TANK

## ARMY RECRUITS

Millions of young men were either called up or volunteered to fight in the war. Countries such as Britain also relied heavily on recruits from their overseas colonies and dominions.



FRANCE



GERMANY



OTTOMAN EMPIRE



US



ITALY



RUSSIA

## TRENCH WEAPONS

Trench warfare called for weapons that could be used at very close quarters. Soldiers on raiding missions behind enemy lines carried daggers and knives so they could attack the enemy silently.



AMERICAN BAYONET

AMERICAN KNUCKLEDUSTER KNIFE

GERMAN BAYONET



PERCUSSION AND STICK GRENADES



HAND GRENADES



BRITISH NAIL CLUB

BRITISH SPIKED CLUB

GERMAN ROD

GERMAN CLUB

## FIREARMS

The most widely used weapons were rifles and machine guns. Machine guns needed only a small crew, were reliable, and had a long range. This made them essential weapons in the trenches.



GERMAN MOUNTED MACHINE GUN



BRITISH LEE ENFIELD RIFLE



ITALIAN CARCANO CARBINE RIFLE



GERMAN SCHWARZLOSE MACHINE GUN



AUSTRIAN STEYR PISTOL

ITALIAN GLISENTI PISTOL

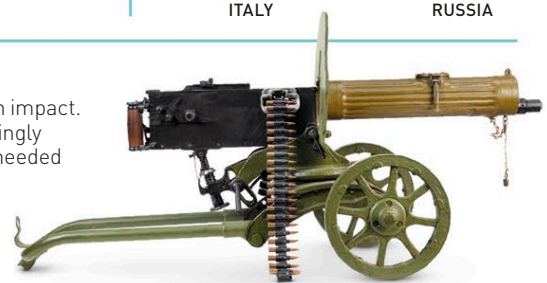
GERMAN LUGER PISTOL

## BOMBARDMENT

Large field guns fired shells that exploded on impact. They had a long range and could be devastatingly effective, but they were not very mobile and needed about 10 men to operate them.



GERMAN GAS SHELLS



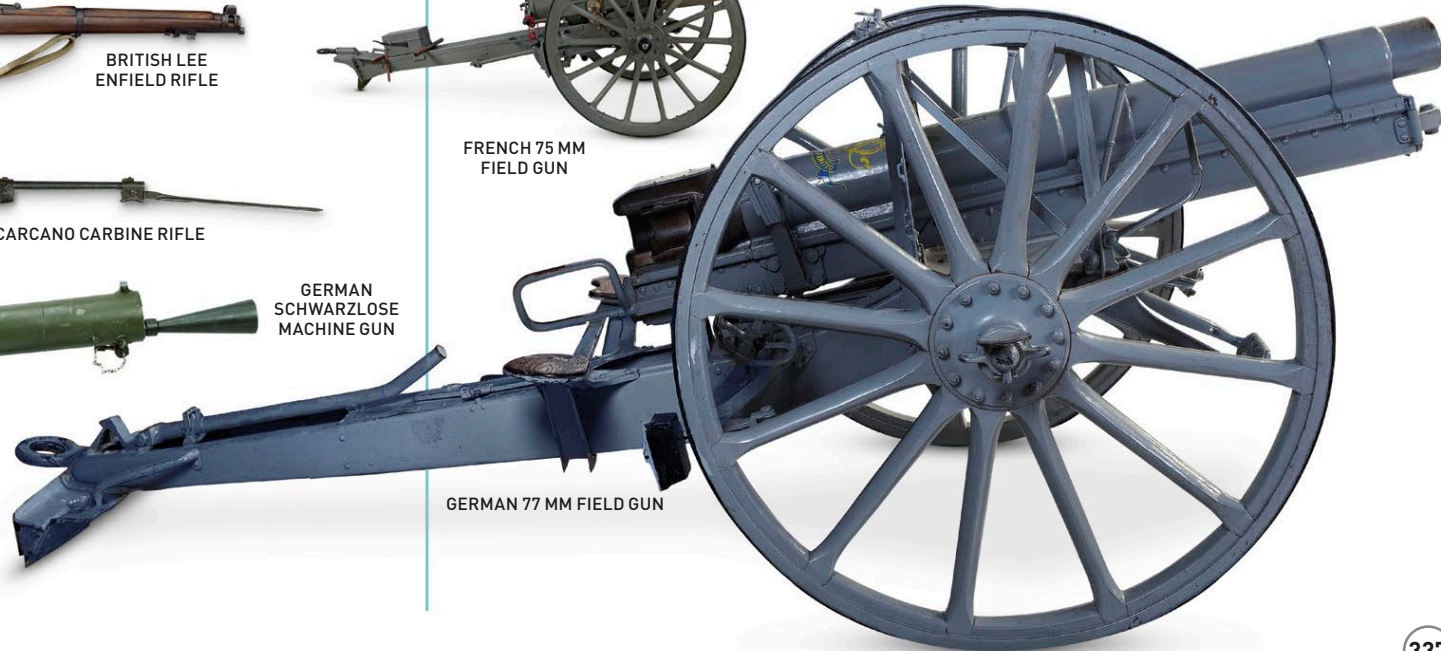
RUSSIAN MAXIM M1910 HEAVY MACHINE GUN



BRITISH MORTAR SHELLS



FRENCH 75 MM FIELD GUN



GERMAN 77 MM FIELD GUN



## THE COURSE OF THE WAR

At the beginning of the war, the Germans' progress seemed unstoppable, until a harsh winter and fierce resistance halted them in Russia. When the US joined the war at the end of 1941, the tide turned. The Allies won victories in North Africa and the Pacific, then, in 1944, they landed in France and began to take back Europe.

1939

**SEPTEMBER 1, 1939**  
Germany, led by Nazi leader Adolf Hitler, invades Poland.



Nazi flag

**SEPTEMBER 3, 1939**  
Britain and France declare war on Germany.

**APRIL-JUNE 1940**  
Germany uses Blitzkrieg "Lightning War" tactics to take over France and most of Western Europe.



Statue of Winston Churchill

**MAY 10, 1940**  
Winston Churchill becomes Prime Minister of Great Britain.

**JULY-OCTOBER 1940**  
Battle of Britain: German and British aircraft fight for control of the skies; Britain is the winner.

**SEPTEMBER 27, 1940**  
Germany, Italy, and Japan join forces as the Axis Alliance.

**SEPTEMBER 1940-MAY 1941**  
The Blitz (German bombing raids on British cities) kills more than 60,000 civilians.

Statue of Theodore Roosevelt



**DECEMBER 8, 1941**  
President Roosevelt takes the US into the war against the Axis Alliance.



British child's gas mask

**DECEMBER 7, 1941**  
Japan mounts a surprise attack on the US Navy at Pearl Harbor, Hawaii.

# World War II

In September 1939, led by dictator Adolf Hitler, Germany invaded Poland and triggered World War II, the deadliest conflict in history. By the end of the war six years later, around 60 million people had been killed, more than half of them civilians. A large part of Europe was in ruins, and two Japanese cities had been obliterated by nuclear bombs.

## AXIS vs ALLIES

The Axis alliance was formed in 1939 by Germany and Italy. In 1940, Japan joined and the countries formed the Tripartite Pact. The original members of the Allies were Britain and France, until 1940, when Germany invaded France and the French government was exiled to London. In 1941, the Soviet Union and the US joined the Allies. In 1943, Italy surrendered, then changed sides to fight on the side of the Allies.



GREAT BRITAIN

FRANCE

US

SOVIET UNION



GERMANY

ITALY

JAPAN

## THEATERS OF WAR

For the first two years of the war, fighting raged across Western Europe, on the Eastern Front in Russia, and in North Africa. By the end of 1941, when Japan and the US joined in, the conflict had spread to the Pacific and Southeast Asia. Few nations were able to stay neutral as war engulfed the whole world.



**THE WAR IN EUROPE, NORTH AFRICA, AND THE MEDITERRANEAN**  
Germany began the war with the upper hand, rampaging through Europe and taking over a series of countries. Gradually, the Allies pushed back, and by 1943 Germany was in retreat.

**KEY**  
 ■ Allied areas  
 ■ Allied-occupied areas  
 ■ Axis countries  
 ■ Axis-occupied areas  
 ■ Axis allies  
 ■ Neutral countries



**THE WAR IN THE PACIFIC AND ASIA**  
Japan joined the Axis countries in 1941 and quickly overran much of Southeast Asia, including Malaya and Singapore. The Allies fought back on land and sea, but it was superior airpower—and the dropping of two atomic bombs—that led to the Allies' victory.

**KEY**  
 ■ Allied areas  
 ■ Axis countries  
 ■ Axis-occupied areas  
 ■ Axis allies  
 ... Limit of Japanese advance

## AIR POWER

World War II was the first war in which fighting took place as much in the air as on land or sea. There were three main types of planes: fighters, bombers, and transport planes.



JUNKERS JU87B DIVE BOMBER  
Germany

SUPERMARINE SPITFIRE MK.24  
UK

HEINKEL HE 111  
Germany

MESSERSCHMITT BF 110  
Germany

BELL P-39-D AIRACOBRA  
US

HANDLEY PAGE HALIFAX II  
UK

FOCKE-WULF FW 190 WÜRGER  
Germany

YAKOVLEV YAK-3  
Soviet Union

## SMALL ARMS

Technology played a crucial role in the war, with both sides competing to produce weapons more efficient and deadlier than ever before. Rifles, machine guns, mortars, and hand grenades were all improved during the course of the war.



