



FIRE ENGINE



HYACINTH



CATTLE HEART SWALLOWTAIL



COCKER SPANIEL



RASPBERRY



ROUNDERS BALL



TUTANKHAMUN



JUNGLE NYMPH STICK INSECT



BENGAL TIGER



APOLLO 7 MISSION BADGE



DUSKY SHARK



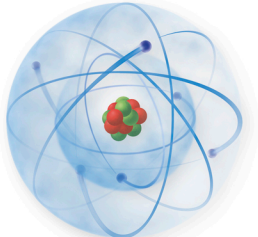
SUIT OF ARMOUR



SULPHUR



ATLANTIC PUFFIN



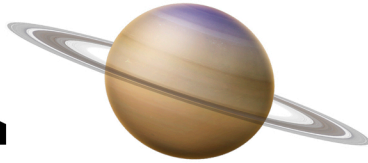
ATOM



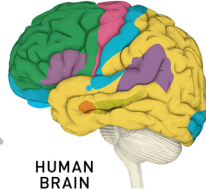
ROMAN SHIELD



ABRAHAM LINCOLN



SATURN



HUMAN BRAIN



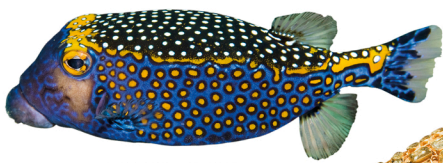
RED LAND CRAB



TOKAY

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SPOTTED BOXFISH



OTTOMAN DAGGER



EASTERN YELLOW ROBIN



GUAVA



BUFFY FISH OWL



EGYPTIAN BEAD COLLAR



PEACOCK FEATHER



CONFEDERATE DRUM



VIOLIN



FERRARI SUPERCAR



MORAY EEL



WEEVIL



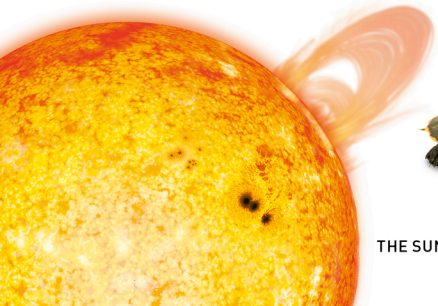
TRACK BIKE



ZEBRA



GREEN-YELLOW TOURMALINE



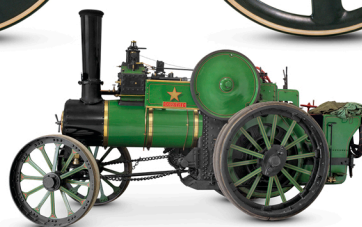
THE SUN



NORTHERN RED-BELLIED TURTLE



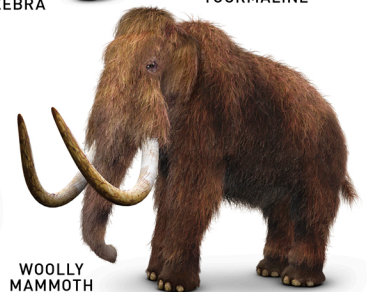
FRENCH HORN



STEAM-POWERED TRACTOR



TRITON'S TRUMPET SHELL



WOOLLY MAMMOTH







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# CONTENTS

## Science and technology

- 10 The Universe
- 12 The planets
- 14 The Moon
- 16 Space exploration
- 18 Stargazing
- 20 Northern skies
- 22 Southern skies
- 24 Physics
- 26 Electricity
- 28 Chemistry
- 30 The elements
- 32 Biology
- 34 The human body
- 36 Skeleton
- 38 Muscles
- 40 The brain
- 42 Computers
- 44 Inventions
- 46 Numbers
- 48 Geometry
- 50 Cars
- 52 Tractors
- 54 Trucks and diggers
- 56 Trains
- 58 Motorbikes
- 60 Aircraft
- 62 The story of flight
- 64 Bicycles







# Nature

---

<b>68</b>	Tree of life	<b>118</b>	Birds of prey
<b>70</b>	How life began	<b>120</b>	Feathers
<b>72</b>	Fossils	<b>122</b>	Animal journeys
<b>74</b>	Plant-eating dinosaurs	<b>124</b>	Rodents
<b>76</b>	Meat-eating dinosaurs	<b>126</b>	Monkeys and apes
<b>78</b>	Prehistoric animals	<b>128</b>	Wild cats
<b>80</b>	Plants	<b>130</b>	Whales and dolphins
<b>82</b>	Flowers	<b>132</b>	Animal skeletons
<b>84</b>	Trees	<b>134</b>	Dogs
<b>86</b>	Mushrooms	<b>136</b>	Cats
<b>88</b>	Spiders and scorpions	<b>138</b>	Horses
<b>90</b>	Crustaceans	<b>140</b>	Farm animals
<b>92</b>	Insects	<b>142</b>	Forest
<b>94</b>	Butterflies and moths	<b>144</b>	Rainforest
<b>96</b>	Slugs and snails	<b>146</b>	Savanna
<b>98</b>	Fish	<b>148</b>	Deserts
<b>100</b>	Sharks	<b>150</b>	Polar habitats
<b>102</b>	Seashells	<b>152</b>	Ocean
<b>104</b>	Amphibians	<b>154</b>	Coral reef
<b>106</b>	Turtles and tortoises		
<b>108</b>	Lizards		
<b>110</b>	Snakes		
<b>112</b>	Crocodiles and alligators		
<b>114</b>	Eggs		
<b>116</b>	Birds		





# Geography

---

- 158** Earth
- 160** Volcanoes
- 162** Earthquakes
- 164** Shaping the land
- 166** Rocks and minerals
- 168** Gems
- 170** Water on Earth
- 172** Climate and weather
- 174** Extreme weather
- 176** Environment in danger
- 178** Our physical world
- 180** Our political world
- 182** Asia
- 184** North America
- 186** South America
- 188** Europe
- 190** Africa
- 192** Oceania
- 194** Antarctica
- 196** Flags
- 198** Where food comes from

# Culture

---

- 202** World religions
- 204** World celebrations
- 206** World languages
- 208** The story of art
- 210** Musical instruments
- 212** How music works
- 214** Dance
- 216** Ballet
- 218** Great buildings
- 220** Great books
- 222** Great thinkers
- 224** Food around the world
- 226** Fruit
- 228** Vegetables
- 230** Cheese
- 232** Bread
- 234** Pasta
- 236** Fish for food
- 238** Meat
- 240** Men's fashion
- 242** Women's fashion







# Sports and hobbies

---

- 246** Ball sports
- 248** Football
- 250** American football
- 252** Baseball
- 254** Basketball
- 256** Racket sports
- 258** Tennis
- 260** Athletics
- 262** Winter sports
- 264** Cycling
- 266** Water sports
- 268** Sailing
- 270** Fishing
- 272** Combat sports
- 274** Knots
- 276** Games
- 278** Magic
- 280** Horse riding

# History

---

- 284** The first humans
- 286** Early civilizations
- 288** Ancient Egypt
- 290** Ancient Greece
- 292** Greek myths
- 294** Ancient Rome
- 296** The Vikings
- 298** Ancient Americas
- 300** The Ottoman Empire
- 302** The Mughal Empire
- 304** Imperial Japan
- 306** Imperial China
- 308** Medieval Europe
- 310** Castles
- 312** The Renaissance
- 314** Exploration
- 316** Revolutions
- 318** US Presidents
- 320** US Civil War
- 322** European empires
- 324** British monarchs
- 326** The Industrial Revolution
- 328** World War I
- 330** World War II
- 332** The Cold War
- 334** Spies
  
- 336** Index









# Science and technology



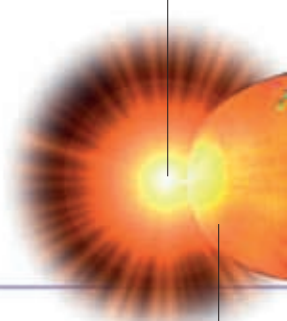
# The Universe

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 per cent empty space. It has been expanding constantly since its beginning 13.8 billion years ago, when it exploded into life with the “Big Bang”.

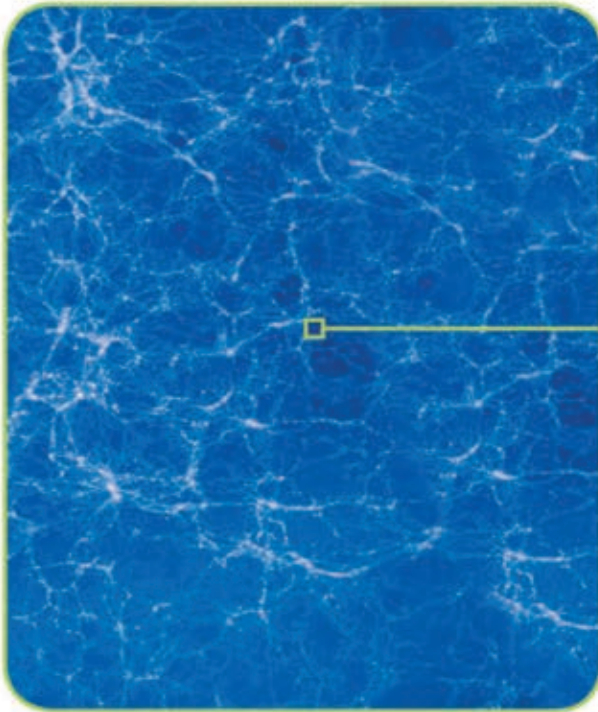
## THE BIG BANG

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 carried 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

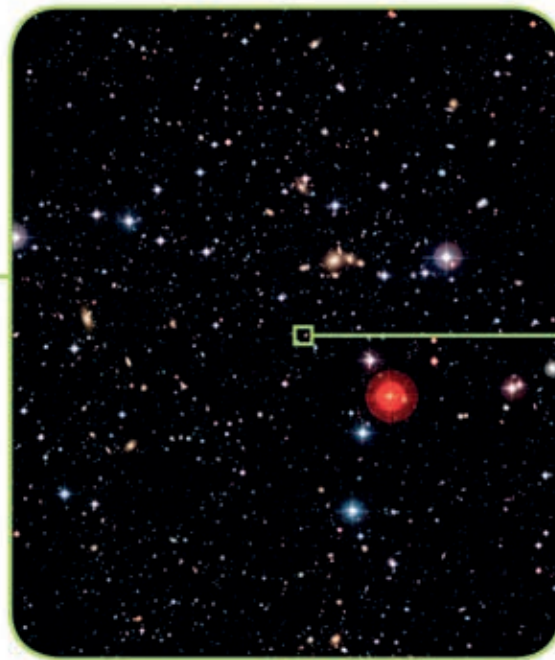


Energy turns into matter



### UNIVERSE

The Universe is ever-expanding. It is full of dark energy, dark matter, and other 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 that 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 lots of different shapes, and most of them are thought to have a massive black hole at their centre.



SPIRAL



BARRED SPIRAL



ELLIPTICAL

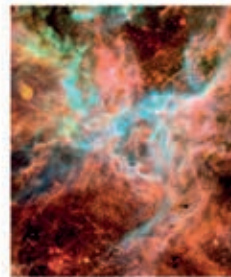


IRREGULAR

**OUR GALAXY – THE MILKY WAY – IS A BARRED SPIRAL GALAXY WITH FIVE FULL OR PART ARMS**

## NEBULAE

Nebulae are the “nurseries” of the Universe – they are huge clouds of gas and dust in which stars form. They may be trillions of kilometres wide and many have amazing shapes and colours.



TARANTULA NEBULA



ROSETTE NEBULA



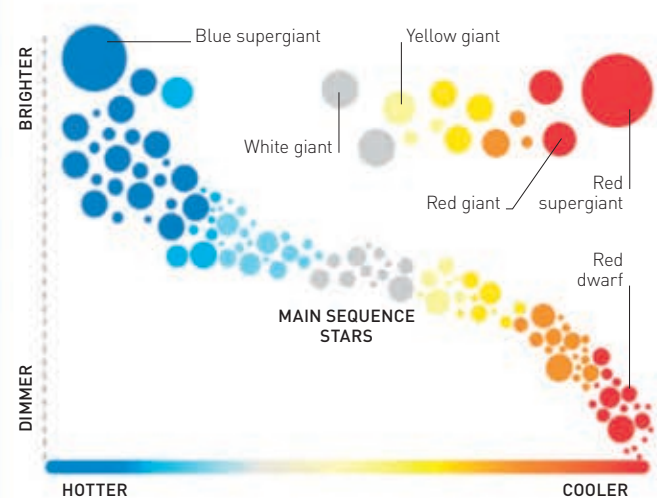
EAGLE NEBULA



N90

## STARS

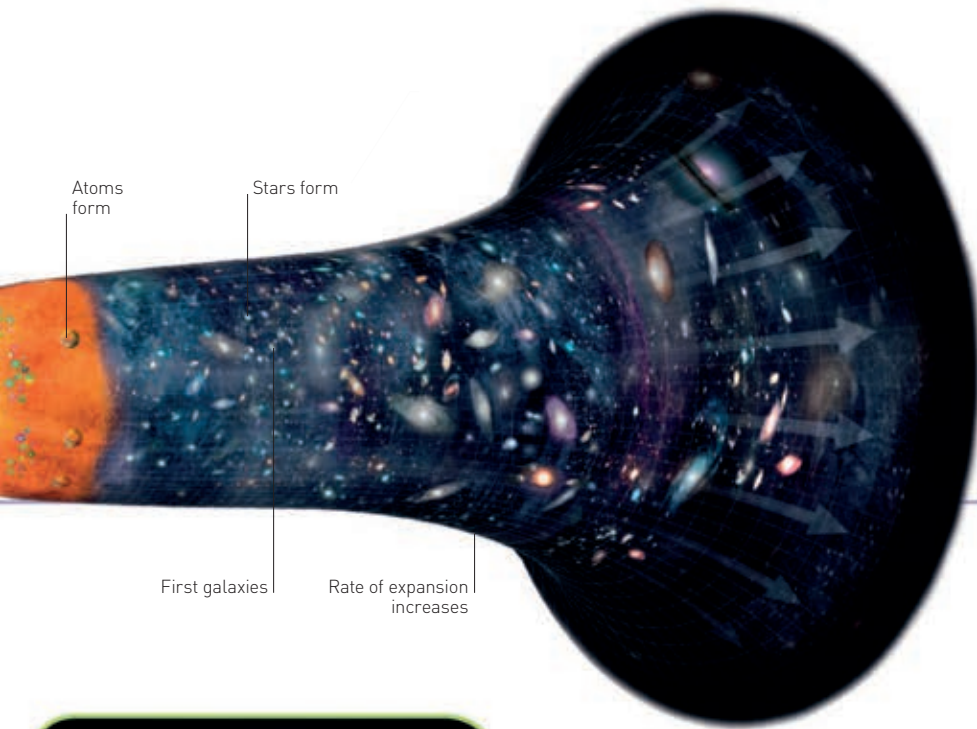
Stars are classified into different types depending on their temperature and brightness. Scientists use the Hertzsprung-Russell graph (shown below) to compare the size, temperature, and brightness of individual stars.



### STAR TYPES

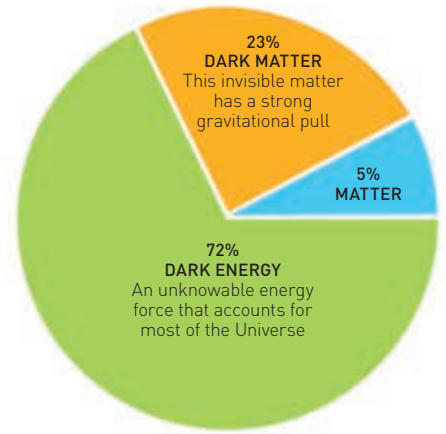
Most of the stars, including our Sun, are found along a part of the graph called the Main Sequence. As they age, these become giants or supergiants, and then dwarfs or supernovas.





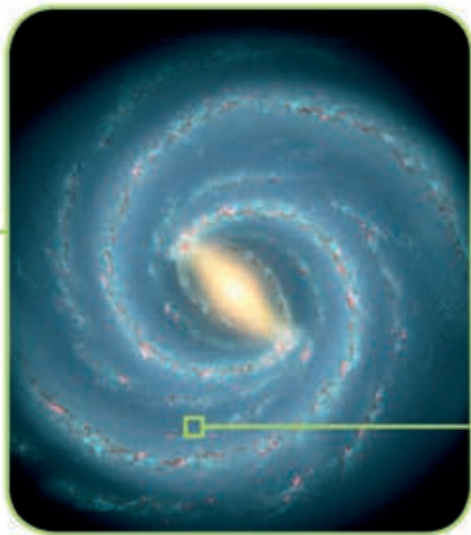
## WHAT MAKES UP THE UNIVERSE?

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 so 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 nearly 10 trillion km [6 trillion miles].



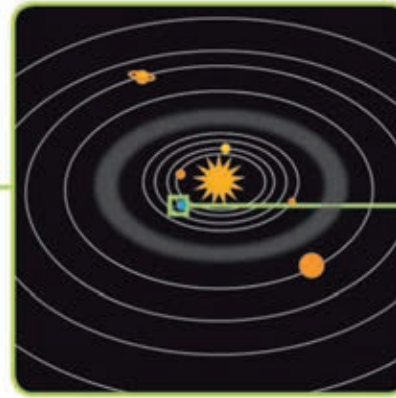
### MILKY WAY GALAXY

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



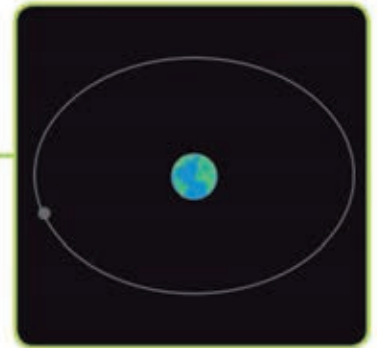
### STELLAR NEIGHBOURHOOD

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



### SOLAR SYSTEM

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

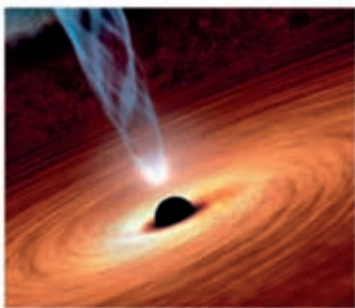


### EARTH AND MOON

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

Large planets have enough self-gravity to make them form into a round shape as they move through space. Smaller planets that cannot do this, but do orbit the Sun, are called “dwarf planets”. Pluto is one of the largest dwarf planets in our solar system.