LEE ENFIELD NO.5 MK 1  
UK

HAND GRENADE  
US

WALTHER P38 PISTOL  
Germany

VICKERS MARK IV MACHINE GUN  
UK

ORDNANCE QF 25-POUNDER  
UK

## FIGHTING SOLDIERS

In most countries, men were conscripted during the war, meaning they had to join the armed forces. Only those doing certain jobs, such as miners or farmers, or people in poor health were not required to join up.



BRITISH SOLDIER

AMERICAN SOLDIER

SOVIET SOLDIER

GERMAN SOLDIER

JAPANESE SOLDIER

ITALIAN SOLDIER



**JUNE 4-7, 1942**  
The US defeats Japan's navy at the Battle of Midway in the Pacific Ocean, halting the Japanese advance.

**Soviet medal for the Battle of Stalingrad**



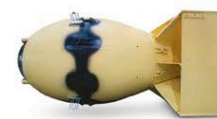
**FEBRUARY 2, 1943**  
Soviet troops are victorious at Stalingrad and begin to march on Germany.



German V1 flying bomb, 1944

**AUGUST 25, 1944**  
Paris is liberated by the Allies from German occupation.

**MARCH 7, 1945**  
Allied troops cross the River Rhine and enter Germany.



Model of "Fat Man" atomic bomb, dropped on Nagasaki

**AUGUST 6-9, 1945**  
US drops atomic bombs on the Japanese cities of Hiroshima and Nagasaki.

**1945**



Japanese Aichi D3A bomber plane

**AUGUST 23, 1942**  
Germany launches an attempt to take over the Soviet city of Stalingrad.

**MAY 13, 1943**  
The Axis armies in North Africa surrender.

**JULY 25, 1943**  
Italian dictator Mussolini is overthrown. A month later, the Allies invade mainland Italy, leading to Italy's surrender.

**JUNE 6, 1944**  
D-Day: Allied forces land in Normandy, France, and begin to advance inland.



Badge worn by Jews in Latvia

**JANUARY 27, 1945**  
Soviet army liberates the Auschwitz death camp in Poland.

**MAY 7, 1945**  
Following Hitler's suicide a week earlier, Germany surrenders.

**AUGUST 15, 1945**  
Japan announces its intention to surrender. On September 2, it signs the Instrument of Surrender, and World War II is officially over.



**GERMAN ARMY BADGE**  
The Nazis used the swastika cross as their symbol.

## HITLER AND THE NAZIS

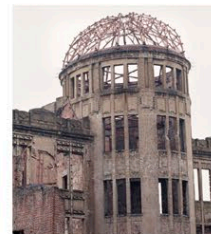
Adolf Hitler was the leader of the Nazi (National Socialist) party. Nazis believed that Germans were naturally superior to what they called "inferior races." Hitler especially hated Jewish people and blamed them for all of Germany's economic and political problems.

## CASUALTIES OF WAR

Both sides suffered terrible losses during the war. Poland lost 20 percent of its population, and whole cities across Europe were left in ruins. The Nazis and their sympathizers executed 6 million Jewish people. This brutal, systematic murder is now known as the Holocaust. In Japan, two nuclear bombs dropped by the US caused mass destruction. In the city of Hiroshima, 65,000 people were killed, and in Nagasaki, 40,000 lost their lives.



HOLOCAUST MEMORIAL IN BERLIN, GERMANY



PEACE MEMORIAL IN HIROSHIMA, JAPAN

**DURING THE BLITZ OF 1940-1941, MORE THAN A MILLION HOMES IN LONDON WERE DESTROYED.**

### APPROXIMATE TOTAL CASUALTIES PER COUNTRY

SOVIET UNION	24 MILLION
CHINA	20 MILLION
GERMANY	6.6-8.8 MILLION
POLAND	5.6 MILLION
JAPAN	2.6-3.1 MILLION
YUGOSLAVIA	1 MILLION
ROMANIA	833,000
HUNGARY	580,000
FRANCE	567,600
PHILIPPINES	500,000-1 MILLION
ITALY	457,000
UNITED KINGDOM	450,700
UNITED STATES OF AMERICA	418,500
NETHERLANDS	301,000
GREECE	300,000-800,000
FINLAND	97,000
BELGIUM	86,100
CANADA	45,400
AUSTRALIA	40,500
BULGARIA	25,000
NORWAY	9,500

## LAND POWER

Advances in technology meant that armored vehicles and tanks played a much bigger part in World War II than in previous conflicts. Panzer tanks, supported by air bombers, were the main power behind the Germans' swift and brutal takeover of most of Western Europe in the first months of the war.



UNIVERSAL CARRIER  
UK



SHERMAN FIREFLY  
UK/US



M2 HALF-TRACK CAR  
US



BMW R12 MOTORCYCLE  
Germany



WHITE SCOUT CAR  
US



STURMGESCHÜTZ III  
Germany



CHURCHILL TANK  
UK



JAGDPANZER 38(T) HETZER  
Germany



PANZERKAMPFWAGEN II  
Germany



PANZERKAMPFWAGEN III  
Germany



PANZERKAMPFWAGEN  
"TIGER" II  
Germany

## SEA POWER

Naval battles took place in both the Atlantic and Pacific oceans. In the North Atlantic, German U-boats (submarines) stalked and attacked the Allies' essential supply ships. In the Pacific, the US took on the Japanese in a series of massive naval battles.



HMS AVON VALE  
Escort destroyer, UK



HMS AGINCOURT  
Battle class destroyer, UK



U-BOAT (SUBMARINE)  
Germany



USS HORNET  
Aircraft carrier, US



HMS HOOD  
Battlecruiser, UK



I-400-CLASS SUBMARINE  
Japan



HMS HOOD  
Battlecruiser, UK



PRINZ EUGEN  
Heavy cruiser, Germany



# The Cold War

After World War II, the US and the Soviet Union (USSR) emerged as the world's most powerful countries. Although bitter enemies, the threat of nuclear destruction stopped them from declaring war. Instead, they each tried to weaken the other by spying, supporting other countries in conflicts, and developing new technologies.

## THE WORLD DIVIDED

As tensions grew between the two superpowers, they each tried to form alliances with other countries. By the mid-1950s, all of Europe and most of the world had chosen sides in the Cold War.



**NATO**  
The North Atlantic Treaty Organization, an alliance of 12 Western democratic countries, formed in 1949.



US



LUXEMBOURG



GREECE  
Joined 1952



BELGIUM



NETHERLANDS



TURKEY  
Joined 1952



CANADA



NORWAY



DENMARK



PORTUGAL



FRANCE



UNITED KINGDOM



ICELAND



ITALY

### EUROPE 1955

■ Warsaw Pact countries  
■ NATO countries  
■ Other USSR allies  
■ Other US allies



**WARSAW PACT**  
Formed by the USSR in 1955, in opposition to NATO.



SOVIET UNION



ALBANIA  
Left 1962



BULGARIA



CZECHOSLOVAKIA



EAST GERMANY



HUNGARY



POLAND



ROMANIA

## NATO LEADERS

In 1949, the US brought together a group of countries to form a military union. NATO's aims were to stop the spread of Communism and help prevent future war in Europe. As the US was the most powerful country in NATO, the US president was seen as its leader.



**DWIGHT D. EISENHOWER**  
Became US president in 1953. He promised help to countries who were under threat from the spread of Communism.



**JOHN F. KENNEDY**  
When Kennedy confronted the USSR in 1962 over weapons they held in Cuba, many feared that it would trigger a third world war.



**RICHARD NIXON**  
Nixon started a slight thaw in the Cold War when he met the Soviet leader Leonid Brezhnev in 1972, to discuss reducing weapons.



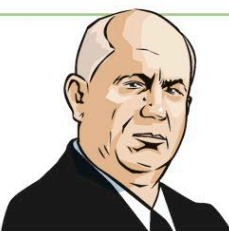
**RONALD REAGAN**  
The US president in charge at the end of the Cold War, Reagan signed a peace treaty in 1989 with Soviet leader Mikhail Gorbachev.

## WARSAW PACT LEADERS

The Pact was an anti-NATO alliance between Communist nations. Communism was based on the belief that property should not be owned by individuals, but shared by everyone.



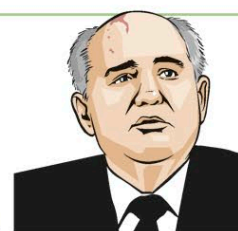
**JOSEPH STALIN**  
Set the Cold War in motion by bringing much of Eastern Europe under Soviet control after World War II.



**NIKITA KHRUSHCHEV**  
Tried to establish better relations with the US, but was ousted as Soviet leader by rivals in 1964.



**FIDEL CASTRO**  
Led a Communist revolution in Cuba in 1959. The US supported many attempts to remove him from power.



**MIKHAIL GORBACHEV**  
Became leader of the USSR in 1985, and introduced many reforms that helped bring an end to the Cold War.

## NUCLEAR ARMS

After World War II, only the United States had nuclear bomb technology, but in 1949, the USSR successfully tested a nuclear device of its own. The nuclear arms race began, with both countries building more and more powerful weapons and stockpiling thousands of warheads.

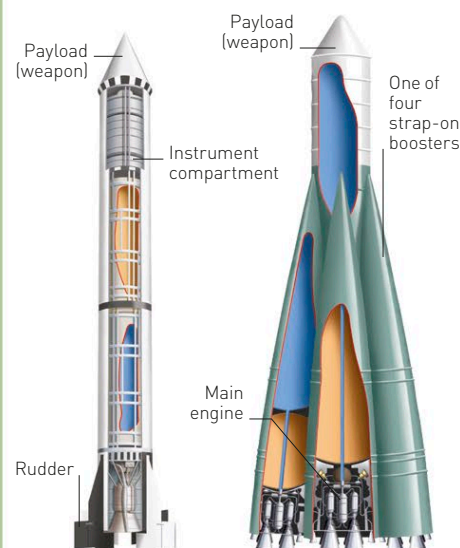
### NUCLEAR WEAPON STOCKPILES, 1950-2010



USS VIRGINIA (SSN-74) NUCLEAR SUBMARINE (US)



AKULA-CLASS NUCLEAR SUBMARINE (USSR)



**PGM-11 REDSTONE (US)**  
First missile to carry a live nuclear warhead.

**R-7 SEMYORKA (USSR)**  
First intercontinental ballistic missile.

## THE BERLIN WALL

After World War II, Germany's capital was divided up between the Allied countries—UK, US, France, and USSR. In 1961, the Soviets built a wall 6.5 ft (2 m) high that enclosed the three sectors of West Berlin to stop people escaping from the Communist Soviet sector to the Allied sector. The heavily guarded wall was finally demolished in 1989, at the end of the Cold War.



**KEY**  
— Berlin Wall



## THE ENEMY AT HOME AND ABROAD

Espionage (spying) was an important Cold War tactic. Both sides developed military reconnaissance spy planes and anti-spy planes to counter the other's surveillance planes. They also deployed secret agents, whose job was either to uncover political and industrial information about the enemy or to seek out spies and traitors in their own country.



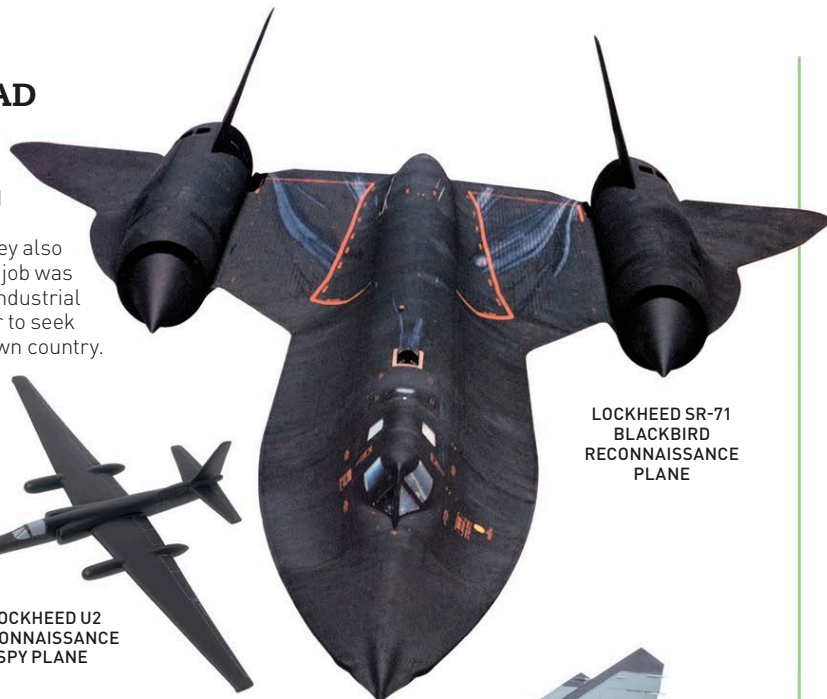
LOGO OF THE CIA,  
US'S COUNTER-  
INTELLIGENCE FORCE



LOGO OF THE KGB,  
SOVIET SPY AGENCY



LOCKHEED U2  
RECONNAISSANCE  
SPY PLANE



LOCKHEED SR-71  
BLACKBIRD  
RECONNAISSANCE  
PLANE



MIKOYAN-GUREVICH MIG-25 "FOXBAT" INTERCEPTOR PLANE



MIKOYAN-GUREVICH MIG-23 INTERCEPTOR PLANE

## SPACE RACE

Both the US and USSR desperately wanted to be world leaders in space exploration. They each poured huge amounts of money and resources into the race to be the first to land a human on the Moon.

### FIRST SATELLITE TO ORBIT EARTH: USSR

On October 4, 1957, the Soviets launched Sputnik I. The US launched their first satellite Explorer I four months later.

### FIRST HUMAN IN SPACE: USSR

On April 12, 1961, Yuri Gagarin was the first human to orbit Earth in his spacecraft, Vostok I.



COMMEMORATIVE  
STAMP SHOWING  
YURI GAGARIN

### FIRST WOMAN IN SPACE: USSR

Valentina Tereshkova became the first female cosmonaut when she flew Vostok 6 in 1963. It took the US another 20 years to send Sally Ride up in the space shuttle Challenger.

### FIRST "SPACE WALK": USSR

On March 18, 1965, Alexei Leonov spent about 10 minutes floating outside his spacecraft, Voskhod 2. The Americans lost out again by just three months.

### FIRST PERSON TO LAND ON THE MOON: US

On July 20, 1969, Neil Armstrong, Commander of the Apollo 11 moon mission, stepped out of the lunar landing module, Eagle, and onto the surface of the Moon.



MOON LANDING  
COMMEMORATIVE  
BADGE

## VIETNAM WAR

In 1954, Vietnam was split when the Communists (Vietcong) in the North split from the South. In 1965, the US sent troops to help the South Vietnamese, leading to a 20-year war, which ended in victory for the Vietcong.



US MARINES  
HELMET



US MARINES  
ARMORED  
VEST



US MARINES  
SUNGLASSES



M16 AUTOMATIC  
RIFLE (US)



US MARINES CAMOUFLAGE JACKET AND TROUSERS



US MARINES  
TROPICAL BOOTS



VIETCONG FIGHTER'S TUNIC AND TROUSERS



VIETCONG  
HAT



VIETCONG RUBBER  
SANDALS



VIETCONG MACHETE  
AND SCABBARD



VIETCONG  
GRENADE  
LAUNCHER

## COLD WAR STORY

The Cold War divided Europe between democratic west and Communist east and spread worldwide as both sides tried to undermine each other by influencing global events.

1945

### FEBRUARY 1945

Yalta conference held to decide Germany's postwar future. Germany is split into four zones of Allied occupation.

### MARCH 1947

US President Truman declares the Truman Doctrine: that it was the US's duty to fight Communism all over the world.

### MAY-OCTOBER 1949

Communist East Germany and capitalist West Germany are founded.

### JUNE 1950

The Korean War begins; USSR and US take opposing sides.

### NOVEMBER 1956

The USSR invades Hungary to put down an anti-Communist uprising.

### AUGUST 1961

Soviets build the Berlin Wall.

### MAY 1972

US and USSR sign a treaty agreeing to limit their nuclear weapons.

### DECEMBER 1987

US and USSR agree to remove all medium- and short-range nuclear missiles.

1990

### MARCH 1946

British ex-prime minister Winston Churchill describes the division between Communist and non-Communist countries as an "iron curtain."

### JUNE 1948

The Soviets try to squeeze the other Allies out of Berlin by blockading the city, forcing the Allies to airlift in supplies.

### OCTOBER 1949

Mao Zedong declares the foundation of the Communist People's Republic of China.

### OCTOBER 1957

USSR launches Sputnik I, the first satellite to orbit Earth.

### OCTOBER 1962

US and USSR face off in the Cuban Missile Crisis.

### MARCH 1965

US sends 200,000 troops to fight in Vietnam.

### JULY-AUGUST 1980

US boycotts the Moscow Olympic Games in protest at the Soviet invasion of Afghanistan.

### NOVEMBER 1989

Berlin Wall is torn down.

### DECEMBER 1989

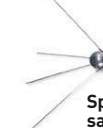
The Cold War is declared over.



Memorial to  
Berlin Airlift



Book by Mao  
Zedong, Chinese  
communist  
leader



Sputnik I  
satellite



Statue of  
Che Guevara,  
one of Cuba's  
leaders at the  
time of the  
Missile Crisis

## GLOBAL FLASHPOINTS

The effects of the Cold War were felt all over the world, as the US and USSR backed different sides in various conflicts and uprisings.



### KOREA 1950-1953

The US and United Nations backed South Korea, while USSR and China supported the Communists in the North.



### CZECHOSLOVAKIA 1968

An attempted uprising against the Communist regime was violently put down by the USSR. The West disapproved but did not intervene.



### NICARAGUA 1979

When Sandinista revolutionaries overthrew the government, the US funded a guerrilla war against the new regime.



### AFGHANISTAN 1979

When the Soviets invaded Afghanistan, Afghan resistance fighters (Mujahideen) were secretly armed and funded by the US.



# Spies

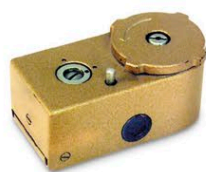
Spying, or espionage, is all about finding out secret information, known as “intelligence.” Spies have been operating for thousands of years. In ancient times, they sneaked into enemy camps to uncover their battle plans. If they were caught, they were killed. Spying is still a dangerous business. Secret agents carry weapons, as well as the latest surveillance gadgets.