PLUTO

## COMETS

Comets are small, icy worlds that orbit the Sun. They are made of frozen gases, rock, and dust. As they orbit the Sun, jets of gas and dust vaporize behind them to create long “tails” visible in space.



COMET

## PLANETS

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



EARTH

## MOONS

A moon is a rocky 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

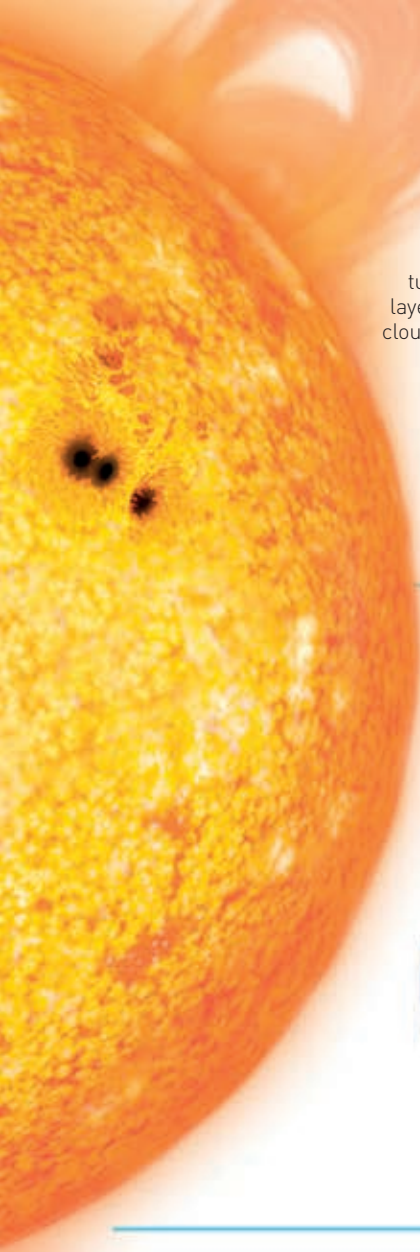
## ASTEROIDS

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.

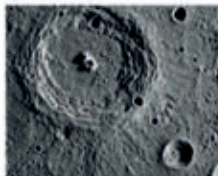
**THE SUN IS SO HUGE THAT EARTH COULD FIT INSIDE IT ONE MILLION TIMES**

# 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 orbiting the Sun. The four planets closest to the Sun formed from rock and metal. The four bigger outer planets formed from 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.



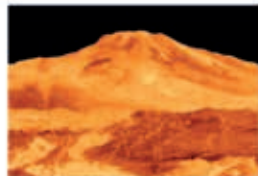
**BRAHMS CRATER**  
Mercury is covered in craters made by debris crashing into its surface.

### MERCURY

**ROCKY PLANET**  
**DISTANCE FROM THE SUN:** 69.8 million km (43.3 million miles)  
**DIAMETER:** 4,879 km (3,030 miles)  
**TIME TAKEN TO ORBIT THE SUN:** 87.97 Earth days  
**NUMBER OF MOONS:** 0

## VENUS

Venus is the second planet from the Sun. It is about the same size as Earth and 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:** 108.9 million km (67.6 million miles)  
**DIAMETER:** 12,104 km (7,520 miles)  
**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 a giant ball of gas ringed by colourful bands of chemical gases that race around it as fierce winds.



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

### JUPITER

**GAS GIANT**  
**DISTANCE FROM THE SUN:** 816 million km (507 million miles)  
**DIAMETER:** 142,984 km (88,845 miles)  
**TIME TAKEN TO ORBIT THE SUN:** 11.86 Earth years  
**NUMBER OF MOONS:** 67+

## 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 kilometres from the planet but are only 9 m (30 ft) thick.



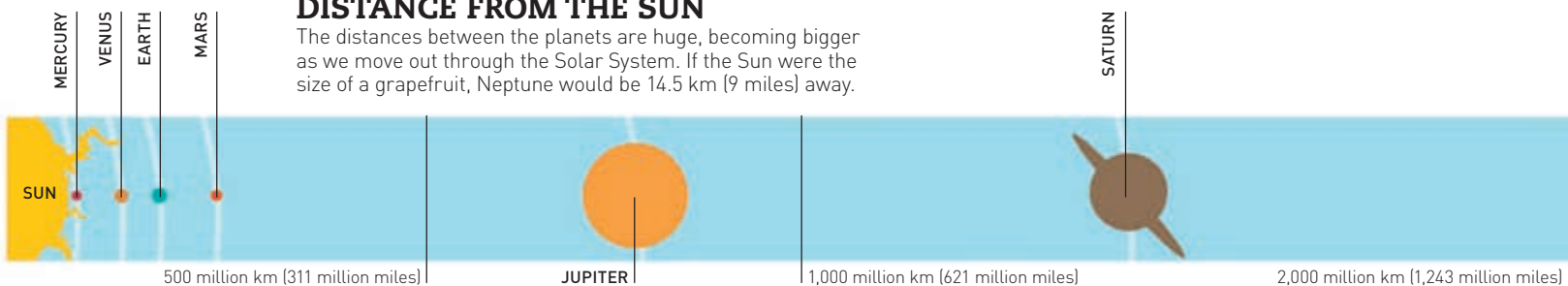
**RINGS OF SATURN**  
Saturn's rings are made up of ice crystals and rock.

### SATURN

**GAS GIANT**  
**DISTANCE FROM THE SUN:** 1.5 billion km (932 million miles)  
**DIAMETER:** 120,536 km (74,900 miles)  
**TIME TAKEN TO ORBIT THE SUN:** 29.46 Earth years  
**NUMBER OF MOONS:** 62+

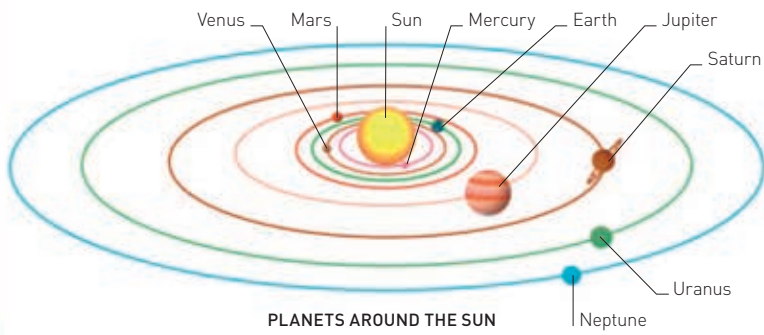
## DISTANCE FROM THE SUN

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 14.5 km (9 miles) away.



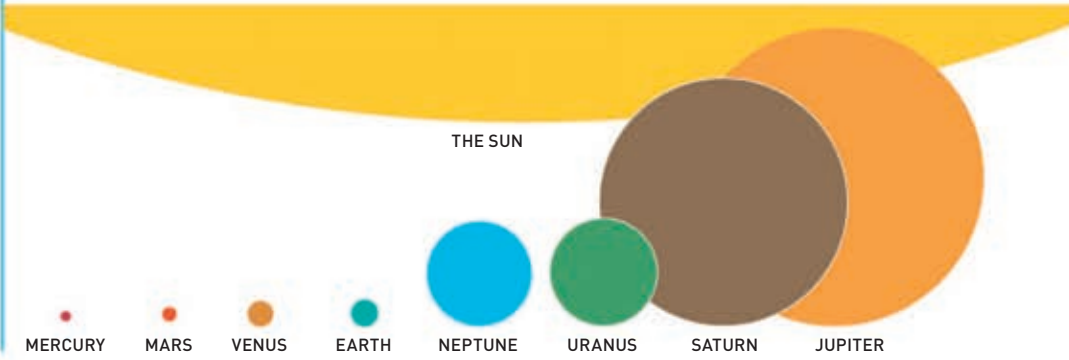
## ORBITS

All of the planets orbit the Sun anticlockwise, in an elliptical, or oval pattern. This means they are closer to the Sun at some points in their orbits than others. They are trapped by the Sun's gravity and will stay in the same plane of orbit for ever.



## PLANET SIZES

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



## EARTH

Earth moves around the Sun at 30 km per second (18.6 miles per second) and takes 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:** 152.6 million km (94.5 million miles)

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

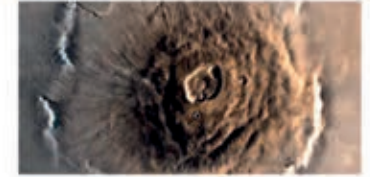
**TIME TAKEN TO ORBIT**

**THE SUN:** 365.26 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 also volcanic.

### MARS

#### ROCKY PLANET

**DISTANCE FROM THE SUN:** 228 million km (142 million miles)

**DIAMETER:** 6,780 km (4,213 miles)

**TIME TAKEN TO ORBIT**

**THE SUN:** 687 Earth days

**NUMBER OF MOONS:** 2

## URANUS

Methane in Uranus's atmosphere gives it a rich blue colour. This planet is often called the "ice giant" because 80 per cent of it is made up of frozen methane, water, and ammonia.



### RINGS

Uranus has very faint rings compared to the other gas giants.

### URANUS

#### GAS GIANT

**DISTANCE FROM THE SUN:** 3 billion km (1.86 billion miles)

**DIAMETER:** 51,118 km (31,760 miles)

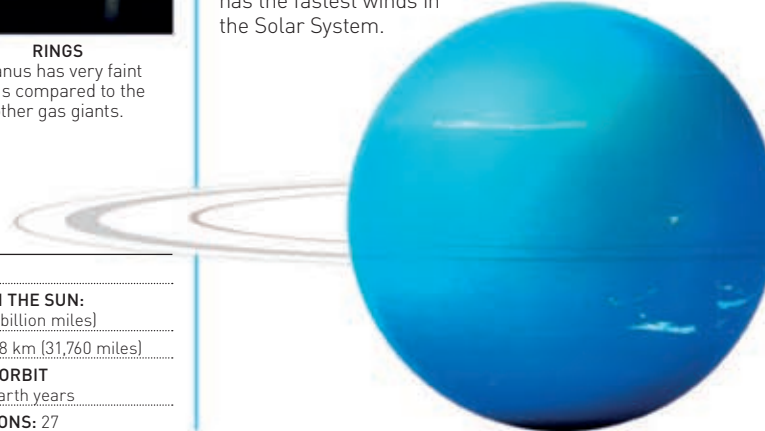
**TIME TAKEN TO ORBIT**

**THE SUN:** 84.3 Earth years

**NUMBER OF MOONS:** 27

## NEPTUNE

Neptune is the furthest planet from the Sun, so it gets little sunlight to warm its atmosphere. Its vivid blue colour 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 1,200 km/h (750 mph).

### NEPTUNE

#### GAS GIANT

**DISTANCE FROM THE SUN:** 4.5 billion km (2.8 billion miles)

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

**TIME TAKEN TO ORBIT**

**THE SUN:** 168.4 Earth years

**NUMBER OF MOONS:** 14

URANUS

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

NEPTUNE

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

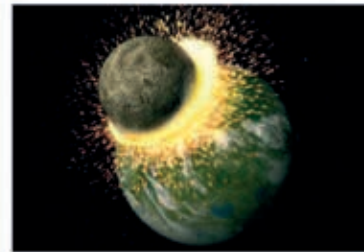


# The Moon

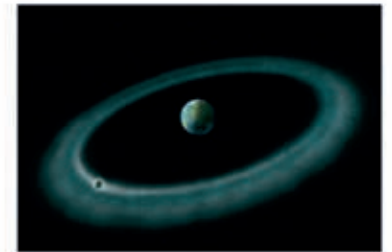
Always in orbit around Earth, the Moon is known as Earth's satellite. It provides Earth with light during the night, though it has no light of its own – it merely reflects the Sun's light, like a mirror. It is the closest object to Earth in space, and we can see its cratered surface even with the naked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

## 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.



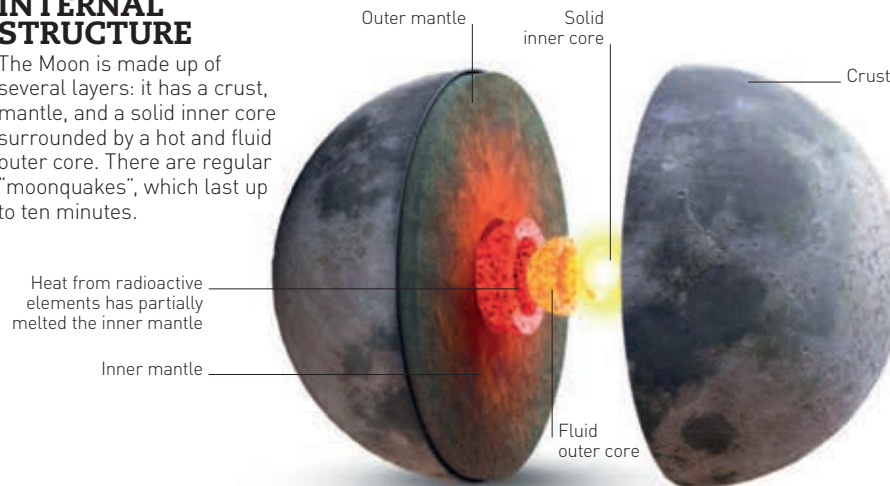
**1 IMPACT**  
A giant astronomical object hit the primitive molten Earth. The object was absorbed, but debris shot into space.



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

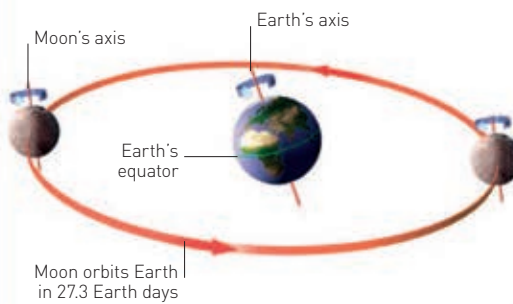
## INTERNAL STRUCTURE

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



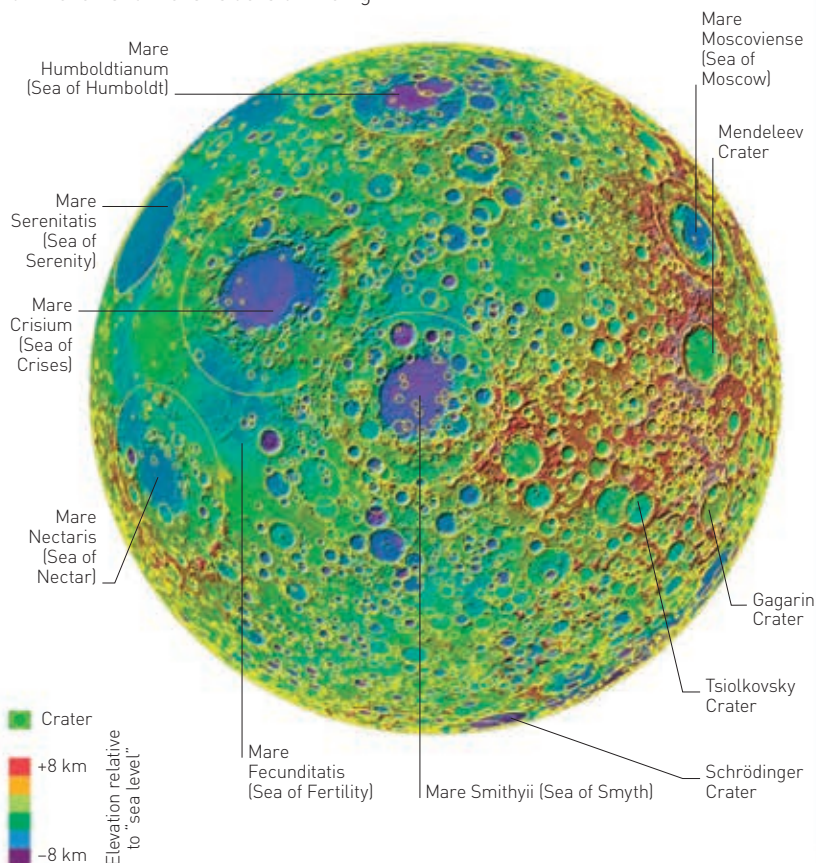
## ORBITING EARTH

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.



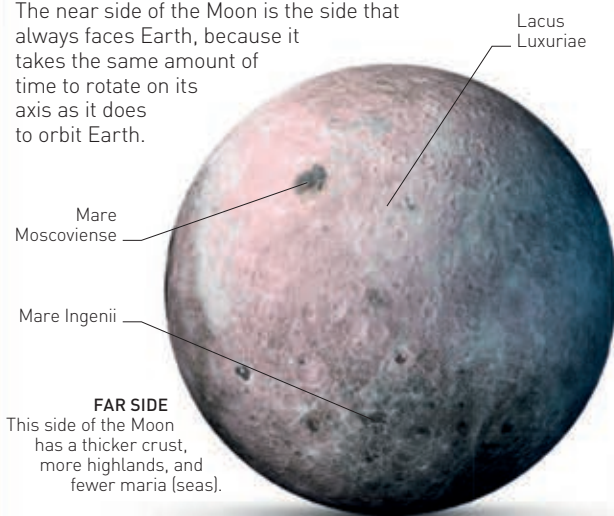
## CRATERS

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.



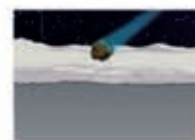
## FAR SIDE AND NEAR SIDE

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.



## 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.



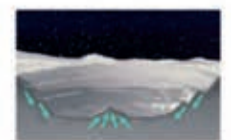
**1 INCOMING SPACE ROCK**  
There is no atmosphere to protect the Moon from flying objects.



**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 vapour over a huge area.



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



## PHASES OF THE MOON

The Moon seems to get larger and smaller in the sky, but this illusion is caused by the fact that we can only see the face of the Moon that faces Earth. One half of the Moon is always bathed in sunlight, but most of the time only part of the sunlit area is visible from Earth.



**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.

**WE ALWAYS SEE THE SAME FACE OF THE MOON FROM EARTH – IT IS KNOWN AS THE “NEAR SIDE” OF THE MOON**

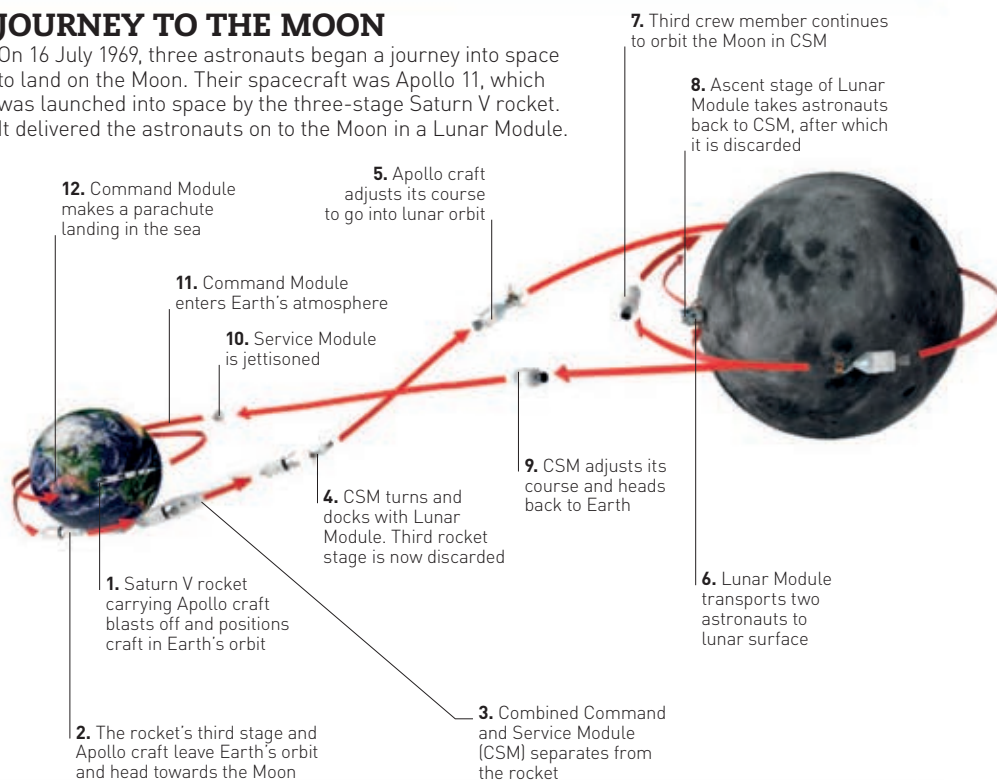


Darker areas are “maria” – smooth, low-lying areas (like seas without water)

The Lunar Highlands are hilly regions with lots of craters

## JOURNEY TO THE MOON

On 16 July 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.



## MEN ON THE MOON

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



## 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 other life, past or present.



**YOU WEIGH LESS ON THE MOON**  
“Weight” depends on the pull between two gravitational forces. The Moon's gravity is less than Earth's, so you would weigh less.



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



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



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



**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.

## MOON MISSIONS

In the second half of the 20th century, there was a “Space Race” between the USA 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 USA landed people on the Moon. Since then, other countries have sent spacecraft to find out more about the Moon.

**THE LAST TIME A MAN LANDED ON THE MOON WAS IN 1972**

	AGENCY	SUCCESSFUL MISSIONS
	NASA (USA)	27
	RFSa (USSR/RUSSIA)	20
	CNSA (CHINA)	3
	JAXA (JAPAN)	2
	ESA (EUROPE)	1
	ISRO (INDIA)	1



# Space exploration

At the start of 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. The spacecraft of the 21st century are beginning to explore the furthest reaches of our Solar System.

## APOLLO MISSION BADGES

The US space programme 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.



## MISSIONS TO SPACE

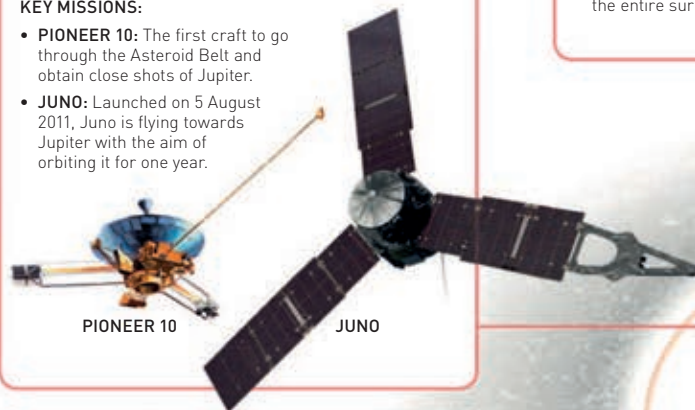
Space missions have landed people on the Moon and rovers on Mars. They have sampled the atmosphere of Jupiter and explored Saturn, Mercury, and even the Asteroid Belt. These missions help us understand the Solar System and our own planet.

### MISSIONS TO JUPITER

NUMBER OF MISSIONS SENT: 9

#### KEY MISSIONS:

- **PIONEER 10:** The first craft to go through the Asteroid Belt and obtain close shots of Jupiter.
- **JUNO:** Launched on 5 August 2011, Juno is flying towards Jupiter with the aim of orbiting it for one year.



### MISSIONS TO ASTEROID BELT

NUMBER OF MISSIONS SENT: 10

#### 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 on the way through.

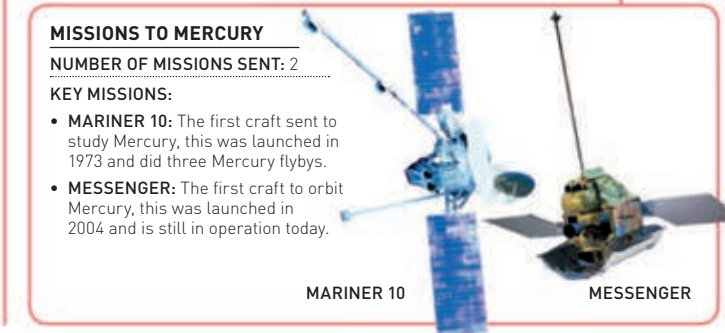


### MISSIONS TO MERCURY

NUMBER OF MISSIONS SENT: 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, this was launched in 2004 and is still in operation today.

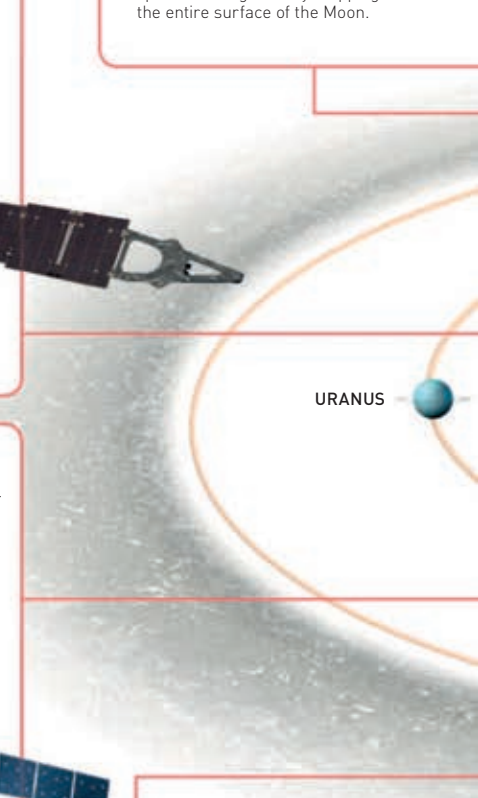


## MISSIONS TO THE MOON

NUMBER OF MISSIONS SENT: 100+

#### KEY MISSIONS:

- **APOLLO 15:** Launched in 1971, this was the first of the longer missions, where astronauts stayed for three days on the Moon.
- **LUNAR RECONNAISSANCE ORBITER:** Launched in 2009, this spacecraft is gradually mapping the entire surface of the Moon.



## THE SPACE AGE

In 1957 the Soviet Union (USSR) launched a polished aluminium ball containing a temperature control system, batteries, and radio transmitter outside Earth's atmosphere. This was the beginning of the Space Age.

**1959** The USSR launches Luna 2, which crashes on the Moon, becoming the first man-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.



Neil Armstrong

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

**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 man-made satellite.



Sputnik 1

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

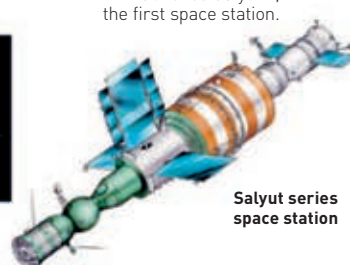
Rocket carrying Explorer 1

**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



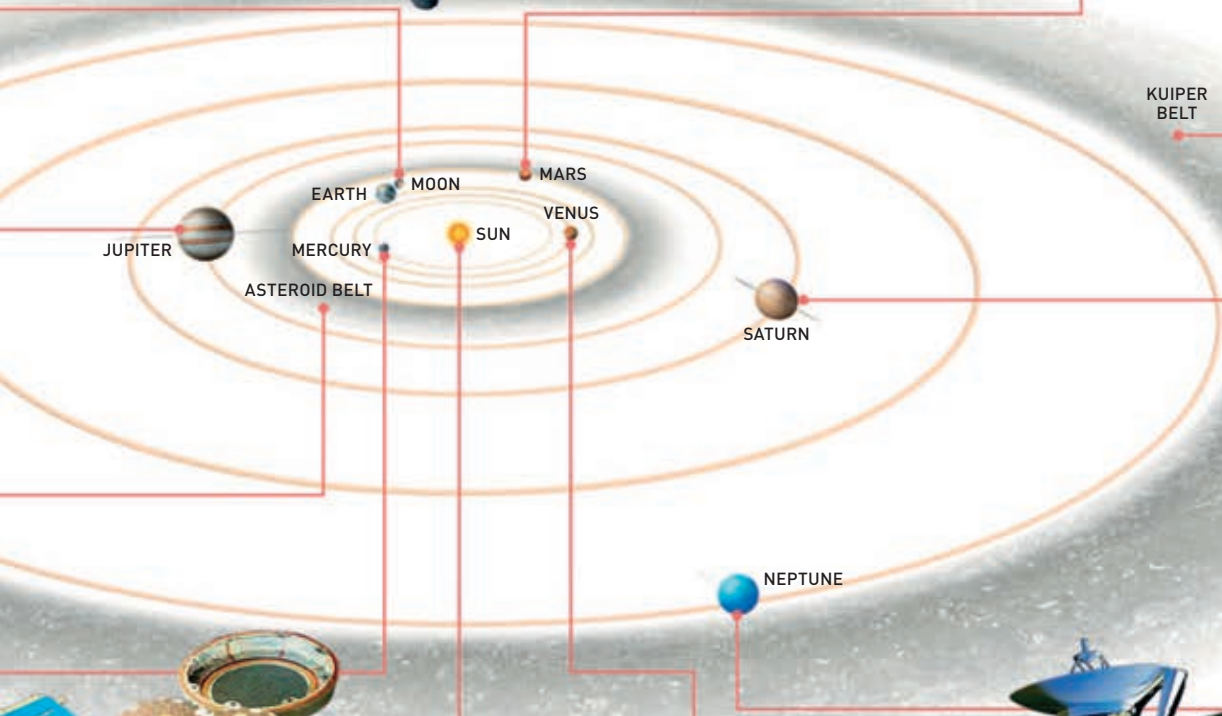
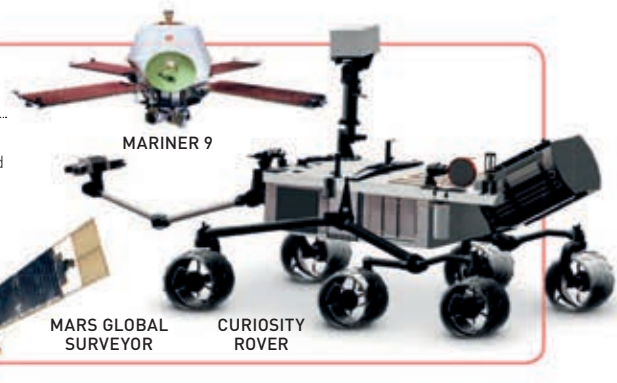


### MISSIONS TO MARS

NUMBER OF MISSIONS SENT: 40+

#### KEY MISSIONS:

- **MARS GLOBAL SURVEYOR:** Launched in 1996, aiming to map the whole surface of Mars.
- **CURIOSITY:** An active mission, this landed on Mars in 2012 and has already discovered organic material.



### MISSIONS TO KUIPER BELT

NUMBER OF MISSIONS SENT: 1

#### KEY MISSIONS:

- **NEW HORIZONS:** Launched in 2006 to take close-up pictures of the icy worlds in the Kuiper Belt, such as Pluto and its moons. By 2015 it had travelled 5 billion km (3 billion miles).

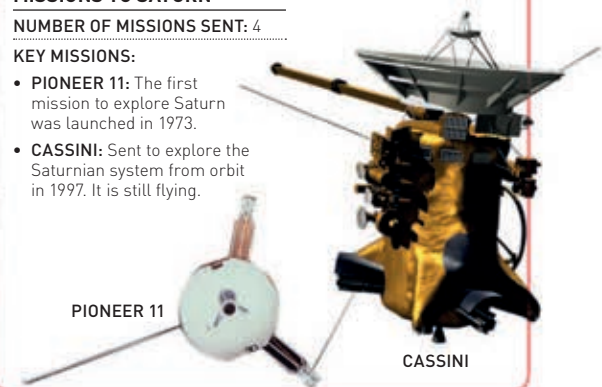


### MISSIONS TO SATURN

NUMBER OF MISSIONS SENT: 4

#### KEY MISSIONS:

- **PIONEER 11:** The first mission to explore Saturn was launched in 1973.
- **CASSINI:** Sent to explore the Saturnian system from orbit in 1997. It is still flying.

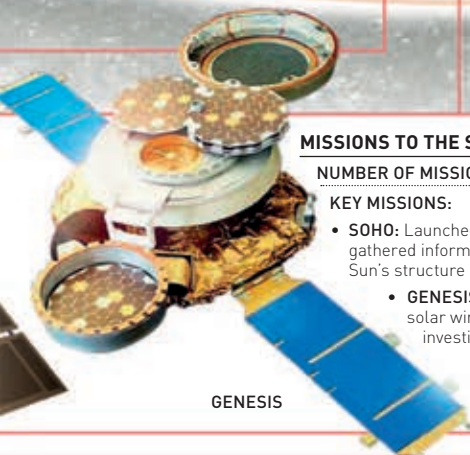


### MISSIONS TO THE SUN

NUMBER OF MISSIONS SENT: 15

#### KEY MISSIONS:

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

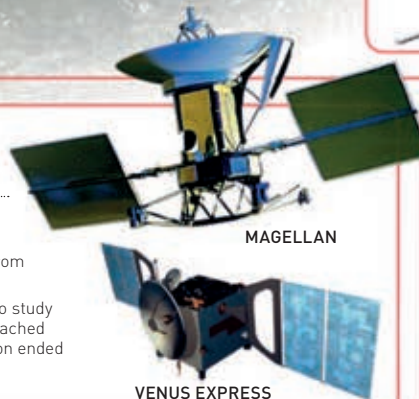


### MISSIONS TO VENUS

NUMBER OF MISSIONS SENT: 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.

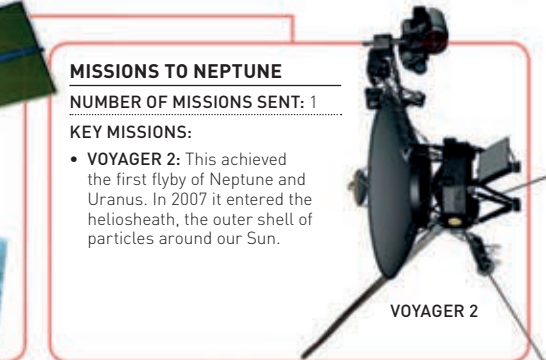


### MISSIONS TO NEPTUNE

NUMBER OF MISSIONS SENT: 1

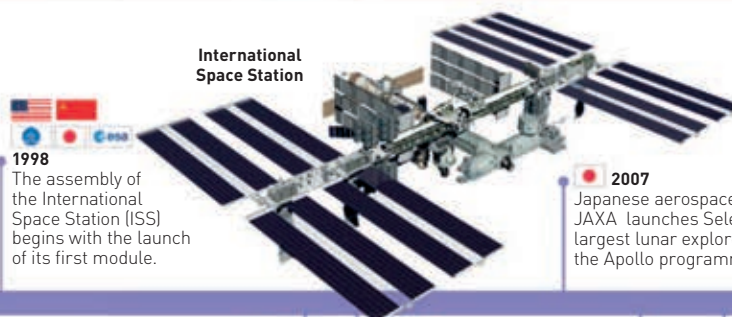
#### KEY MISSIONS:

- **VOYAGER 2:** This achieved the first flyby of Neptune and Uranus. In 2007 it entered the heliosheath, the outer shell of particles around our Sun.



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

**1995**  
NASA's Galileo spacecraft becomes the first to orbit Jupiter. It studies the composition of the planet's atmosphere.



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

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

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

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



**1990**  
NASA launches the Hubble Space Telescope into Earth's 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**  
NASA launches the Mars Reconnaissance Orbiter (MRO) with scientific instruments on board.