## CAMERAS

Used to photograph top-secret plans or provide evidence of a private meeting, the camera is an essential part of a spy's kit. These days, a secret agent can use a smartphone to take a snap without attracting attention. In the past, cameras had to be ingeniously concealed inside everyday objects.



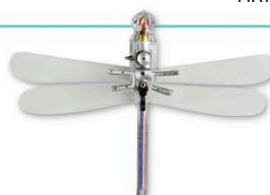
MICRODOT CAMERA



DCD-1 (CIA SUBMINIATURE CAMERA)



WRAL (CIA SUBMINIATURE CAMERA)



INSECTOHOPTER (FLYING SURVEILLANCE CAMERA)



MOLLY (CIA SUBMINIATURE CAMERA)



Lighter flips open to reveal camera.

LIGHTER CAMERA

## FAMOUS SPIES

Successful spies rarely become famous, because their cover is never blown. A handful of spies do find fame as heroes or after being found guilty of espionage.

### JOHN ANDRÉ

This British army officer was hanged as a spy in 1780 during the American Revolution.

### JAMES ARMISTEAD LAFAYETTE

A former African slave, Lafayette was a double agent in the American Revolution.

### MATA HARI

Dutch dancer Mata Hari was executed for spying for Germany in World War I (1914–1918).

### VIRGINIA HALL

After helping the British in World War II (1939–1945), this American spy joined the CIA.

### THE ROSENBERGS

This American husband and wife were executed in 1953 for passing secrets to the Soviet Union (USSR).



MATA HARI

THE FICTIONAL SPY JAMES BOND WAS CREATED BY IAN FLEMING IN 1953.

## RADIOS

Radio allowed secret agents of the past to communicate quickly over long distances—they did so in code, because radio messages can be easily intercepted. Radio waves also transmitted sounds from listening devices, such as the one hidden in the hotel lamp below.



KGB RADIO WRISTWATCH



PORTABLE MILITARY RADIO



ATTACHÉ CASE RADIO



HOTEL LAMP TRANSCEIVER

## RECORDING DEVICES

With the help of bugs and other secret recording devices, spies can ensure that no conversation is ever private. Wiretaps allow an agent to listen in on phone conversations.



CIA WRISTWATCH MICROPHONE



MEZON RECORDING DEVICE



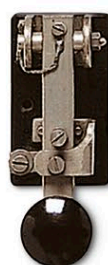
PEN-TOP MICROPHONE

## CODES AND CIPHERS

Keeping communications secret and intercepting enemy messages were prime concerns during World Wars I and II. Codes allow words or instructions to be replaced by letters, numbers, or symbols. Ciphers are a clever kind of code, where a secret “key” encrypts the message.



M-94 CIPHER DEVICE



MORSE CODE KEY



LETTER-REMOVING DEVICE



HANDKERCHIEF WITH SECRET WRITING



GERMAN ENIGMA CIPHER MACHINE USED BY JAPANESE

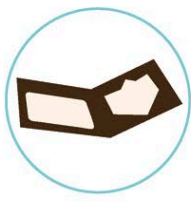


GERMAN ENIGMA CIPHER MACHINE



## WHO SPIES?

Most spies work for someone else—usually a government, a company, or another person. Spying is their job. It involves finding out information that others would rather keep hidden and passing those secrets on.



### GOVERNMENTS

Every government runs its own intelligence agency. The agency employs spies to gather information.



### PRIVATE COMPANIES

Private intelligence agencies spy on behalf of individuals, companies, and governments.



### POLITICAL GROUPS

Campaigners may work to find out "dirty" secrets kept by big companies or the government.



### INDIVIDUALS

Some people spy without being hired. They may discover a secret and share it.

## ... AND WHY?

Spying is a risky business, so why do people do it? They are usually motivated by one of four reasons. Experts explain these using the term "MICE," which stands for Money, Ideology, Compromise, and Ego.



### MONEY

Most spies do what they do for the money. Top spies are paid huge sums for the secrets they uncover.



### IDEOLOGY

Some spy because of beliefs, or ideology. They work for a government or organization that shares their beliefs.



### COMPROMISE

Sometimes people fall into spying because they have a secret of their own. They are blackmailed into the job.



### EGO

A small number of spies are motivated by ego. They think being a spy will be glamorous.

## SECRET COMPARTMENTS

Spies need to be able to transport top-secret information, tickets, or messages without them being intercepted. Spies in World Wars I and II used special microdot cameras to shrink documents on to tiny pieces of film that could be concealed in the smallest hiding places.



RING TO CONCEAL MICRODOTS



BOOT HEEL COMPARTMENT



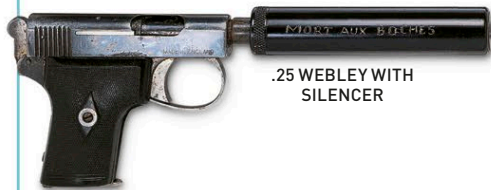
COIN WITH SECRET COMPARTMENT



HOLLOW SOAP CASE TO HIDE DEVICES

## WEAPONS

Used to threaten people and wring out information, to silence an enemy for good, or for self-defense, guns and other weapons are an espionage essential. For some missions, they may be carried openly; on others, they must be carefully disguised.



.25 WEBLEY WITH SILENCER



PUSH DAGGER



GAS-FIRING CARTRIDGE ASSASSINATION WALLET



Strap attaches gun to arm



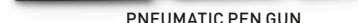
TIP OF POISON-PELLET CANE



SINGLE-SHOT ASSASSINATION DEVICE



Pen gun bullet



PNEUMATIC PEN GUN



TEAR-GAS PEN

SLEEVE GUN



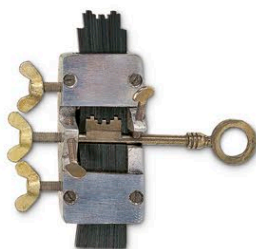
CIA DEER GUN

## GENERAL TOOLS

One challenge spies face is gaining entry to places where secrets are stored. Secret agents carry equipment for breaking and entering, including fence cutters, key copiers, and lock picks.



LOCK PICK GUN



KEY PATTERN DEVICE



WIRE FENCE CUTTER



COVERT ENTRY KIT

## CYBER SPIES

Computers and the Internet have changed the face of espionage. Cyber sleuths can now steal information remotely by hacking into computers. Governments and companies take cyber espionage very seriously.



## INTELLIGENCE AGENCIES

Governments need spies to tell them about threats from other countries. Some also carry out surveillance on their own citizens.

### MSS, CHINA

In 1983, China merged existing agencies to make its Ministry of State Security (MSS).



### RAW, INDIA

Created in 1968, India's Research and Analysis Wing (RAW) reports directly to the Prime Minister, not Parliament.



### CIA, US

The Central Intelligence Agency (CIA) focuses on foreign threats to the US.



### ISI, PAKISTAN

Founded in 1948, Inter-Services Intelligence (ISI) collects information that affects Pakistani security.



### FSB, RUSSIA

The Federal Security Service (FSB) was formed in 1995. It took over from the KGB after the fall of the Soviet Union.



### BND, GERMANY

Germany's Federal Intelligence Service, or Bundesnachrichtendienst, was founded in 1956.



### DGSE, FRANCE

Formed in 1982, the Direction Générale de la Sécurité Extérieure (DGSE) investigates threats to France.



### MI6, UK

Formally called the Secret Intelligence Service, MI6 reports to the UK government and tracks terror threats.



### ASIS, AUSTRALIA

The Australian Secret Intelligence Service (ASIS) was founded in 1952 to protect Australia's interests.



### MOSSAD, ISRAEL

Formed in 1949, Israel's intelligence agency has around 1,200 employees.





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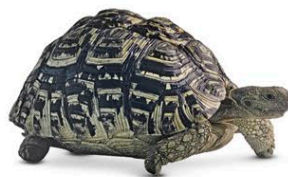
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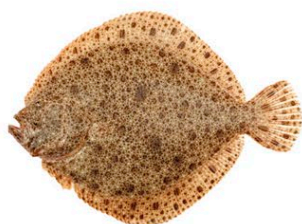


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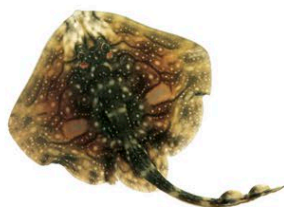
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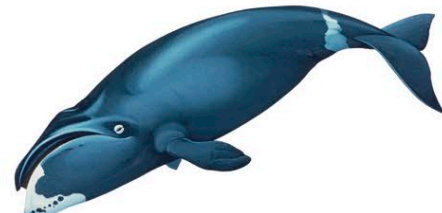
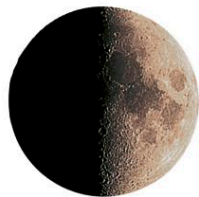


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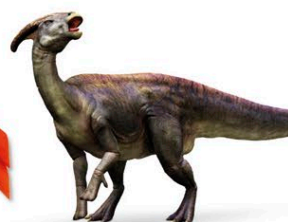
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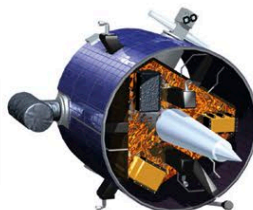