**2010**  
Virgin Galactic, a private company, flies the first suborbital plane.



Virgin Galactic

**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

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



Dawn



# 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 ten 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



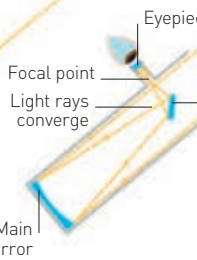
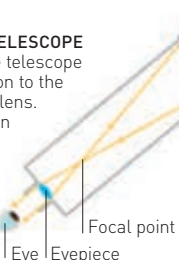
TELESCOPE VIEW OF THE ORION NEBULA

## HOW OPTICAL TELESCOPES WORK

Galileo Galilei made the first refracting telescope in 1609, and in the 1680s Isaac Newton invented the reflecting telescope, which uses mirrors to collect light and form it into an image.

### 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 the right size for your eye.



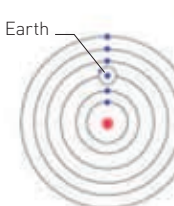




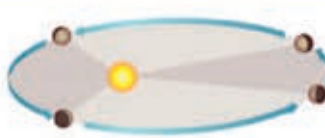



### REFLECTING TELESCOPE

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.

## TIMELINE

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

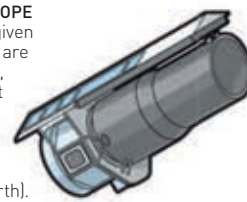
<p><b>c.330 BCE</b> Greek philosophers begin to believe that Earth is a sphere.</p>  <p>Aristotle</p>	<p><b>240 BCE</b> Eratosthenes, a Greek astronomer, estimates Earth's circumference with accuracy.</p>	<p><b>c.150 BCE</b> Claudius Ptolemy says that Earth sits at the centre of the cosmos. Belief in the Ptolemaic system continues for the next 1,400 years.</p>  <p>Ptolemy</p>	<p><b>1543 CE</b> The Polish astronomer Nicolaus Copernicus publishes his revolutionary model of the Solar System, putting the stationary Sun at the centre.</p>  <p>Copernicus's Solar System</p>	<p><b>1633</b> The Catholic Church puts Italian astronomer Galileo Galilei on trial for teaching Copernicus's heliocentric (Sun-centred) theory.</p>  <p>Galileo Galilei</p>
<p><b>2500 BCE</b> <b>2500 BCE</b> Building of Stonehenge. The stones here mark the rising and setting points of the Sun at the solstices.</p>  <p>Stonehenge</p>	<p><b>700 BCE</b> Babylonians predict regular patterns of Sun and Moon eclipses.</p>  <p>Aristarchus's calculations</p> <p><b>280 BCE</b> Ancient Greek astronomer Aristarchus calculates the size of the Sun and Moon and their distances from Earth.</p>	<p><b>240 BCE</b> The first certain appearance of Halley's Comet is described in the Chinese <i>Records of the Grand Historian</i>.</p>  <p>Halley's Comet</p>	<p><b>1054 CE</b> Chinese astronomers observe a supernova that is visible in the daytime. The matter blasted outwards by it remains observable as the Crab Nebula.</p>  <p>Elliptical orbit</p> <p><b>1609</b> German mathematician Johannes Kepler calculates that the planets follow noncircular, elliptical orbits.</p>	<p><b>1687</b> English scientist Isaac Newton discovers that gravity keeps the Moon in orbit around Earth, and the planets in orbit around the Sun.</p>  <p>Isaac Newton</p>

## PICTURING SPACE

Astronomers learn about space using telescopes. These telescopes are designed to each 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 viewed through different types of telescopes.

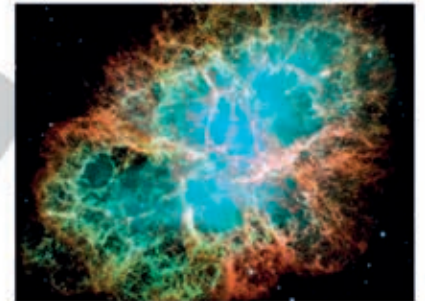
### INFRARED TELESCOPE

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).



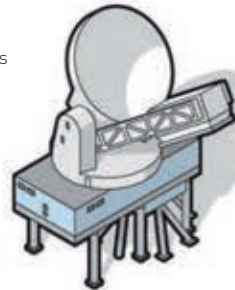
### OPTICAL TELESCOPE

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



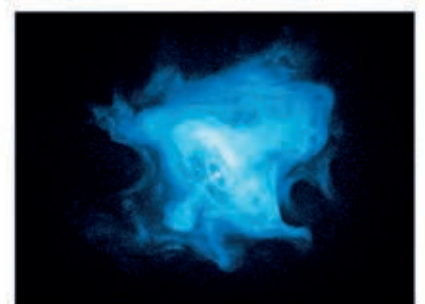
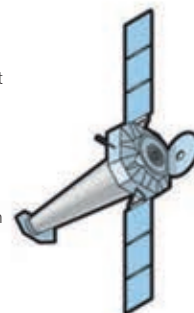
### ULTRAVIOLET TELESCOPE

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



### X-RAY TELESCOPE

These telescopes capture high-energy rays from extremely hot objects. X-rays from celestial objects are partly blocked by the Earth's atmosphere, so these telescopes are sent into space. They gather information from space objects as they orbit around Earth.





## VIEW FROM EARTH

It is impossible to tell how large a star or planet is by looking at it from Earth, because some are huge but very far away. The Sun's diameter is 400 times that of the Moon, but it is also about 400 times further away.



SUN



MOON



MARS



POLARIS



METEOR



VENUS



SATURN

## LIGHTS IN THE SKY

Sometimes we can see the interaction of light and magnetism in the skies through colourful light displays such as the northern lights.



### 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.



### MOONDOG

A moon dog appears as a halo around the Moon. It is caused by the refraction of moonlight on ice crystals in clouds.



### SUNDOG

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

## LIFE OUT THERE

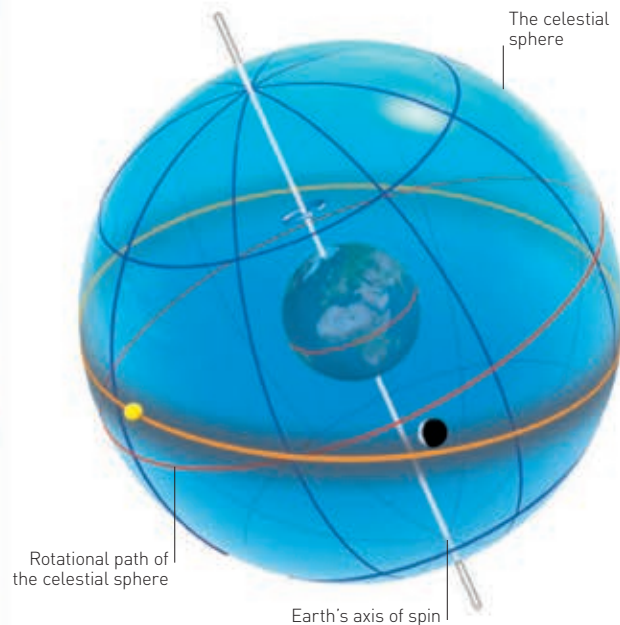
The SETI (search for extraterrestrial intelligence) project was set up in 1960 to search for signs of life beyond Earth. Its powerful radio telescopes scan the skies but have not picked up an artificial (non-natural) radio signal so far.



SETI TELESCOPES

## 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 hemispheres by an equator.



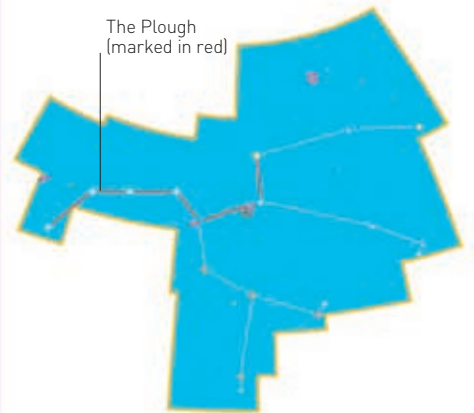
The celestial sphere

Rotational path of the celestial sphere

Earth's axis of spin

## 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 find the stars. There are 88 constellations in total, and each one is only visible at certain times and from certain places.



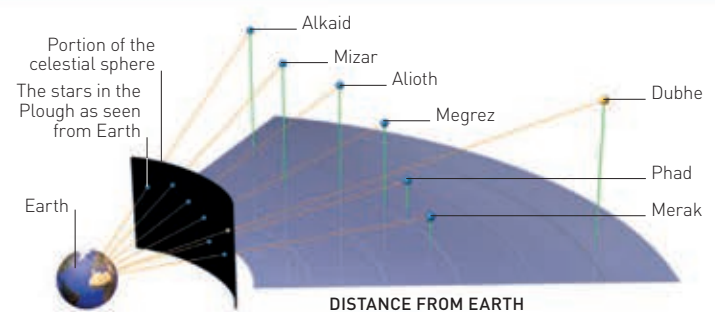
The Plough (marked in red)

### URSA MAJOR

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

## LINE OF SIGHT

Wherever you stand on Earth, you can see a portion of the celestial sphere. For example, the Plough seems to be a fixed shape, but it is actually formed by stars moving far out in space, all at different distances from the Earth.



Portion of the celestial sphere  
The stars in the Plough as seen from Earth



Earth

DISTANCE FROM EARTH



Uranus

1781

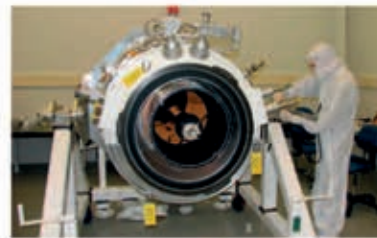
German-born astronomer, William Herschel discovers Uranus, a planet beyond Saturn, doubling the size of the known Solar System.

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

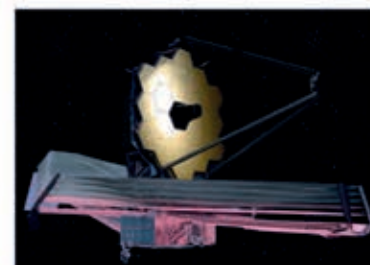
German amateur astronomer Samuel Heinrich Schwabe observes that sunspots (areas of lower temperature) follow regular cycles.



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

2018

The James Webb Space Telescope (JWST) is a space observatory scheduled to launch in October 2018. It is a successor to the Hubble Space Telescope and will offer the clearest images ever seen of objects in space.



# 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.

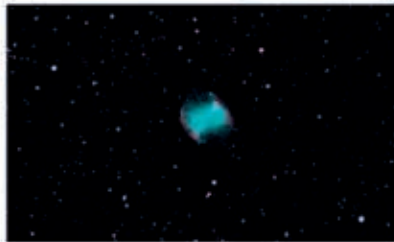
- Yellow star
- Red star
- Orange star
- White star
- Blue star

- Magnitude brighter than 0.0
- Magnitude brighter than 1.0
- Magnitude brighter than 2.0

- Magnitude brighter than 3.0
- Magnitude brighter than 4.0
- Magnitude brighter than 5.0

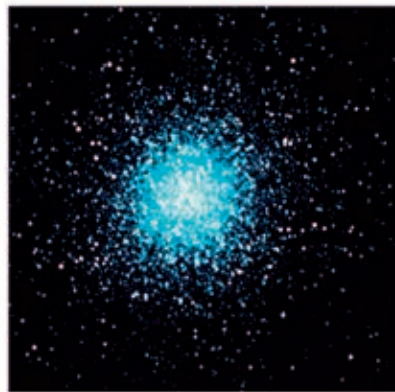
## THINGS TO LOOK FOR

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 means it is made up of clouds of material shed by a star. 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 Hercules constellation.



### HYADES STAR CLUSTER

This star cluster makes up the face of the bull in the constellation Taurus. The brightest star here is the giant star Aldebaran, which marks the eye of Taurus.



### LEO CONSTELLATION

The constellation Leo contains three spiral galaxies: M65, M66, and NGC 3628. They are known as the Leo Triplet.



### 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.



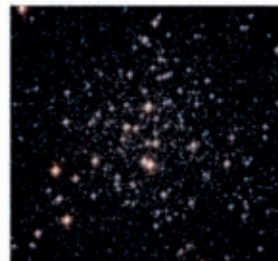
### PERSEUS CONSTELLATION

This constellation is best known for its yearly Perseid meteor shower, which takes place in mid-August. It lies just below the "W" shape of the constellation of Cassiopeia.



### 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.



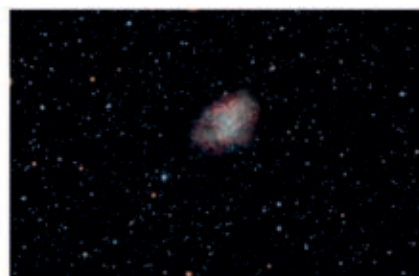
### REFLECTION NEBULA

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



### LYRA CONSTELLATION

The small constellation Lyra has one brilliant star, Vega. It is the fifth-brightest of all the stars.



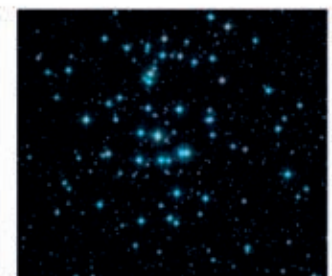
### CRAB NEBULA

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



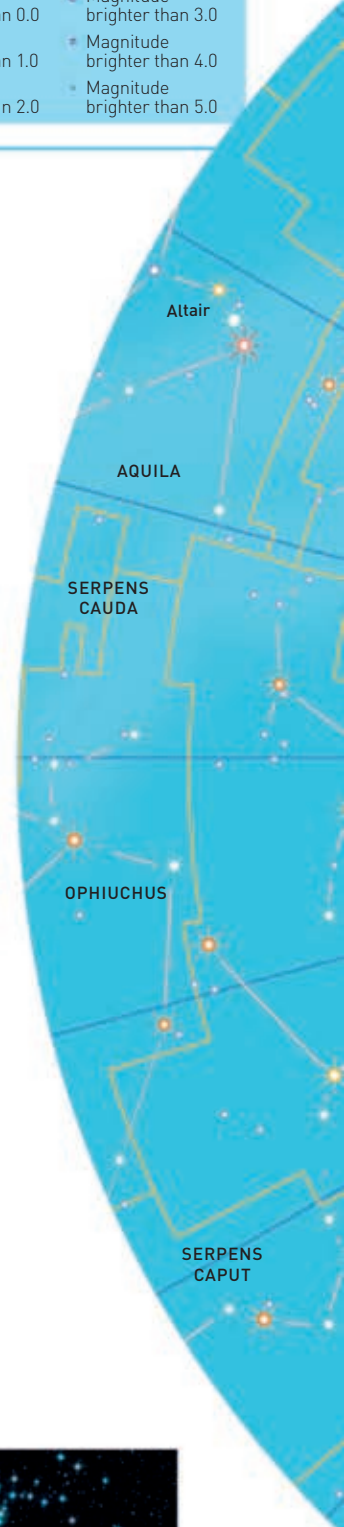
### M15 STAR CLUSTER

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



### BEEHIVE CLUSTER

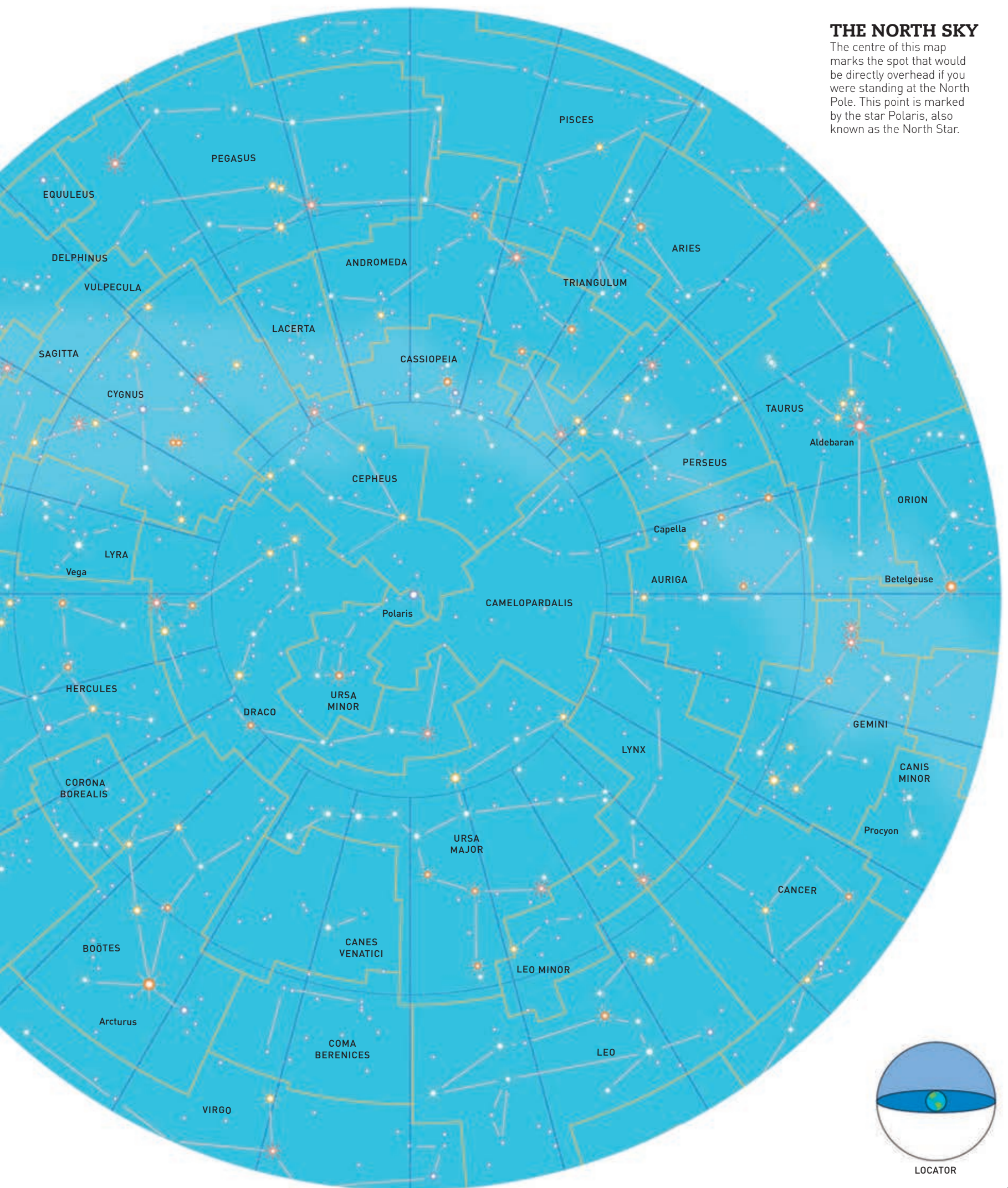
This swarm of stars in the constellation of Cancer is about three times the diameter of the Moon.