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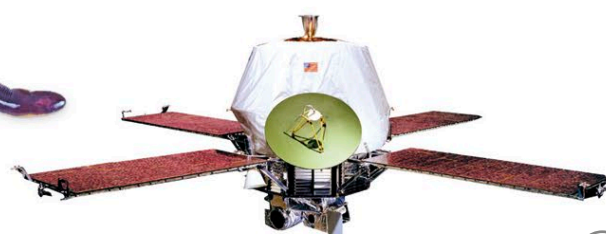
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crb/Lace Coral); Oxford Museum of Natural History (cb). **The Trustees of the Natural History Museum, London:** (bc). **72–73 Dorling Kindersley:** Senckenberg Gesellschaft Fuer Naturforschugn Museum (b). **73 Dorling Kindersley:** The American Museum of Natural History (cla); The Natural History Museum, London (fcl); Natural History Museum, London (cl, c/vertebrae, c/Pliosaur Skull, ca/Mammal-like Skull, c/ *Mammuthus*, cb, cra/Tooth, crb/Frog, crb/*Baryonyx* theropod dinosaur, fcr); State Museum of Nature, Stuttgart (cra/ *Plateosaurus*); Oxford Museum of Natural History (bc, tr); Sedgwick Museum of Geology, Cambridge (fcra); Royal Tyrrell Museum of Palaeontology, Alberta, Canada (br). **74 123RF.com:** Michael Rosskothén (crb). **Dorling Kindersley:** James Kuether (crb/*Shunosaurus*). **Dreamstime.com:** Leonello Calvetti (tr); Mr1805 (br). **75 Dorling Kindersley:** Jon Hughes (cla/ *Titanosaurus*, bc); James Kuether (ca, c, clb, cl, cr). **76 Dorling Kindersley:** James Kuether (crb, cra, bc, cl/*Caudipteryx*, ca, cr, cl/*Guanlong*). **77 Dorling Kindersley:** James Kuether (clb). **78 Dorling Kindersley:** Jon Hughes and Russell Gooday (cra, cr, c/*Sphenosuchus*, bc/*Placodus*, br/*Lariosaurus*); Jon Hughes (cla, cl/*Peteinosaurus*, c, clb, bc, bc/*Mixosaurus*, br/*Ichthyosaurus*, fbr/*Geosaurus*); Peter Minister and Andrew Kerr (cl); James Kuether (cr/*Lystronotus*, cr/*Herrerasaurus*, bc). **79 Alamy Images:** Elvele Images Ltd (tr). **Dorling Kindersley:** Jon Hughes and Russell Gooday (cla, ca, fcr, clb); Natural History Museum, London (tc); Jon Hughes / Bedrock Studios (cr, bl/*Kronosaurus*); Jon Hughes (crb, bl, fclb/*Liopleurodon*, cb, crb/*Ischyodus*). **82 Getty Images:** Martin Harvey / Photodisc (c). **83 Dreamstime.com:** Chonlawut Brahmasakha (bl); Xianghong Wu (fbl); Whiskybottle (bc). **Getty Images:** (cr). **84 Dorling Kindersley:** Chris Gibson (cb). **90 Dorling Kindersley:** Linda Pitkin (fcrb/ Aesop). **91 Dorling Kindersley:** Linda Pitkin (fcl/ Porcelain, cl/ Hermit crab, clb/ slipper, clb/ marble, cb/ squat, bl, bc); Linda Pitkin / lindapitkin.net (cl/ Panamic); Jerry Young (crb/ Pill). **Dreamstime.com:** Olga Demchishina / Olgysa (fclb/ Mantis). **92 Alamy Images:** Brand X Pictures / Brian Hagiwara (cl/ June). **Dorling Kindersley:** The Natural History Museum, London (cl/ Weevil, cr/ Longhorn, cb, fcr, clb/ Weevil, fcrb); Jerry Young (c/ jewelled). **Dreamstime.com:** Isselee (fclb); The Natural History Museum, London (bl/ bush). **93 Dorling Kindersley:** Forrest L. Mitchell / James Laswel (cla/ Clutbait, ca/ Comet, ca/ Flame, cra, cl/ Gray, c/ Baskettail, cb/ River); The Natural History Museum, London (ftr, cla/ Damselfly, crb/ Giant Hawker, fcra, fcr, fcr/ Tiger, fcrb); Neil Fletcher (crb/ dmsel); Oxford University Museum of Natural History (fclb). **Dreamstime.com:** Ryszard Laskowski / Ryszard (tl/ Army ants). **94–95 Dorling Kindersley:** The Natural History Museum, London (All Images). **96 Dorling Kindersley:** Linda Pitkin (cl/ varicose, ca/ annae, ca/ Headshield, tr/ Spanish, ftr/ elegans). **Dreamstime.com:** Jannekespr (cr/ lipped). **NOAA:** Estuarine Research Reserve Collection (cra). **96–97 Dorling Kindersley:** Linda Pitkin (tl). **97 Dorling Kindersley:** Linda Pitkin (tc/ hare, ca/ Variable Neon, crb/ Bigfin); Richard Ling (cra/ Cuttlefish). **Dreamstime.com:** Selahattin Ünsal Karhan (c/ Trumpet). **98 Dorling Kindersley:** Marc Bosch Mateu (fcl/ Meagre); Linda Pitkin (tc/ bluestripe, fcla/ seahorse, fcla/ mullet, cl/ Parrotfish, fcra/ box, cra/ lizardfish, clb); The Weymouth Sea Life Centre (fclb/ stonefish). **Dreamstime.com:** Andyld (tl/ Turbot); Lunamarina (ca/ Bluefish); Eric Isselee / Isselee (cr); Asher Lau Choon Siew / Pufferfishy (fclb/ Gurnard). **Fotolia:** uwimages (cb/ anemone). **98–99 Dorling Kindersley:** Terry Goss (cb). **99 Dorling Kindersley:** Frank Greenaway (ftr); Linda Pitkin (cl); Jerry Young (tl, ca/ Catfish). **Dreamstime.com:** Stefan Hermans / Perrush (tr/ goldfish); Peter Leahy / Pipehorse (ftl/ trumpet); Stephan Pietzko / Pilens (fcrb/ Burbot); Tonny Wu (cb). **100 Dorling Kindersley:** Linda Pitkin (crb); Brian Pitkin (cla). **101 Dorling Kindersley:** Dr. Peter M. Forster (crb). **Dreamstime.com:** Greg Amptman (fbr); Dongfan Wang / Tabgac (cr); Yobro10 (crb/ Southern stingray). **104 Dorling Kindersley:** Dr. Peter Janzen (cla, cla/ leaf frog, cla/ Splendid leaf frog); Peter Janzen (ca, cra); Twan Leenders (c, clb, clb/ Red). **105 Dorling Kindersley:** Twan Leenders (ftr, fcra, ca, cr); Jan Van Der Voort (fcl); Ignacio De la Riva (cl). **Dreamstime.com:** Kamnuan Suthongsaa (fcrb). **106 Dorling Kindersley:** James H. Harding (ftr/ Blanding); Twan Leenders (cla); Jerry Young (fcla, c/ Red-legged, crb/ hinge); Jan Van Der Voort (cr/ Spur-thighed); The Natural History Museum, London (br). **Dreamstime.com:** Amwu (clb/ Elongated); Torsten Kuenzlen / Kuenzlen (tc/ Loggerhead); Am Wu / Amwu (cra). **107 Dorling Kindersley:** Twan Leenders (cra/ Terrapin); Jerry Young (ftl, bc/ Kinixys). **Dreamstime.com:** Amwu (fcla). **Getty Images:** Photographer's Choice RF / Peter Pinnock (bc). **108 Dorling Kindersley:** Twan Leenders (cb). **Dreamstime.com:** Amwu (clb). **108–109 Dorling Kindersley:** Andy and Gill Swash (cb). **109 Dorling Kindersley:** Twan Leenders (crb, crb/ Percival's Legless Skink, fcrb). **Dreamstime.com:** Iulian Gherghel (bc). **Fotolia:** Eric Isselee (fcra). **111 Dorling Kindersley:** Twan Leenders (cra/ Rough); Jan Van Der Voort (cl/ Orsini's). **Dreamstime.com:** Wahyudinfirmar (tc, tr, ftr). **112 Dreamstime.com:** Mikhail Blajenov (cl). **113 Dorling Kindersley:** Jerry Young (fcr/ dwarf). **Dreamstime.com:** Lukas Blazek (tl); Nico Smit / Ecophoto (fcrb); Edurivero (cl). **114–115 Dorling Kindersley:** The Natural History Museum, London (All Images). **116 Dorling Kindersley:** Greg and Yvonne Dean (cb); E. J. Peiker (cra); The National Birds of Prey Centre, Gloucestershire (crb); Jari Peltomaki (cla, clb); Markus Varesvuo (ca); Brian E. Small (cra, cl/ runner, br); Barry Hughes (cl); Roger Tidman (bc, fbr). **Getty Images:** Frank Krahmer / Photographer's Choice RF (fbl). **117 Dorling Kindersley:** Mike Danzenbake (cl/ swift); The Natural History Museum, London (cra); E. J. Peiker (c, cr); Andy and Gill Swash (fcl); Mike Danzenbake (cl/ LUCIFER); Mike Read (cl/ today); Tomi Muukkonen (clb); Markus Varesvuo (crb, fbl); Garth McElroy (crb/ duck); Melvin Grey (bl, clb/ gallinule); Chris Gomersall Photography (crb/ puffin); Brian E. Small (br, br/ warbler, fbr); Mike Lane (br/ skylark). **118 Dorling Kindersley:** Chris Gomersall (fcr); The

National Birds of Prey Centre, Gloucestershire (c, fcr/ Harris hawk, cb/ egyptian); Hanne and Jens Erikson (cla); Melvin Grey (br). **Dreamstime.com:** Isselee (c/ Bald Eagle). **119 Dorling Kindersley:** Greg and Yvonne Dean (fcrb, fbr); E. J. Peiker (c); E. J. Peiker (clb); The National Birds of Prey Centre, Gloucestershire (fclb, bl); Andy and Gill Swash (bc); Jari Peltomaki (tr); Bob Steele (cla, cr, bc/ whet); Barry Hughes (cl); Brian E. Small (cb, br); Mark Hamblin (cb/ short); Markus Varesvuo (crb). **120 123RF.com:** mycteria (crb). **Dorling Kindersley:** The Natural History Museum, London (cla, bc/ Tawny Owl); Evgeniya Moroz (cl/ peacock). **Dreamstime.com:** Iakov Filimonov (bl); Irisangel (br); Feathercollector (cb/ Tragopan); Wollertz (cr). **121 Dorling Kindersley:** Barnabas Kindersley (bc). **Dreamstime.com:** David Medina claesson (br); Vtorous (fcl); Smileus (bl); Feathercollector (br/ Kingfisher); Roman Ivaschenko (clb/ crow). **iStockphoto.com:** nadytyok (cl/ Lovebird). **122 Dorling Kindersley:** The Natural History Museum, London (cla). **123 Dreamstime.com:** Torsten Kuenzlen / Kuenzlen (crb). **Fotolia:** Chrispo (cr). **124 Dorling Kindersley:** Greg and Yvonne Dean (cb/ Sun); Exmoor Zoo, Devon (fcra). **Fotolia:** Eric Isselee (crb). **124–124 Dorling Kindersley:** The Marwell Zoological Park, Winchester (tl). **125 Dorling Kindersley:** The Booth Museum of Natural History, Brighton (fcr/ Hopi); Rebecca Dean (fcl/ african); E. J. Peiker (c/ harrisi); Drusillas Zoo, Alfriston, West Sussex (fbr). **Dreamstime.com:** Per Björkdahl (cra/ lemming); Edward Kyslinsky (cr); Dule964 (cra/ Dormouse); Martha Marks (fcrb/ prairie). **126 Dorling Kindersley:** Greg and Yvonne Dean (cra/ Pig-tailed); Jerry Young (tr/ Capuchin, ca/ Cotton-top, fcra/ Marmoset). **Dreamstime.com:** Daniel Bellhouse (cl); Eric Isselee (cra/ Pygmy). **127 Dorling Kindersley:** Andy and Gill Swash (cla/ Toque); Jerry Young (ftl). **Dreamstime.com:** Lin Joe Yin / Joeyin (fcl/ Gibbon). **Fotolia:** Eric Isselee (cl/ Pileated Gibbon). **128 Dorling Kindersley:** Prof. Marcio Motta (cr); Wildlife Heritage Foundation, Kent, UK (br). **Dreamstime.com:** Rafael Angel Irueta Machin / Broker (ca); Isselee (bl). **129 Dorling Kindersley:** Berlin Zoo (cr); Wildlife Heritage Foundation, Kent, UK (cl, bl, bc); Blackpool Zoo, Lancashire, UK (crb). **Dreamstime.com:** Jeff Grabert / Jgrabert (cra); Outdoorzman (cr/ Canadian lynx). **Fotolia:** Shchipkova Elena (br). **131 Dorling Kindersley:** The Tank Museum (cl). **132 Dorling Kindersley:** The Natural History Museum, London (cla, cl, cra/ tortoise, c, cb, cb/ Crow); Booth Museum of Natural History, Brighton (cra, fbr). **133 Dorling Kindersley:** The Natural History Museum, London (tr, fcrb, crb). **Fotolia:** giuliano2022 (tc/ Rhinocer). **134 Dorling Kindersley:** Jerry Young (tr). **136 Dreamstime.com:** Ekaterina Cherkashina / Katerinache (cra/ Munchkin). **137 Dreamstime.com:** Eric Isselee / Isselee (clb/ persian). **138 Dorling Kindersley:** Haras Nationale de Saint Lo, France (cl/ Norman Cob). **Dreamstime.com:** Isselee (br). **139 Fotolia:** Jan Will (bl/ Zebra). **140 Dorling Kindersley:** Barleylands Farm Museum and Animal Centre, Billericay (tr, ca, fcra); South of England Rare Breeds Centre, Ashford, Kent (cla, br); Cotswold Farm Park, Gloucestershire (crb). **Fotolia:** Eric Isselee (clb). **140–141 Dorling Kindersley:** Barleylands Farm Museum and Animal Centre, Billericay (cl). **141 Dorling Kindersley:** Barleylands Farm Museum and Animal Centre, Billericay (cla); South of England Rare Breeds Centre, Ashford, Kent (tl, cla/ pig); Odds Farm Park, High Wycombe, Bucks (cr). **142 Alamy Images:** Big Pants Productions (fcr). **Dorling Kindersley:** Jerry Young (fcra). **Dreamstime.com:** Inga Nielsen (ca); Svehlik21 (cra). **143 Alamy Images:** Photofrenetic (fclb). **Dorling Kindersley:** Cotswold Wildlife Park (fcl); Andy and Gill Swash (c/ Coyote); Jerry Young (c, cl/ Mandarin Duck); E. J. Peiker (cb); Natural History Museum, London (crb); Natural History Museum, London (cr). **Dreamstime.com:** Anton Kozyrev (br); Urospoteko (fclb); Jnhuz (clb); ljacky (bl). **Fotolia:** Eric Isselee (ca). **144 Dorling Kindersley:** Natural History Museum, London (tr); Jerry Young (ca/ Red Eyed Tree Frog). **Dreamstime.com:** Eric Isselee (cra); Isselee (ca); Kira Kaplinski / Kkaplin (clb). **145 Alamy Images:** Life on White (clb). **Dorling Kindersley:** Natural History Museum, London (ca, ca/ Tawny Rajah, cl); Jerry Young (ftl, cla/ Black spider monkey, cl/ Nymph, cb); Twan Leenders (cr). **Fotolia:** Eric Isselee (cla). **146 Dreamstime.com:** Anankm1 (tr); Ryszard Laskowski (cl). **Fotolia:** Andreas Altenburger / arrxxx (cra). **146–147 Dorling Kindersley:** Jerry Young (bc). **147 Dorling Kindersley:** Cotswold Wildlife Park (cra). **Fotolia:** Shchipkova Elena (clb). **148 Dorling Kindersley:** Jerry Young (ca, cr). **Dreamstime.com:** Smellme (ftr); Stefan Gottschild (br). **Fotolia:** Steve Lovegrove (fcrb). **149 Dorling Kindersley:** E. J. Peiker (cla). **150 Corbis:** (cra). **Getty Images:** Sandy Carey, Photodisc / Alan (br). **150–151 Dreamstime.com:** Steven Oehlenschläger (bc). **151 Dorling Kindersley:** Drusillas Zoo, Alfriston, West Sussex (bc); Jerry Young (tl). **Dreamstime.com:** Achim Baqué (cr/ leopard seal); Helen Panphilova / Gazprom (cla); Vladimir Seliverstov / Vldasilver (fcr); Isselee (bl). **Fotolia:** Stefan Zeitz / Lux (cl). **Getty Images:** Joel Sartore (tc); Purestock (crb/ Harp Seal). **152 Dorling Kindersley:** Linda Pitkin (tr, ca/ cuttlefish, tr/ seahorse, cl). **152–153 Dorling Kindersley:** Rick Hibpsman (bl). **153 Dorling Kindersley:** The Weymouth Sea Life Centre (fcla); Linda Pitkin (tc, tc/ Seamoth, tl, tc/ Sea strawberry, ca, cla); Linda Pitkin / lindapitkin.net (tc/ arrow crab); Terry Goss (cla/ Tiger Shark); Natural History Museum, London (ca/ Horseshoe Crab). **Dreamstime.com:** Jamiegodson (cl); Teguh Tirtaputra / TeguhTirta (cb); Dejan Sarman / Dejan750 (crb). **154 Dorling Kindersley:** Linda Pitkin / lindapitkin.net (br). **Dreamstime.com:** Carol Buchanan (cra). **154–155 Dorling Kindersley:** Dr. Peter M. Forster (cl). **155 Alamy Images:** Martin Strmiska (br). **Dorling Kindersley:** The Goldfish Bowl (cr/ Jewelfish). **Dreamstime.com:** Eric Isselee (clb/ Hermit crab); Krzysztof Odziomek / Crisod (tc); Tazdevitreg (c/ Coral Trout). **156 Dorling Kindersley:** Natural History Museum, London (cra, cb). **157 Dorling Kindersley:** Planetary Visions Ltd (crb). **Dreamstime.com:** Dan Breckwoldt / Danbreckwoldt (cla). **Fotolia:** Mark Higgins (cra/ kangaroo). **Getty Images:** Dene Miles (ca). **158 Dreamstime.com:** Staphy (bc). **159 Dreamstime.**