## THE NORTH SKY

The centre of this map marks the spot that would be directly overhead if you were standing at the North Pole. This point is marked by the star Polaris, also known as the North Star.





# 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, colourful nebulae – and even whole galaxies.

**OMEGA CENTAURI IS THE LARGEST STAR CLUSTER IN OUR GALAXY, CONTAINING AROUND TEN 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.

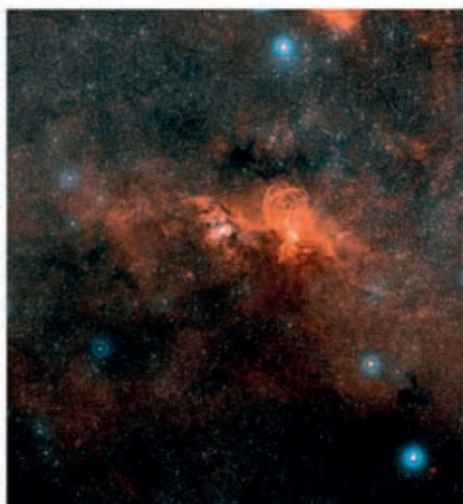
- Yellow star
- Red star
- Orange star
- White star
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- Magnitude brighter than 0.0
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- Magnitude brighter than 3.0
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- Magnitude brighter than 5.0

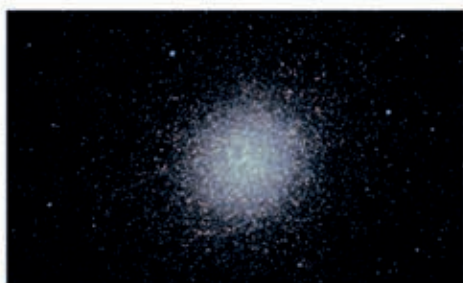
## THINGS TO LOOK FOR

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.



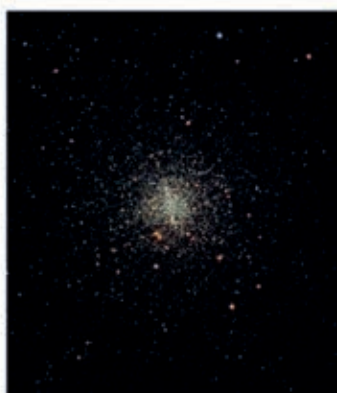
### NGC 3603 NEBULA

This giant nebula in the constellation Carina is composed of huge glowing clouds of gas. In its centre are thousands of hot, young stars.



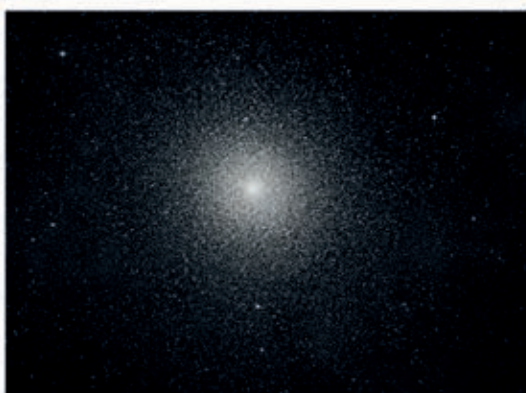
### OMEGA CENTAURI CLUSTER

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 centre of the Centaurus constellation.



### M4 GLOBULAR CLUSTER

This cluster is around 12.2 billion years old. It is found near the bright star Antares, in the constellation Scorpius.



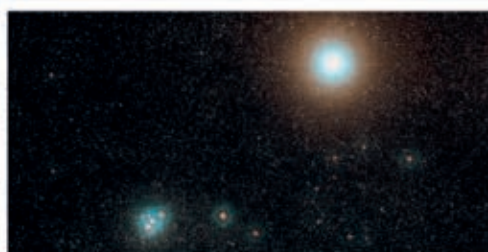
### 47 TUCANAEE GLOBULAR CLUSTER

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.



### CORVUS CONSTELLATION

Corvus, the crow, is made up of four bright stars, shown in the lower-right half of this image. It sits close to the very bright double star known as Spica (top left).



### THE JEWEL BOX CLUSTER

Shown at the bottom left here, this cluster includes a red supergiant and smaller blue stars. It is in the constellation Crux. The bright star in the upper right here is called Mimoso.



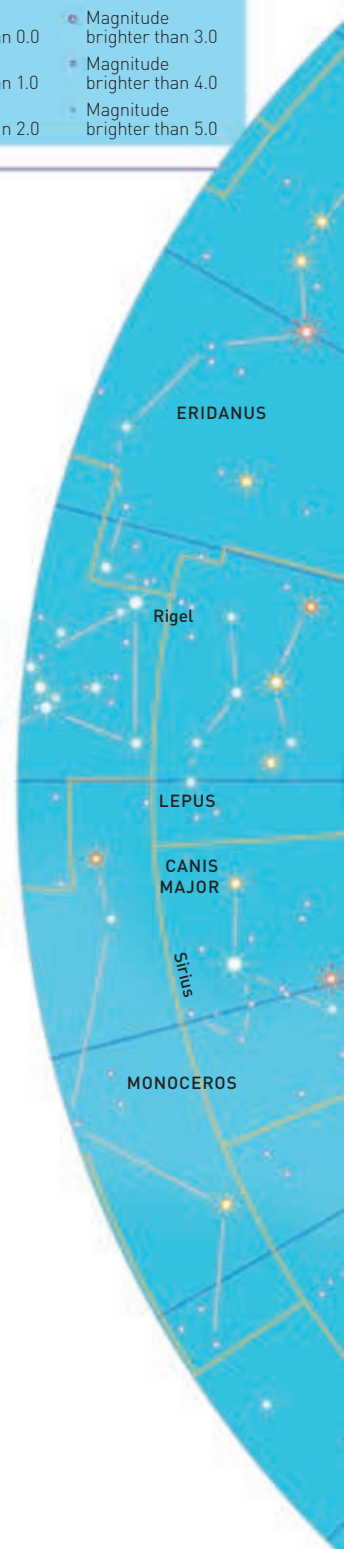
### LARGE MAGELLANIC CLOUD

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.



### ROSETTE NEBULA

This flower-shaped nebula is a star nursery – stars are being created within it – and there is a cluster of new stars at its centre. It can be seen with a small telescope in the constellation Monoceros.



ERIDANUS

LEPUS

CANIS MAJOR

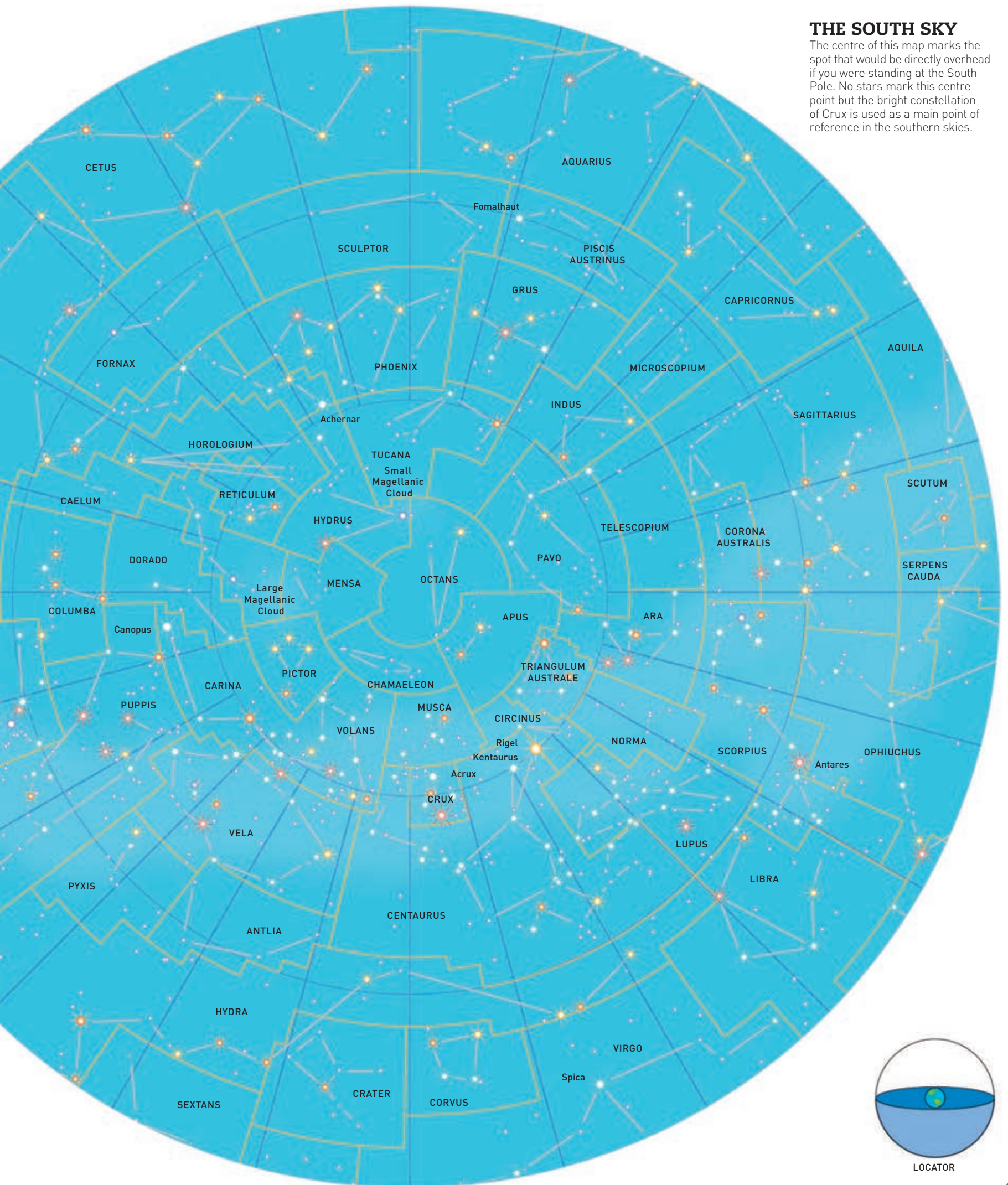
SIRIUS

MONOCEROS



## THE SOUTH SKY

The centre of this map marks the spot that would be directly overhead if you were standing at the South Pole. No stars mark this centre point but the bright constellation of Crux is used as a main point of reference in the southern skies.



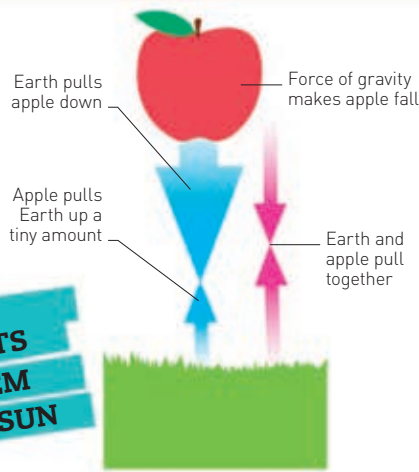


# Physics

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 1,670 km/h (1,037 mph). Gravity pulls together all matter, but larger things with more mass have more gravitational force.



FALLING APPLE

## 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 further it travels

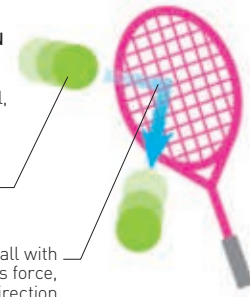


### CHANGING DIRECTION

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

Ball moves in one direction towards the racket

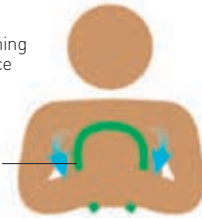
Hitting the ball with the racket applies force, changing the ball's direction



### 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. 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 only force acting on a rocket is gravity.

### SECOND LAW

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

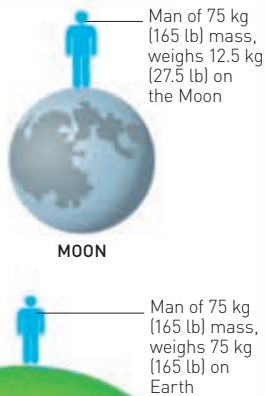
### THIRD LAW

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.

**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.



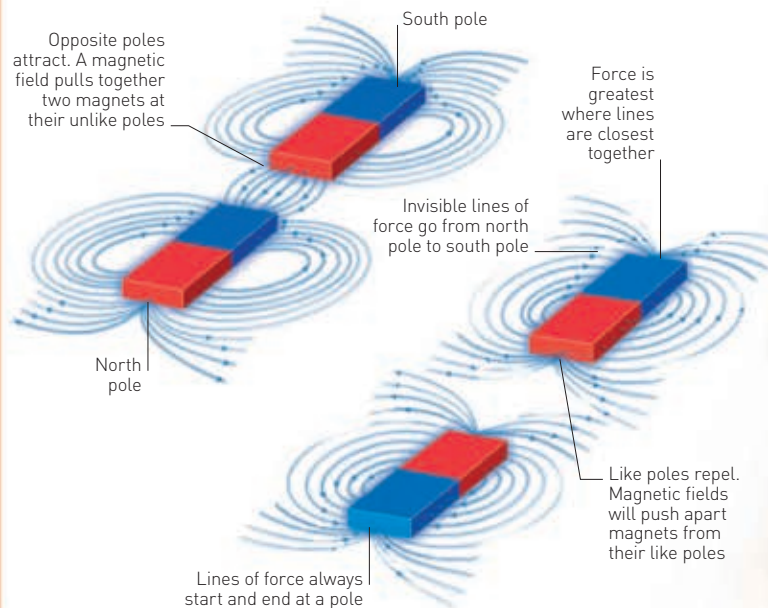
Man of 75 kg (165 lb) mass, weighs 12.5 kg (27.5 lb) on the Moon

Man of 75 kg (165 lb) mass, weighs 75 kg (165 lb) on Earth

EARTH

## 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.



Opposite poles attract. A magnetic field pulls together two magnets at their unlike poles

Force is greatest where lines are closest together

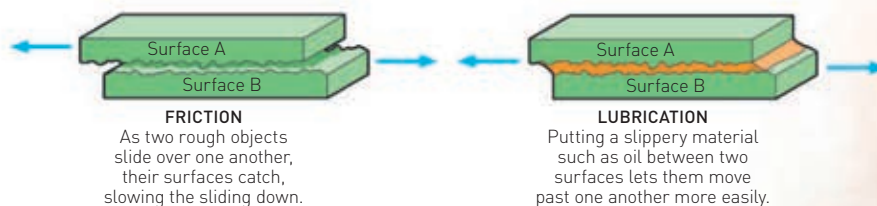
Invisible lines of force go from north pole to south pole

Like poles repel. Magnetic fields will push apart magnets from their like poles

Lines of force always start and end at a pole

## 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.





## 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.



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



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



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



**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.



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



**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.

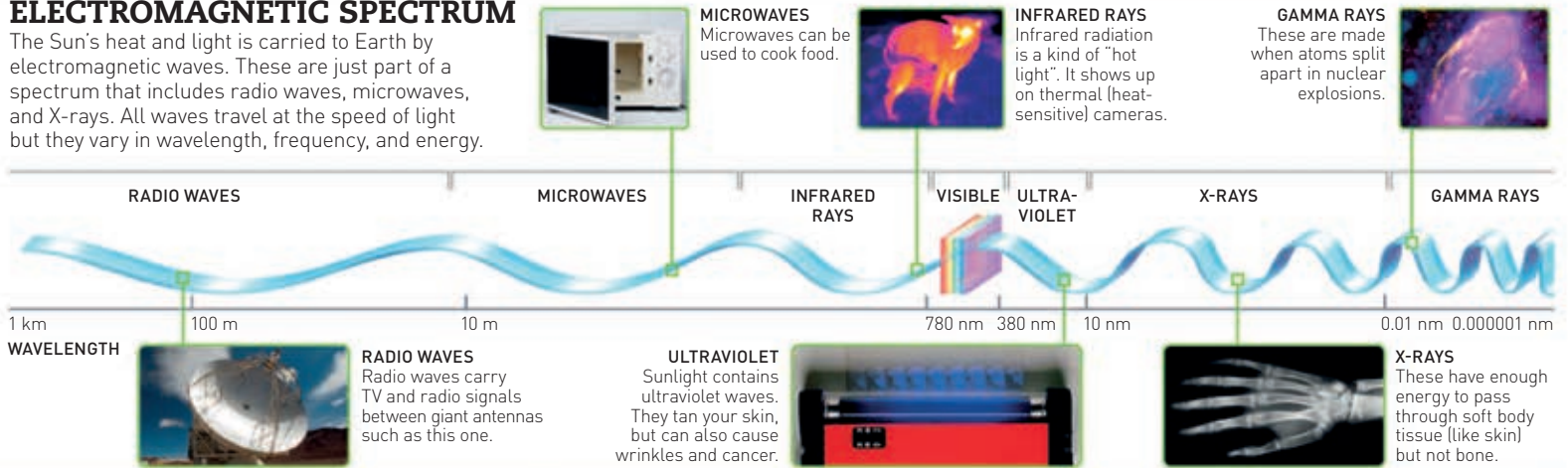
**HEAT IS USUALLY ON THE MOVE - IT TRAVELS ABOUT, SO COLD THINGS GET HOT AND HOT THINGS GET COLD**



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

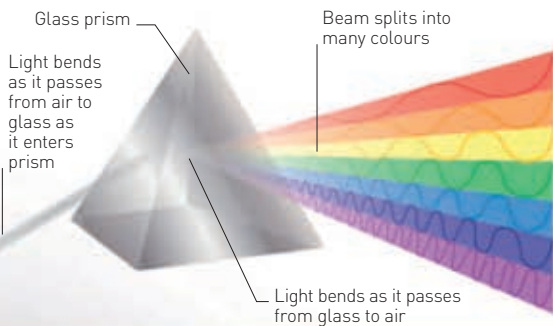
## ELECTROMAGNETIC SPECTRUM

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.



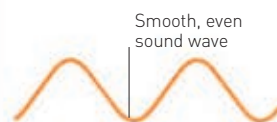
## LIGHT AND COLOURS

The light from the Sun looks white, but it is actually made up of lots of different colours. If you shine light through a prism, the whole spectrum of colours 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.

Spiky sound wave



**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.

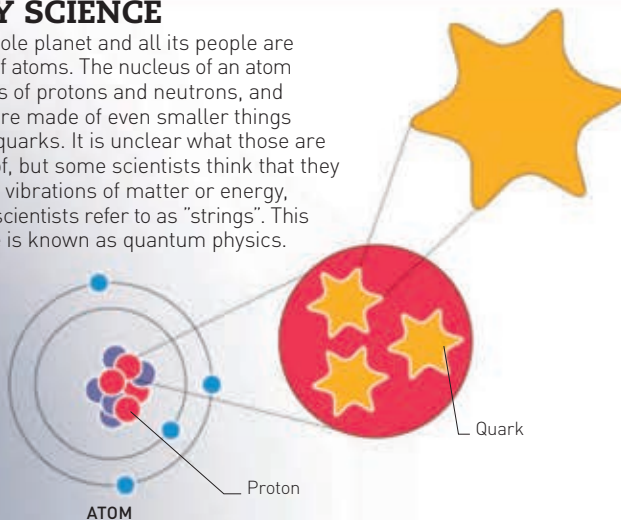
A bigger cymbal vibrates a greater volume of air so it sounds louder



**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.

## TINY SCIENCE

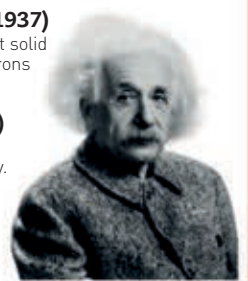
Our whole planet and all its people are made of atoms. The nucleus of an atom consists of protons and neutrons, and these are made of even smaller things called quarks. It is unclear what those are made of, but some scientists think that they may be vibrations of matter or energy, which scientists refer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



## GREAT PHYSICISTS

People have tried to explain our world and the Universe since ancient times. In the last 400 years, physicists have invented theories that underpin much of what we know.

- **ISAAC NEWTON (1643-1727)**  
Newton discovered that sunlight contains all the colours of the rainbow. He also devised the laws of gravity and motion.
- **ERNEST RUTHERFORD (1871-1937)**  
Rutherford proved that the atom was not solid but contained electrically charged electrons orbiting a nucleus.
- **ALBERT EINSTEIN (1879-1955)**  
Einstein discovered many things, but he is most famous for his theory of relativity.
- **RICHARD FEYNMAN (1918-88)**  
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.



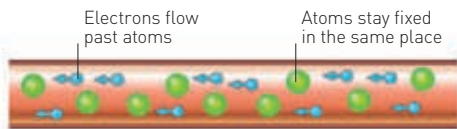
**NERVOUS SYSTEMS**  
Human nerves communicate by electric signals.



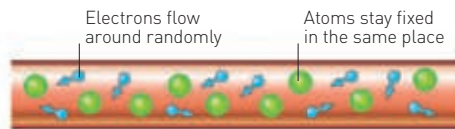
**ELECTRIC EEL**  
This eel discharges electricity in water to kill fish for food.

## ELECTRIC CURRENT

When electrons flow down wires, they carry energy from place to place. So in a torch, electrons march 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 jig 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.



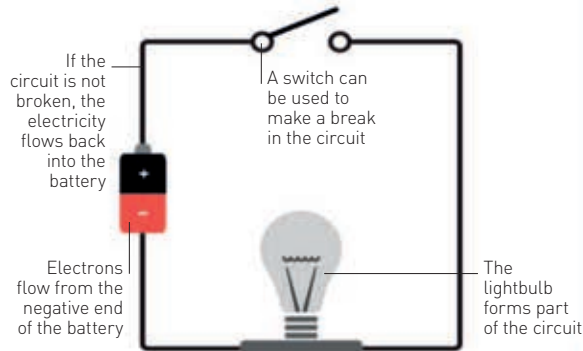
**SERIES CONNECTION**  
All the power moves through each part of the circuit, in a line.



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

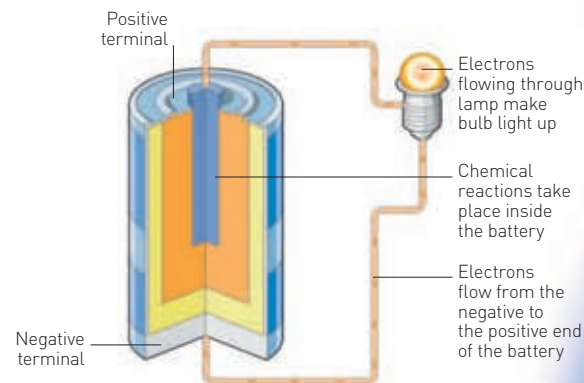
## SWITCHES

If you attach a wire to both ends of a battery, and connect a lightbulb 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.

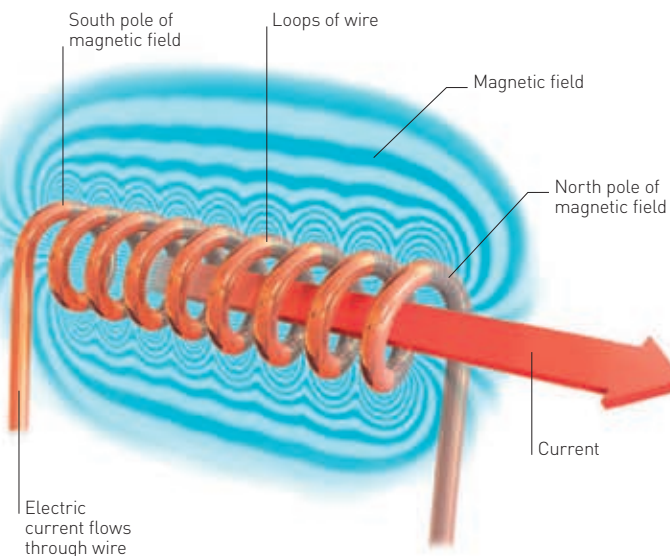


## LIGHTNING BOLTS ARE LARGE-SCALE STATIC SHOCKS

Strands of plasma

## 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.

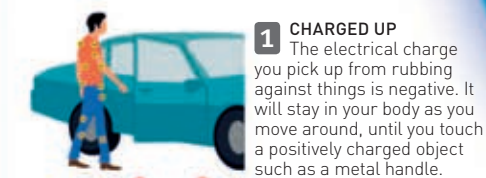


## STATIC ELECTRICITY

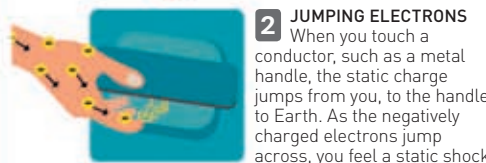
Static electricity is sometimes created when two things are rubbed together. The rubbing creates an electrical charge, which is released when it comes into contact with something else that conducts electricity.

### 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 negative. It will stay in your body as you move around, until you touch a positively charged object such as a metal 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".

### INSULATORS

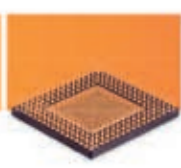


RUBBER



WOOD

### SEMICONDUCTORS

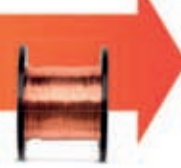


SILICON



WATER

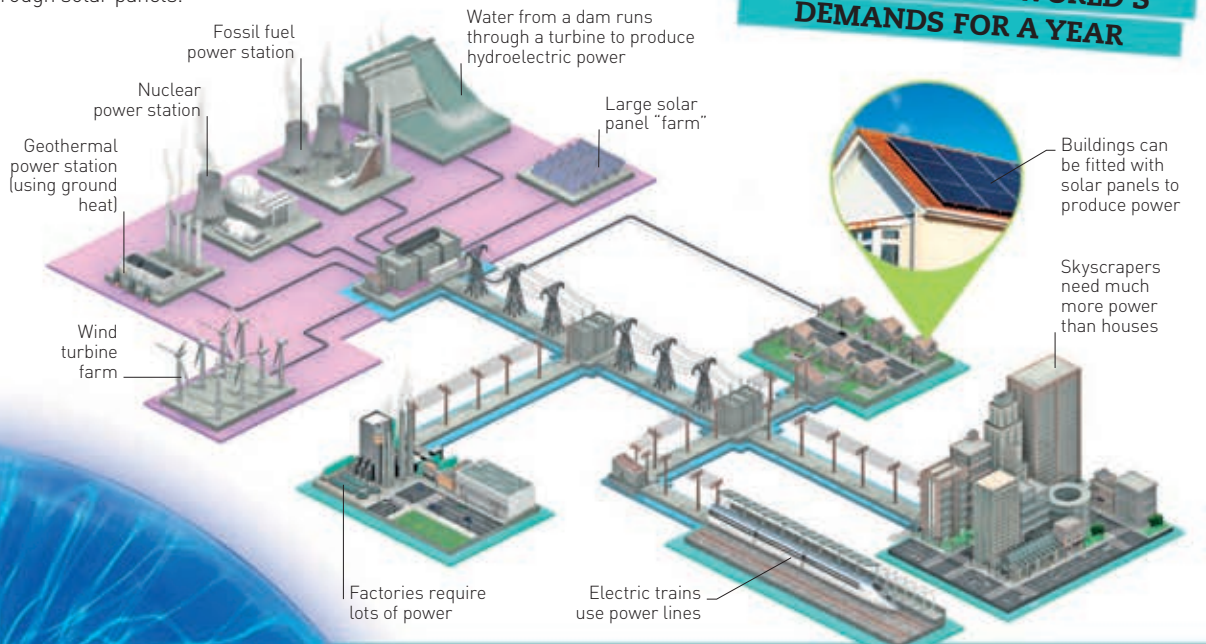
### CONDUCTORS



COPPER

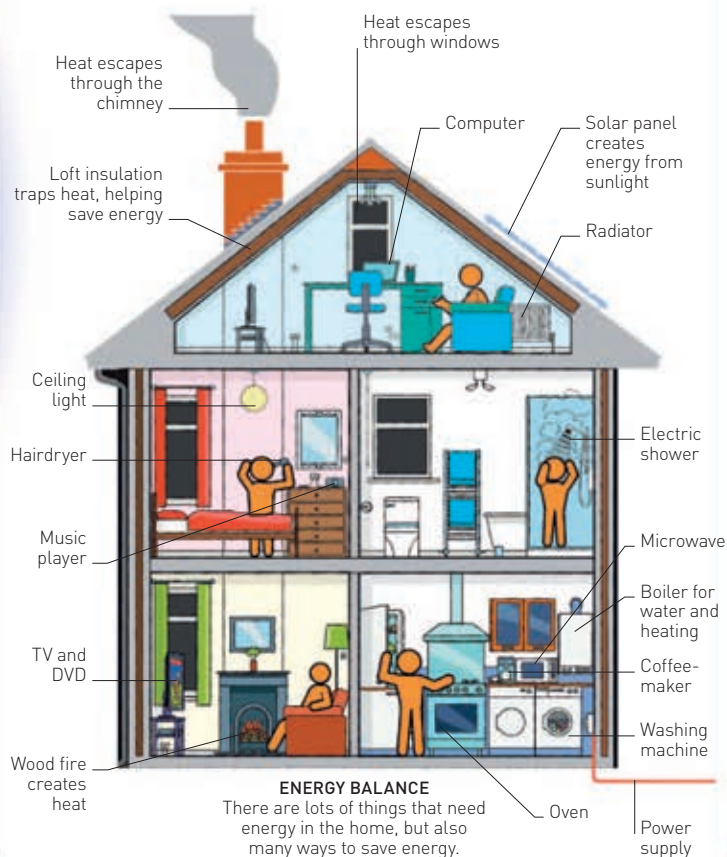
## POWER TO THE HOME

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



## 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 centre 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. One train needs less than 1,000 volts, but the cables are about 25,000 volts. This means many trains can use the line at once.



**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 10–20 volts to charge its battery. Laptops need higher voltages than phones because they have bigger screens and circuits that use more energy.

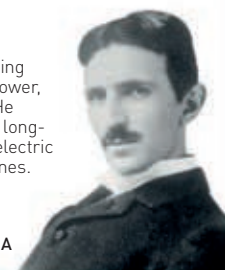


**TORCH BULBS**  
Bulbs for torches and lamps are rated by the voltage and current needed to operate them. The standard AA, C, and D batteries all deliver 1.5 volts each.

## PIONEERS

Electricity has been around forever, because it exists naturally in the world. However, some people were important in finding out how to harness its power.

- **BENJAMIN FRANKLIN (1706–90)**  
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.
- **GEORG SIMON OHM (1789–1854)**  
Ohm discovered electrical resistance. The unit of resistance – ohm – is named after him.
- **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 ALVA EDISON (1847–1931)**  
Edison built the first electric power stations and invented the lightbulb, sound recorder (phonograph), and movie camera.
- **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



# Chemistry

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

## 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.



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



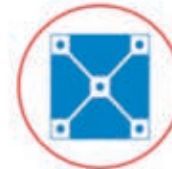
**BIOCHEMISTRY**  
This looks at chemical processes inside living things or affecting them.



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



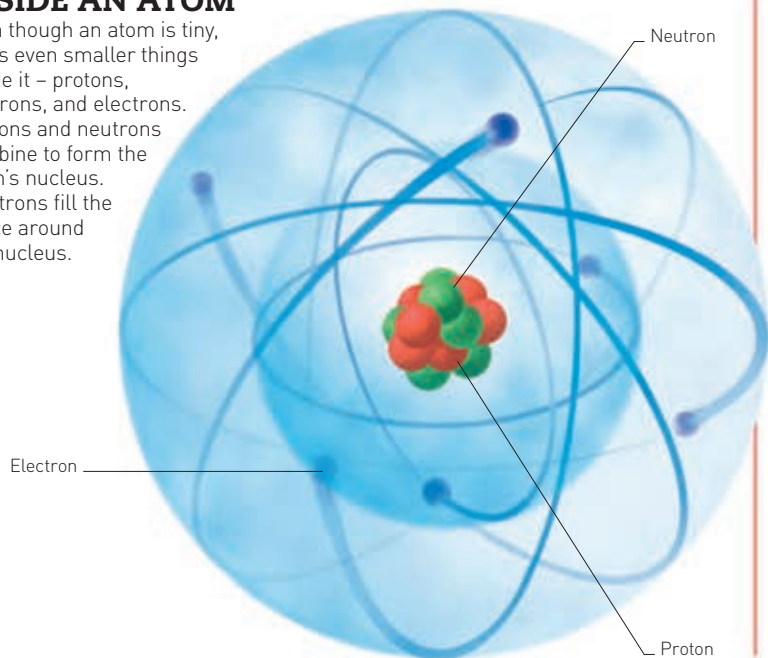
**MATERIALS SCIENCE**  
This science uses physics and chemistry to create new materials.



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

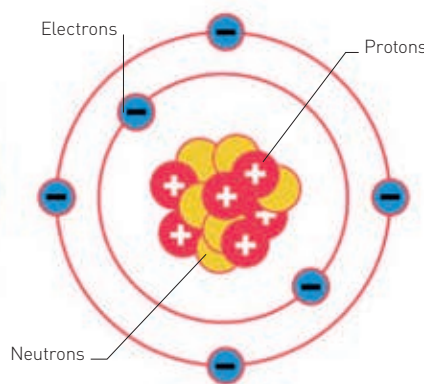
## INSIDE AN ATOM

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.



## STRUCTURE OF AN ATOM

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

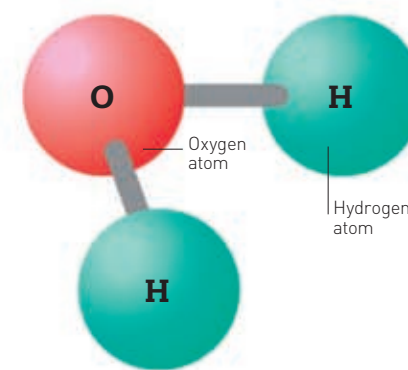


### CARBON ATOM

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 clump 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.