**com:** Yury Tarasov / Sportfoto (bc). **Fotolia:** Galyna Andrushko (bc/ peak). **160 Dreamstime.com:** Jason Yoder / Jasyony00 (br). **161 Dorling Kindersley:** Museo Archeologico Nazionale di Napoli (br); NASA (bc/ Volcano erupting on lo). **165 Dreamstime.com:** Vera Golovina (br). **166 Dorling Kindersley:** The Natural History Museum, London (cl/ magnetite, fclb/ Hornblende, bc/ Corundum, fbr); The Science Museum, London (cla/ Pumice). **167 Dorling Kindersley:** The Natural History Museum, London (cb/ Proustite); The Oxford University Museum of Natural History (cl/ diamond). **168–169 Dorling Kindersley:** The Natural History Museum, London (All images). **169 Dreamstime.com:** Leon Rafael / Lrafael. **172–173 Dorling Kindersley:** Planetary Visions Ltd (c). **173 Dreamstime.com:** Jeremy Richards (cra). **NASA:** (bc, br); (fbr). **174 Corbis:** Warren Faidley (fcra). **Dreamstime.com:** Amnemcova (cr/ Snow storm); Sergey Galushko / Galdzer (cla); Gina111 (ca); Victor Zastol'skiy / Vicnt (cra/ Tornado); Dexitner (cl/ Heatwave); Ollrig (cl/ Drought); Anizza (cl); Antares614 (cr/ Hailstorm). **NOAA:** Carrie Smith / NOAA Central Library (fcr). **U.S. Geological Survey:** (ca/ flood); Seth Munson (fcl). **176 Alamy Images:** Travelib Africa (clb). **177 Alamy Images:** Hugh Threlfall (cra). **Dorling Kindersley:** Dr. Peter Janzen (cra/ frog). **Fotolia:** Scanrail (cra/ globe). **182 Dorling Kindersley:** Barnabas Kindersley (cla). **183 Dreamstime.com:** Byjeng (cra). **185 Dorling Kindersley:** Jerry Young (ftr). **186 Corbis:** DLILLC (bc). **Dreamstime.com:** Misha Shiyano / Kertis (cl). **187 Dorling Kindersley:** Philip Dowell (tr/ Jaguar). **Dreamstime.com:** Chrishowey (bc). **190 Dreamstime.com:** Jeremy Richards (clb). **191 Fotolia:** Eric Isselee (clb). **PunchStock:** Digital Vision (cr). **192 iStockphoto.com:** Drazen (bl). **193 Dreamstime.com:** Dmitry Pichugin / Dmitryp (br); Callan Chesser / Ewanchesser (tc); Bin Zhou / Dropu (bc). **Fotolia:** Mark Higgins (cra); Eric Isselee (tr). **194 Dorling Kindersley:** The Royal Geographical Society, London (cla, clb). **Dreamstime.com:** Staphy (bl, bc). **195 Dorling Kindersley:** Alan Burger (cra/ seal); Arctic Trucks / Gisli Jonsson (tc). **Dreamstime.com:** Xavier Marchant / Xaviermarchant (cr); Jan Martin Will / Freezingpictures (tr/ Adelie penguin). **Getty Images:** Dene Miles (cra); David Tipling / Digital Vision (tr). **198 Alamy Images:** Hugh Threlfall (cb). **Dreamstime.com:** Elena Elisseeva (cl/ soya); Igor Marx (cl); Mafoto (cb/ Triticale); Mateno (clb). **199 Dorling Kindersley:** Odds Farm Park, High Wycombe, Bucks (clb/ pig). **200 Dorling Kindersley:** Blandford Fashion Museum (ca/ Straw hat); Musee du Louvre, Paris (ca/ Mona Lisa). **Dreamstime.com:** Anky10 (clb); Vtupinamba (ca); Goncharuk Maksym (cr). **201 Dorling Kindersley:** Barnabas Kindersley (ca); University of Pennsylvania Museum of Archaeology and Anthropology (cla); The Shoe Museum (cla/ Lower heel); The Royal Academy of Music (cb); Durham University Oriental Museum (fclb). **123RF.com:** Satori / Dorling Kindersley (cra). **202 Dorling Kindersley:** Barnabas Kindersley (crb); Stephen Oliver (bc). **Dreamstime.com:** Murali Nath / Muralinath (fcr); Silentiger (fcl). **203 Dorling Kindersley:** Central London Gurdwara (cb); The Zoroastrian Trust Funds of Europe (cr); Pitt Rivers Museum, University of Oxford (bc); Barnabas Kindersley (bl). **204 Dorling Kindersley:** Barnabas Kindersley (bl). **Dreamstime.com:** Gino Santa Maria (tr); Patrick Poendl (cl). **Fotolia:** Anatolii (cl). **205 Dreamstime.com:** Jamen Percy (tc); Sergey Tsirov (cl); Laura Stone (cr). **Shutterstock.com:** Golden Pixels LLC (br). **208 Dorling Kindersley:** Andy Crawford (bl, bl/ Star-shaped pendant); University Museum of Archaeology and Anthropology, Cambridge (tc, tr); Wallace Collection, London (fcr/ Ornate Elephant); National Museum of Wales (tc/ Stone-Age painting); Museum of the Order of St John, London (cra); Musee du Louvre, Paris (clb); The National Music Museum (bc); University of Pennsylvania Museum of Archaeology and Anthropology (tr/ Ornament, fcra). **Dreamstime.com:** Hasan Can Balcioglu (cr/ mosaic); Steve Estvanik (c); Farhadi (cl). **209 Dorling Kindersley:** The University of Aberdeen (cla); University of Pennsylvania Museum of Archaeology and Anthropology (ftt, tc, tc/ Ancient Egypt Shabti); Ure Museum of Greek Archaeology, University of Reading (tr); Durham University Oriental Museum (ca, ca/ Mummy mask, fcl/ Stoneware, fcl); Villa Giulia and Beniculturali (c/ bust); The American Museum of Natural History (fcr). **Dreamstime.com:** Rolffimages (bc/ Expression). **The Metropolitan Museum of Art, New York:** Gift of Adele R. Levy, 1958 (cb). **210 Dreamstime.com:** Mihail Ivanov (cb); Xing Wang (cra); Vasilis Ververidis (ca). **Los Angeles County Museum of Art:** (cl). **The Metropolitan Museum of Art, New York:** Bequest of Mrs. Charles Wrightsman, 2019 (cr); Purchase, The Annenberg Foundation Gift, 1993 (bl); Mary Griggs Burke Collection, Gift of the Mary and Jackson Burke Foundation, 2015 (fcra); Gift of Phyllis D. Massar, 1972 (crb); The Francis Lathrop Collection, Purchase, Frederick C. Hewitt Fund, 1911 (cl). **211 123RF.com:** Satori / Dorling Kindersley (bl). **Dreamstime.com:** David Sanchez Paniagua Carvajal (fclb); Lilianaesperanza13 (ca). **Fotolia:** HP Photo (cla). **The Metropolitan Museum of Art, New York:** Bequest of Benjamin Altman, 1913 (c); Gift of Elinor Dorrance Ingersoll, 1969 (cr); Bequest of Collis P. Huntington, 1900 (clb); Gift of Arthur A. Houghton Jr., 1970 (cr); Purchase, The Dillon Fund Gift, 1982 (tl). **Rijksmuseum, Amsterdam:** (crb). **212 Dorling Kindersley:** The Bate Collection (cl/ Clarinet, cr/ Bugle); The Powell-Cotton Museum, Kent (bc). **213 Dorling Kindersley:** The Bate Collection (c/ Viol); The Royal Academy of Music (fcl, c). **Dreamstime.com:** Karam Miri (cb). **Getty Images:** Stockbyte (crb/ Ukulele). **216 Dorling Kindersley:** Andy Crawford (cl, cl). **Dreamstime.com:** Afxhome (cla); Hongqi Zhang (laka Michael Zhang) (cra). **217 Dorling Kindersley:** Blandford Fashion Museum (cra/ tango shoes). **Dreamstime.com:** Alexandr Kornienko (cra/ Tap shoes); Anky10 (fcr); Goran Bogicevic (cra); Stable400 (fcra); Derek Tenhues / Derektenhues (fcra/ Ballroom); Samotrebizan (cra/ samba, fcra/ cha cha); Viorel Sima (cr). **218 Dorling Kindersley:** Etablissement public du musee et du domaine national de Versailles; Reunion des Musees Nationaux / Art Resource, NY. (fcl); Etablissement public du musee et du



domaine national de Versailles [cla]. **Dreamstime.com:** Jackq [fcra]; Photobac [ca]. **iStockphoto.com:** vgajic [cra/Apprentice]. **219 Dreamstime.com:** Photobac [tr/Demi plié]. **220 Dorling Kindersley:** Lydia Evans / Rough Guides [crb]; Pompidou Centre [br]. **Dreamstime.com:** Chrisharvey [cr]; Sergii Figurnyi / Bloodua [tc]; Konstantin32 [cl]. **221 Dorling Kindersley:** Demetrio Carrasco / Rough Guides [fcr]; Photos By Chris Christoforou / Rough Guides [tl]; Tim Draper / Rough Guides [ftr, bl]. **Dreamstime.com:** Yykkaa [bc]. **222 Dorling Kindersley:** Pennsylvania Museum of Archaeology and Anthropology [ca]. **223 Fotolia:** Derya Celik [ca]. **225 Rex by Shutterstock:** Geraint Lewis / Dorling Kindersley [br]. **226 Getty Images:** Photographer's Choice RF / Jon Boyes [cb]. **Dreamstime.com:** Anamaria Mejia [cl]. **227 Dreamstime.com:** Vtupinamba [cla]; Chernetskaya [bl/Murgh Makhani]; Susansam90 [bl/Palak Paneer]. **Shutterstock.com:** peacefoo [crb]. **iStockphoto.com:** Vasko Miokovic [cra]. **228 Getty Images:** Creativ Studio Heinemann [fcl/Black currants]. **228–229 Dreamstime.com:** Goncharuk Maksym [c]. **229 Getty Images:** Foodcollection [c/ Damson]. **231 Getty Images:** felipedupouy.com / Photodisc [bl]. **232 Dorling Kindersley:** Westcombe Dairy [ftl, tl, tc]. **233 Dreamstime.com:** Malgorzata Kistryn [tl]. **Fotolia:** Eric Isselee [bl]. **234 Dorling Kindersley:** Barnabas Kindersley [cb/Mantou]. **236 Dreamstime.com:** Bert Folsom [crb]. **238 Dreamstime.com:** Deepcameo [c]. **239 Dorling Kindersley:** The Natural History Museum, London [clb/sea urchin]. **242 Dorling Kindersley:** Blandford Fashion Museum [cl, bl, cb, bc]; Ermine Street Guard [ca]; The Shoe Museum [c, c/brogues]; Contemporary Wardrobe [c/Tweed Cap]; Tim Parker [cb/jacket]. **Dreamstime.com:** Diane Diederich [bl]; Mykola Kravchenko [clb]. **Shutterstock.com:** LightField Studios [br]. **243 Dorling Kindersley:** Banbury Museum [tr/waistcoat, fcr]; Blandford Fashion Museum [tc, fcl, fcl/swim cap]; Central Saint Martins [c, c/Jacket, c/Cloak, cr]. **Getty Images:** Photodisc [bc]. **Dreamstime.com:** Stockyimages [br]. **244 Dorling Kindersley:** Angels Fancy Dress [tr/day dress, fcrb, fbr]; The British Library [tr/handbag]; Banbury Museum [c/ pamphlet]; Blandford Fashion Museum [fcla, fcl, cl/shoes, cr/ evening dress, cr/floral dress, cr/gloves, cr/hat, bc/handbag, bc/ shoes]. **245 Dorling Kindersley:** Angels Fancy Dress [bc/dress]; The Shoe Museum [tl/red footwear, tl/high-heeled shoe, tl/silk boot, cla/slipper, fcl/shoe, cr/high heel]; Blandford Fashion Museum [ftl/dress front, ftl/dress back, tr/dress, tr/fan, tr/ corset, fcl/blue dress, fcl/hat, cl/white dress, cl/shoes, cr/ corset, cr/handbag, fbl/hat]; Museum of London [fcl/red dress]; Worthing Museum and Art Gallery [fbl/shoes]; Christian Dior [br/ bag]. **Dreamstime.com:** Lightfieldstudiosprod [bc]. **Shutterstock.com:** Hans Kim [br]. **246 Dreamstime.com:** Bidouze Stéphane [cla]. **248 Dorling Kindersley:** Stephen Oliver [br]. **Dreamstime.com:** John Kasawa [bl]; Mikumistock [tl]. **Fotolia:** Gudellaphoto [c]. **249 Dreamstime.com:** Dmitry Grushin [cr]. Olaf Speier [ftl]. **Getty Images:** Burazin / Photographer's Choice RF [bl]. **254 Getty Images:** Burazin / Photographer's Choice RF [ca]. **262 Dorling Kindersley:** Stephen Oliver [crb]. **263 Shutterstock.com:** OSTILL is Franck Camhi [cr]; podorojiny [bl]. **268 Dreamstime.com:** Vladimir Ovchinnikov [br]. **123RF.com:** spotpoint74 [clb]. **274 Dorling Kindersley:** Leeda Fishing Tackle, UK [cla, ca]. **275 Dorling Kindersley:** Leeda Fishing Tackle, UK [crb/Deer Hopper]. **Dreamstime.com:** Bidouze Stéphane [tr]; Ka2shka [tr]; Valery Kudryavtsev [tr/portable scale]. **283 iStockphoto.com:** shank\_ali [tc]. **Dorling Kindersley:** Davenport's Magic Kingdom [cra]. **284 Dorling Kindersley:** Pegasus Stables, Newmarket [c]; W&H Gidden Ltd [cr]. **iStockphoto.com:** Weenee [ca]. **286 Dorling Kindersley:** The Board of Trustees of the Royal Armouries [cb]; Vikings of Middle England [cla]; University of Pennsylvania Museum of Archaeology and Anthropology [ca, fcra, clb]; The Tank Museum [crb]; Durham University Oriental Museum [cb/fan, cb/Glass bowl]. **Dreamstime.com:** Ks2008q [ca/coin]. **Alamy Stock Photo:** D. 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Vikings of Middle England [clb, ca, cb, cb/dagger, cr, bl, bl/arrows, bc, fbr]. **304 Dorling Kindersley:** Sarah Cummins / Rough Guides [cb]; Roger D'Olivera Mapp / Rough Guides [clb]; Tim Draper / Rough Guides [crb]. **305 Dorling Kindersley:** The University of Aberdeen [tl, clb/Jade Mask, clb/Frog, clb/Jadette Figure]; Tim Draper / Rough Guides [fcla, cla]; Suzanne Porter / Rough Guides [ca]; University of Pennsylvania Museum of Archaeology and Anthropology [ftl, fclb/ Jaguar Mask, fbl/Pitcher, bl/Stirrup Pot, bl/Vase, cb, bc, crb, br, fbr, fcrb]. **307 Dorling Kindersley:** Board of Trustees of the Royal Armouries [cb/boot]; University of Pennsylvania Museum of Archaeology and Anthropology [clb/Tile, bl]; The Board of Trustees of the Royal Armouries [ftr, tc/chichak, tc, cra, c, c/ dagger, c/sword, cr]; Durham University Oriental Museum [clb, c/Breastplate, fbr]. **Dreamstime.com:** Ahmet Ihsan Arirturk [cl]. **308 Dorling Kindersley:** The Board of Trustees of the Royal Armouries [fclb/helmet, clb/Helmet, cb/Scabbard, cb/Indian, crb/Talwar, fcrb, fcrb/Tongi, fclb, clb, bl, bl/tabar]; 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The Science Museum, London [cl/Earthquake Detector, c]; University of Pennsylvania Museum of Archaeology and Anthropology [clb/Camel]. **314 Dorling Kindersley:** Anthony Barton Collection [clb, clb/harp, cb, cb/hornpipe]; Tsaravets Fortress [c]; The Bate Collection [crb, fcrb]; Board of Trustees of the Royal Armouries [r]. **315 Dorling Kindersley:** Royal Armouries, Leeds [cb]; The Wallace Collection, London [cla]; The Combined Military Services Museum [CMSM] [cra, cb, cb/mercy , cb/dagger, crb, crb/war hammer, crb/cannon, cra/Burgonet]; Robert Harding [fcrb/Church]; Stephen Oliver [fcrb]; The London Dungeon [bl, bc, br]. **317 Dorling Kindersley:** The Board of Trustees of the Royal Armouries [cla]; Cotswold Farm Park, Gloucestershire [clb, crb]; The Order of the Black Prince [cl, bl]. **123RF.com:** Anton Ivanov [cr/Krak des Chevaliers]. **Dreamstime.com:** Carlos Pérez [tl]; Speedo101 [bc]. **318 Dorling Kindersley:** Board of Trustees of the Royal Armouries [br]; Thackray Medical Museum [cb]; The Science Museum, London [crb]; Whipple Museum of History of Science, Cambridge [fcrb]; The Combined Military Services Museum [CMSM] [bc]. **319 Dorling Kindersley:** The Bate Collection [tc, tc/basset recorder, tc/Bass racket, tl, tc/ Tenor crumhorn]; The Royal Academy of Music [tl/lute]; Musee du Louvre, Paris [cr]. **Dreamstime.com:** Anthony Baggett [cl]; Susico [bc]. **320 Dorling Kindersley:** Royal Geographical Society, London [clb]. **321 Dorling Kindersley:** Natural History Museum, London [cra/drawing, cra]; The Science Museum, London [ca/ meter panel]; The Royal Geographical Society, London [crb]; Royal Geographical Society, London [fcrb, crb/chemistry set]. **123RF.com:** Anthony Baggett [cr]. **Dreamstime.com:** Akeeris [cla]; Jochenschneider [tl]. **322 123RF.com:** Ivan Aleshin / ivan604 [clb]. **Dorling Kindersley:** University of Pennsylvania Museum of Archaeology and Anthropology [ca]. **Dreamstime.com:** Ivan Vander Biesen [cr]; Mohamed Osama [cra]; Demerzel21 [br]. **Library of Congress, Washington, D.C.:** LC-DIG-ppmsc-03265 [crb]; 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