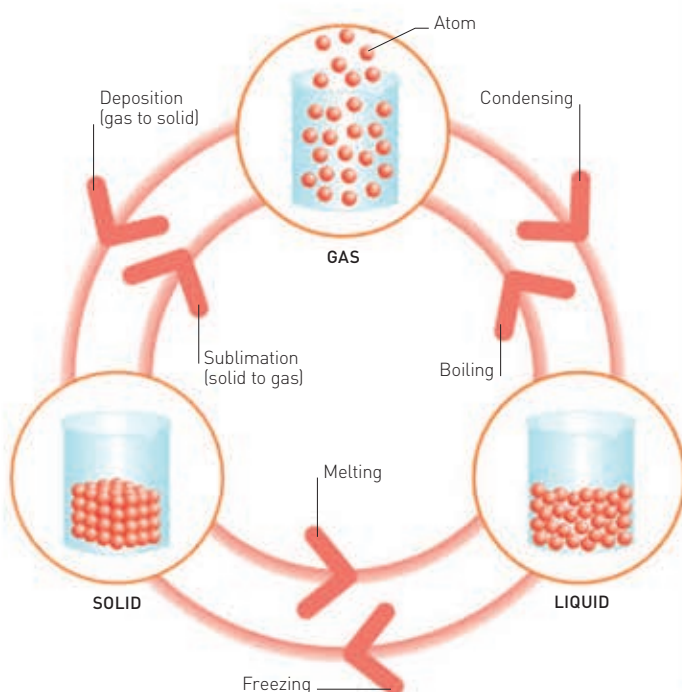


### WATER MOLECULE

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. As a solid, its atoms lock tightly together. As a liquid, they move further apart, and 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 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.



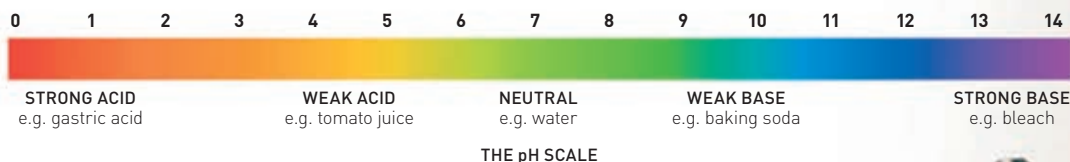
### FILTERING

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



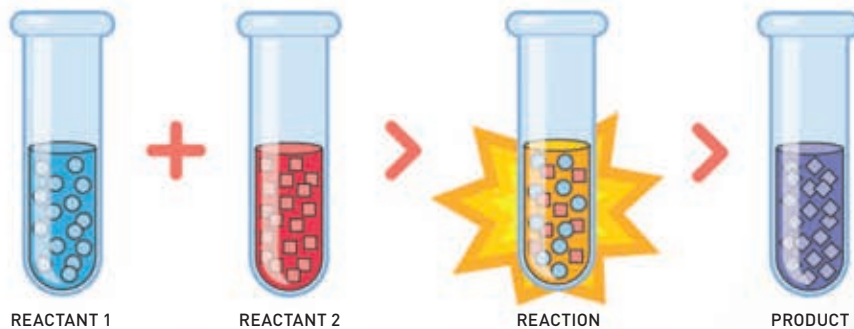
## ACIDS AND BASES

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

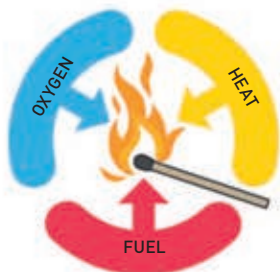
Although the product of a chemical reaction is very different from the reactants, none of the atoms are destroyed – there are the same number before as after the reaction. There are three types of chemical reaction.



**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 petrol 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.



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



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



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



**CERAMIC**  
Fragile if knocked but can withstand high temperatures.

## GREAT CHEMISTS

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

- ROBERT BOYLE (1627–91)**  
The author of *The Sceptical Chymist* was the first to develop rigorous scientific techniques for his experiments in the field of chemistry.
- ANTOINE LAVOISIER (1743–94)**  
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)**  
Twice winner of the Nobel prize, Curie discovered radium.
- LINUS PAULING (1901–94)**  
American scientist who worked out how molecules bond together.
- DOROTHY HODGKIN (1910–94)**  
A pioneer in X-ray techniques who discovered the atomic structure of penicillin.

LINUS PAULING



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



**SYNTHETIC FIBRE**  
Plastic-based fibres are strong and waterproof.



**KEVLAR®**  
High-strength material that withstands high impact and extremes of temperatures.



# The elements

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.

22

47.867

**ATOMIC MASS**  
This is the number of protons and neutrons inside an atom.

**Ti**

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

TITANIUM

### 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

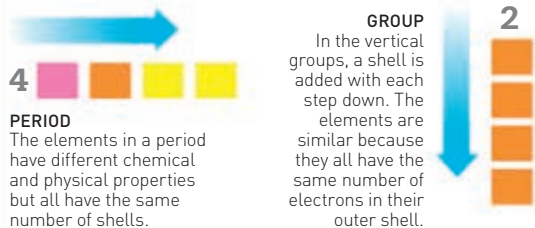
Elements with a similar atomic structure sit together in the grid, which predicts how they will behave. Most of the 118 elements occur in rocks or in the atmosphere, but scientists have also built new ones by smashing smaller atoms together.

1 1.0079 <b>H</b> Jupiter HYDROGEN	2 9.0122 <b>Be</b> Aquamarine BERYLLIUM								
3 6.941 <b>Li</b> Watermelon tourmaline LITHIUM	4 24.305 <b>Mg</b> Peridot MAGNESIUM								
11 22.990 <b>Na</b> Salt SODIUM	12 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	
19 39.098 <b>K</b> Banana POTASSIUM	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 95.94 <b>Mo</b> Steel girder MOLYBDENUM	43 [96] <b>Tc</b> TECHNETIUM	44 101.07 <b>Ru</b> RUTHENIUM	45 102.91 <b>Rh</b> Rhodium-plated buckle RHODIUM
55 132.91 <b>Cs</b> Caesium atomic clock CAESIUM	56 137.33 <b>Ba</b> Crystals BARIUM	57-71 <b>La-Lu</b> LANTHANIDE	72 178.49 <b>Hf</b> Nuclear reactor control rod HAFNIUM	73 180.95 <b>Ta</b> Capacitor TANTALUM	74 183.84 <b>W</b> Filament in light bulb TUNGSTEN	75 186.21 <b>Re</b> Jet turbine blades RHENIUM	76 190.23 <b>Os</b> Tip of fountain pen OSMIUM	77 192.22 <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 [261] <b>Rf</b> RUTHERFORDIUM	105 [262] <b>Db</b> DUBNIUM	106 [266] <b>Sg</b> SEABORGIUM	107 [264] <b>Bh</b> BOHRIUM	108 [277] <b>Hs</b> HASSIUM	109 [268] <b>Mt</b> MEITNERIUM	
		<p><b>MAN-MADE ELEMENTS</b> Elements with a higher number than uranium (92) rarely occur naturally. These transuranic elements are created in particle accelerators or nuclear reactors. They include plutonium, which was used to make the atomic bomb.</p>		57 138.91 <b>La</b> Monazite LANTHANUM	58 140.12 <b>Ce</b> Cerium oxide CERIUM	59 140.91 <b>Pr</b> Permanent magnet PRASEODYMIUM	60 144.24 <b>Nd</b> Earphones NEODYMIUM	61 [145] <b>Pm</b> PROMETHIUM	62 150.36 <b>Sm</b> Samarskite SAMARIUM
		<p><b>96 PER CENT OF THE HUMAN BODY IS MADE UP OF JUST FOUR ELEMENTS: OXYGEN, CARBON, HYDROGEN, AND NITROGEN</b></p>		89 [227] <b>Ac</b> ACTINIUM	90 232.04 <b>Th</b> THORIUM	91 231.04 <b>Pa</b> PROTACTINIUM	92 238.03 <b>U</b> Nuclear power plant URANIUM	93 [237] <b>Np</b> NEPTUNIUM	94 [244] <b>Pu</b> Atomic bomb PLUTONIUM



## READING THE TABLE

The table has horizontal rows called periods and vertical columns called groups. Atoms get bigger and heavier towards 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  
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 man-made.
- **Noble gases**  
Stable gases that do not react naturally.
- **Other metals**  
Malleable, ductile, solid, dense metals.

- **Metalloids**  
Share properties with metals and non-metals.
- **Non-metals**  
Poor solid conductors, brittle, with no metallic lustre, and gases.

- **Halogens**  
These exist in solid, liquid, and gas forms.
- **Unknown**  
Newly discovered synthetic element.

										18																											
										2	4.0026	<b>He</b>  Helium balloon HELIUM	1																								
										10	20.180		<b>Ne</b>  Helium-neon laser NEON	2																							
										13	26.982	<b>Al</b>  Foil ALUMINIUM		14	28.086	<b>Si</b>  Silicon chip SILICON	15	30.974	<b>P</b>  Matchbox PHOSPHORUS	16	32.065	<b>S</b>  Sulphur SULPHUR	17	35.453	<b>Cl</b>  Carnallite CHLORINE	18	39.948	<b>Ar</b>  Light bulb ARGON	3								
5	10.811	6	12.011	7	14.007	8	15.999	9	18.998	13	26.982		14	28.086	15		30.974	16		32.065	17		35.453	18		39.948											
										28	58.693	<b>Ni</b>  Spoon NICKEL	29	63.546	<b>Cu</b>  Wire COPPER	30	65.39	<b>Zn</b>  Sphalerite ZINC	31	69.723	<b>Ga</b>  Solar thermal panel GALLIUM	32	72.64	<b>Ge</b>  Camera lens GERMANIUM	33	74.922	<b>As</b>  Arsenic ARSENIC	34	78.96	<b>Se</b>  Selenium SELENIUM	35	79.904	<b>Br</b>  Bromine BROMINE	36	83.80	<b>Kr</b>  Fluorescent lamp KRYPTON	4
46	106.42	47	107.87	48	113	49	114.82	50	118.71	51	121.76		52	127.60		53	126.90		54	131.29																	
										46	106.42	<b>Pd</b>  Catalytic converter PALLADIUM	47	107.87	<b>Ag</b>  Silver pendant SILVER	48	113	<b>Cd</b>  Yellow paint CADMIUM	49	114.82	<b>In</b>  Light emitting diode (LED) INDIUM	50	118.71	<b>Sn</b>  Tin-plated can TIN	51	121.76	<b>Sb</b>  Bullet ANTIMONY	52	127.60	<b>Te</b>  Compact disc (CD) TELLURIUM	53	126.90	<b>I</b>  Liquid iodine IODINE	54	131.29	<b>Xe</b>  Arc lamp XENON	5
78	195.08	79	196.97	80	201	81	204.38	82	207.2	83	208.96		84	(209)		85	(210)		86	(222)																	
										78	195.08	<b>Pt</b>  Ring PLATINUM	79	196.97	<b>Au</b>  Necklace GOLD	80	201	<b>Hg</b>  Thermometer MERCURY	81	204.38	<b>Tl</b>  Rat poison THALLIUM	82	207.2	<b>Pb</b>  Lead battery LEAD	83	208.96	<b>Bi</b>  Crystal BISMUTH	84	(209)	<b>Po</b>  Polonium POLONIUM	85	(210)	<b>At</b>  Astatine ASTATINE	86	(222)	<b>Rn</b>  Radon RADON	6
110	(281)	111	(272)	112	285	113	284	114	289	115	288		116	293		117	294		118	294																	
										110	(281)	<b>Ds</b>  Darmstadtium DARMSTADIUM	111	(272)	<b>Rg</b>  Roentgenium ROENTGENIUM	112	285	<b>Cn</b>  Copernicium COPERNICIUM	113	284	<b>Uut</b>  Ununtrium UNUNTRIUM	114	289	<b>Uuq</b>  Ununquadium UNUNQUADIUM	115	288	<b>Uup</b>  Ununpentium UNUNPENTIUM	116	293	<b>Uuh</b>  Ununhexium UNUNHEXIUM	117	294	<b>Uus</b>  Ununseptium UNUNSEPTIUM	118	294	<b>Uuo</b>  Ununoctium UNUNOCTIUM	7
63	151.96	64	157.25	65	158.93	66	162.50	67	164.93	68	167.26		69	168.93		70	173.04		71	174.97																	
										63	151.96	<b>Eu</b>  Xenotime EUROPIUM	64	157.25	<b>Gd</b>  Gadolinium GADOLINIUM	65	158.93	<b>Tb</b>  Green fluorescent lamp TERBIUM	66	162.50	<b>Dy</b>  Fergusonite crystals DYSPROSIUM	67	164.93	<b>Ho</b>  Gadolinite HOLMIUM	68	167.26	<b>Er</b>  Fibre optic cable ERBIUM	69	168.93	<b>Tm</b>  Thulium THULIUM	70	173.04	<b>Yb</b>  Atomic clock YTTERBIUM	71	174.97	<b>Lu</b>  Lutetium LUTETIUM	8
95	(243)	96	(247)	97	231.04	98	(251)	99	(252)	100	(257)		101	(258)		102	(259)		103	(262)																	
										95	(243)	<b>Am</b>  Smoke detector AMERICIUM	96	(247)	<b>Cm</b>  Curium CURIUM	97	231.04	<b>Bk</b>  Berkelium BERKELIUM	98	(251)	<b>Cf</b>  Californium CALIFORNIUM	99	(252)	<b>Es</b>  Einsteinium EINSTEINIUM	100	(257)	<b>Fm</b>  Fermium FERMIUM	101	(258)	<b>Md</b>  Mendelevium MENDELEVIUM	102	(259)	<b>No</b>  Nobelium NOBELIUM	103	(262)	<b>Lr</b>  Lawrencium LAWRENCIUM	9



# 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

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 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.

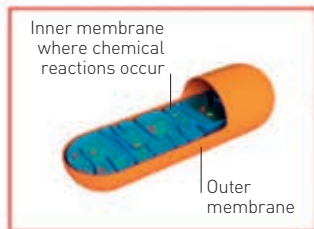


**THE RIGHT TEMPERATURE**  
Few living things can exist in extremely hot or cold temperatures.

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

## WHAT IS A CELL?

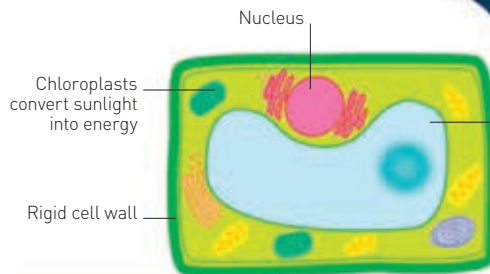
Cells are the building blocks of life. The cells of all living things except archaea and bacteria contain a nucleus, mitochondria, and other organelles. Cells can be specialized to perform different functions – for example, we have nerve, muscle, and bone cells. The human body has around 75 trillion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

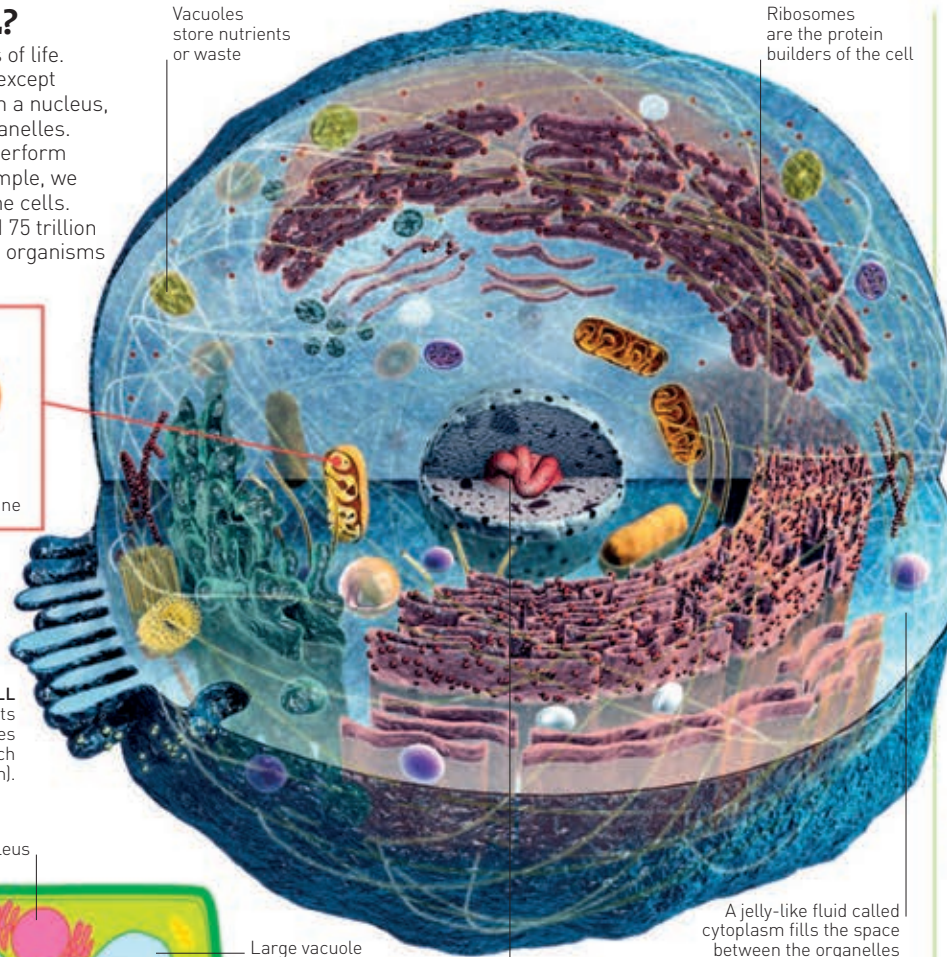
An animal cell contains lots of "machines" called organelles that perform special jobs (such as the mitochondrion).



**PLANT CELL**  
These have much in common with animal cells, but they also have rigid cell walls and chloroplasts.

Vacuoles store nutrients or waste

Ribosomes are the protein builders of the cell

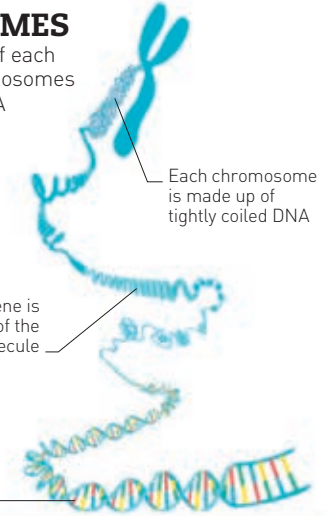


A jelly-like fluid called cytoplasm fills the space between the organelles

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

## CHROMOSOMES

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



Each chromosome is made up of tightly coiled DNA

Each gene is a section of the DNA molecule

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

## GENES

Our genes are inherited from our parents – half from mum and half from dad – and they dictate things like eye colour. 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.

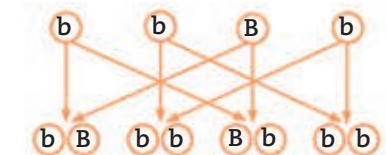


**BLUE-EYED FATHER**



**BROWN-EYED MOTHER**

Each parent carries a different combination of genes for eye colour



Possible gene combinations of children



Children's possible eye colours

### 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.

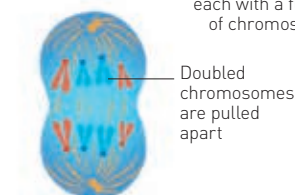
## CELL DIVISION

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.

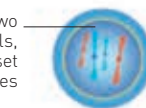


**1 FIRST STAGE**  
The cell contains chromosomes that can be copied to make new identical chromosomes.

**2 CHROMOSOMES ALIGN AND COPY**  
The wall of the nucleus breaks down and chromosomes line up in the middle of the cell.



**3 SEPARATION**  
The doubled chromosome is pulled in half, so one chromosome moves to each end of the cell.



**4 "DAUGHTER" CELLS FORM**  
Cell splits into two identical cells and the nuclear wall reforms.

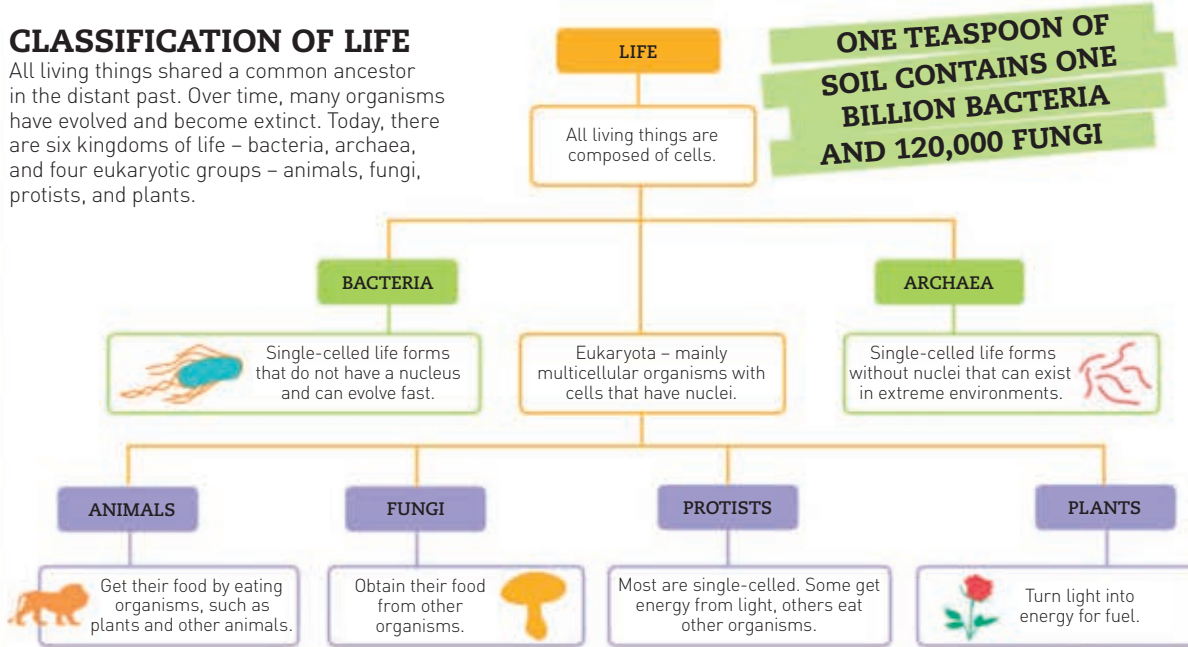
Cell splits into two daughter cells, each with a full set of chromosomes

Doubled chromosomes are pulled apart



## 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.



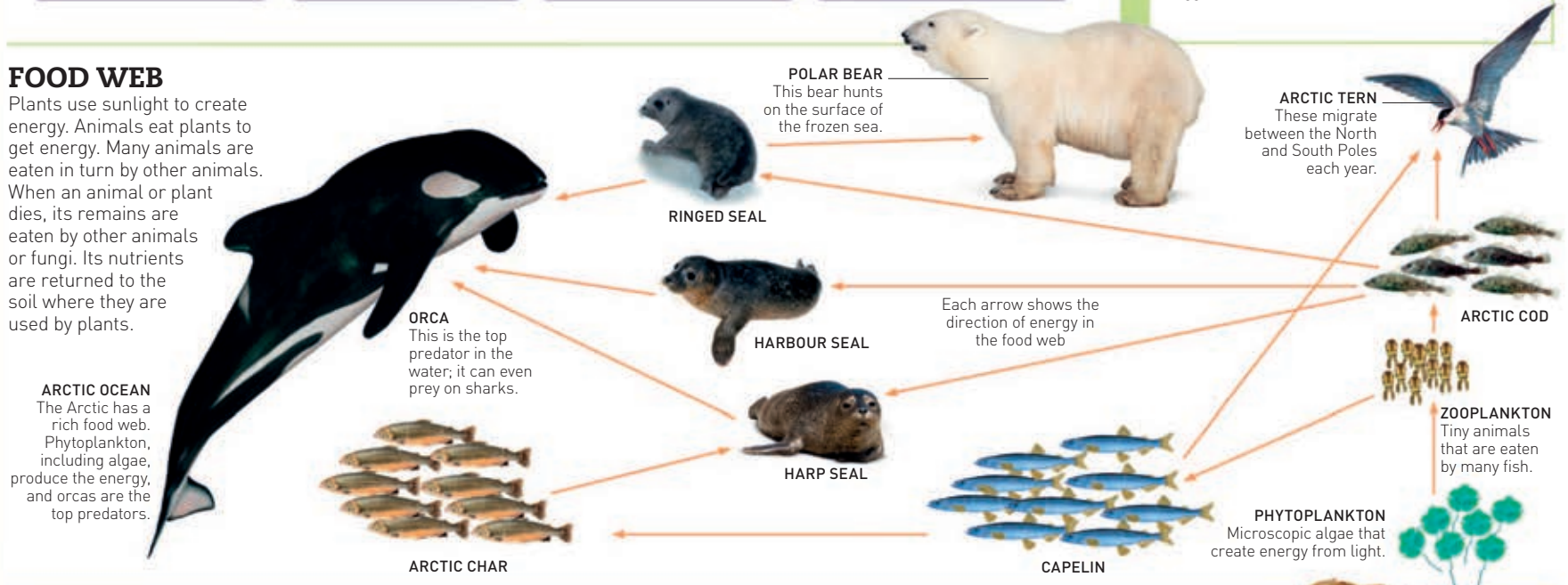
## GREAT BIOLOGISTS

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

- **ARISTOTLE (384–322 BCE)**  
This Ancient Greek philosopher was the first to classify the kingdom of life.
- **CHARLES DARWIN (1809–82)**  
This British naturalist suggested the theory of evolution in his book *On the Origin of Species*.
- **GREGOR MENDEL (1822–84)**  
An Austrian scientist and monk, Mendel showed how traits are inherited.
- **LOUIS PASTEUR (1822–95)**  
Pasteur proved that bacteria can spoil food and then went on to invent pasteurization – a method of killing bacteria in food such as milk and cheese.
- **LOUIS LEAKEY (1903–72)**  
A Kenyan scientist who found evidence of early humans in Olduvai Gorge, Kenya, and suggested humans first evolved in Africa.

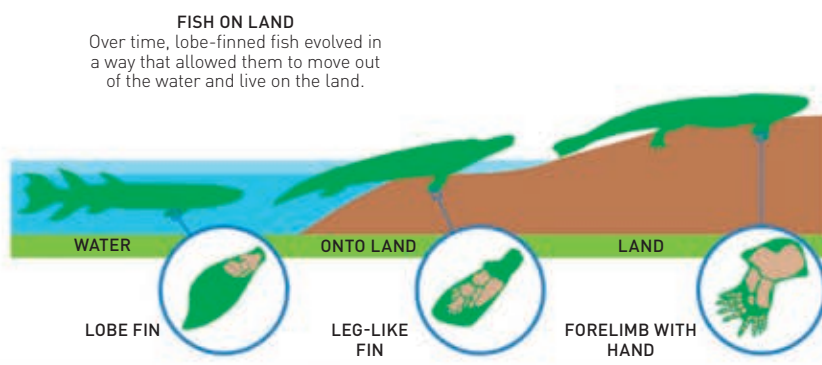
## FOOD WEB

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. Its nutrients are returned to the soil where they are used by plants.



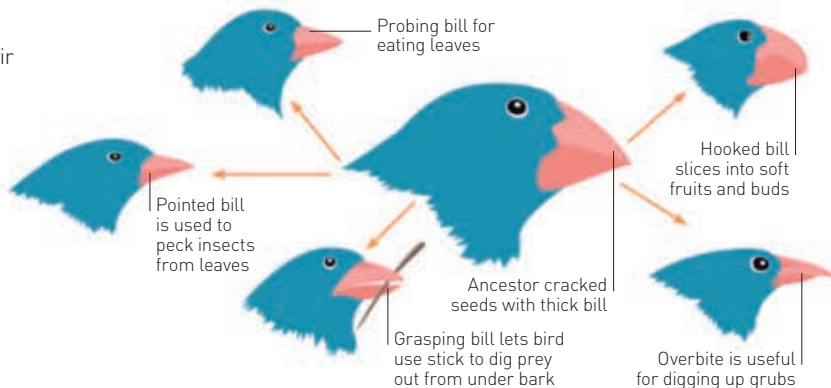
## EVOLUTION

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 favour their existence to their offspring. Over time, this leads to change. This process is known as evolution by natural selection.



## 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 the dinosaurs disappeared.

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

**GEOLOGICAL EVENTS**  
Meteor strikes and volcanic eruptions can cause extinctions. Dinosaurs are thought to have been wiped out by a meteor or volcanic activity.

**HUNTED TO DEATH**  
Overhunting by humans can cause animals to become extinct. This happened to the easily caught and very tasty dodo of Mauritius.

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

**POACHING**  
The tiger is threatened due to use of its body parts 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 brain does all the thinking. It sends electrical messages through the nervous system to other parts of the body

Blood vessels carry blood containing oxygen and nutrients around the body

The heart pumps blood around the body

The lungs fill with oxygen when we breathe in and release carbon dioxide when we breathe out

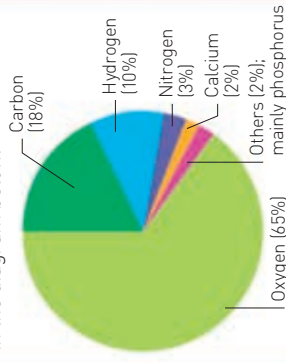
Bones such as the humerus in the upper arm provide a strong framework inside the body

# The human body

The human body is a complex machine, made up 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.



## 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.

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

## 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.



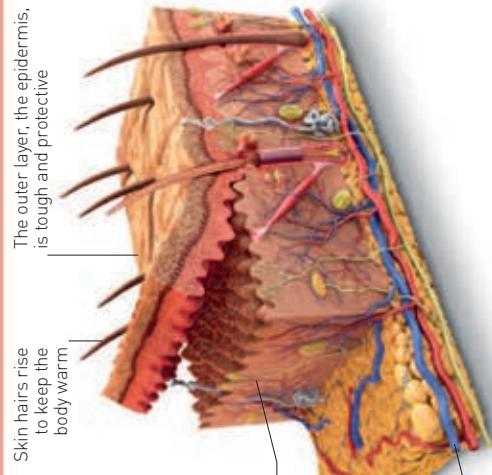
**CELL**  
There are more than 37 trillion cells in a human body.



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



**ORGANS**  
Tissue forms into organs, such as the heart (shown here).



Skin hairs rise to keep the body warm

The outer layer, the epidermis, is tough and protective



## 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.



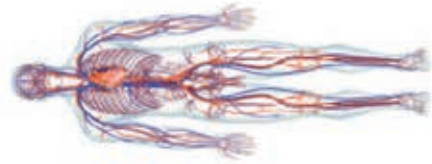
**MUSCULAR**  
The muscles allow the bones and organs of the body to move.



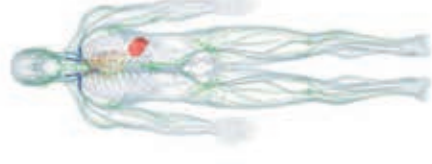
**NERVOUS**  
This is a messaging system between the brain and other parts of the body.



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



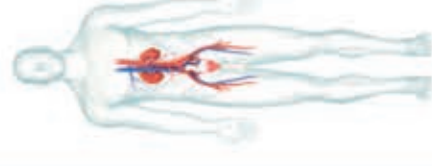
**CARDIOVASCULAR**  
Blood runs through this system, all around the body.



**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.



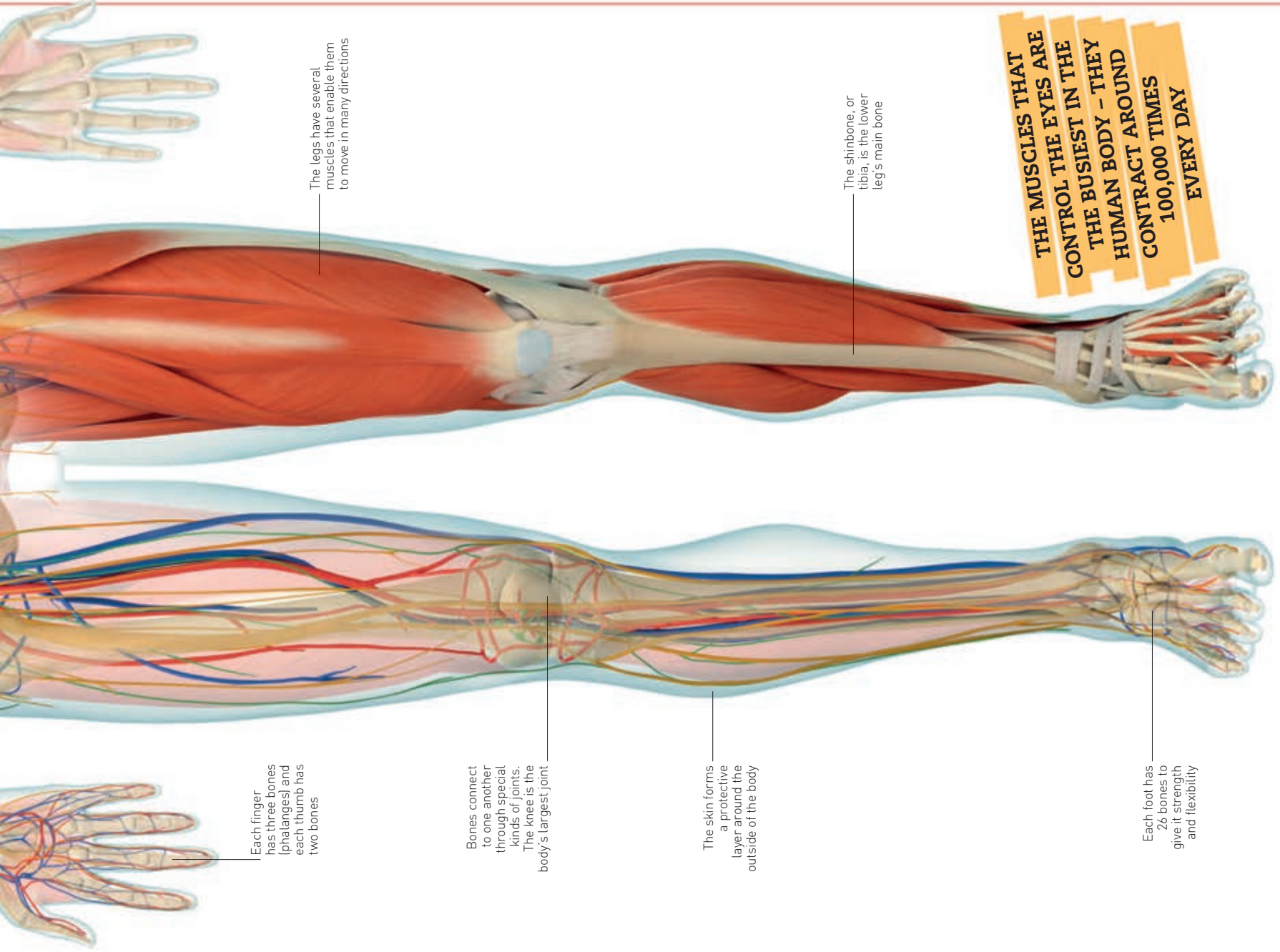
**FEMALE**

**REPRODUCTIVE**  
This is the system that allows people to produce children together. It is different in men and women.



**MALE**

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



Each finger has three bones (phalanges) and each thumb has two bones

Bones connect to one another through special kinds of joints. The knee is the body's largest joint

The skin forms a protective layer around the outside of the body

Each foot has 26 bones to give it strength and flexibility

The shinbone, or tibia, is the lower leg's main bone

**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 to 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

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

Ulna (outer lower arm)

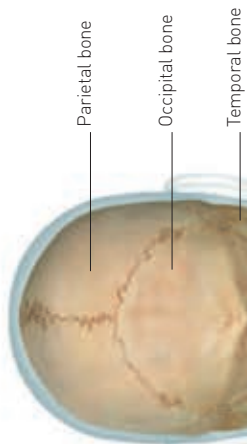
Radius (inner lower arm)

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

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



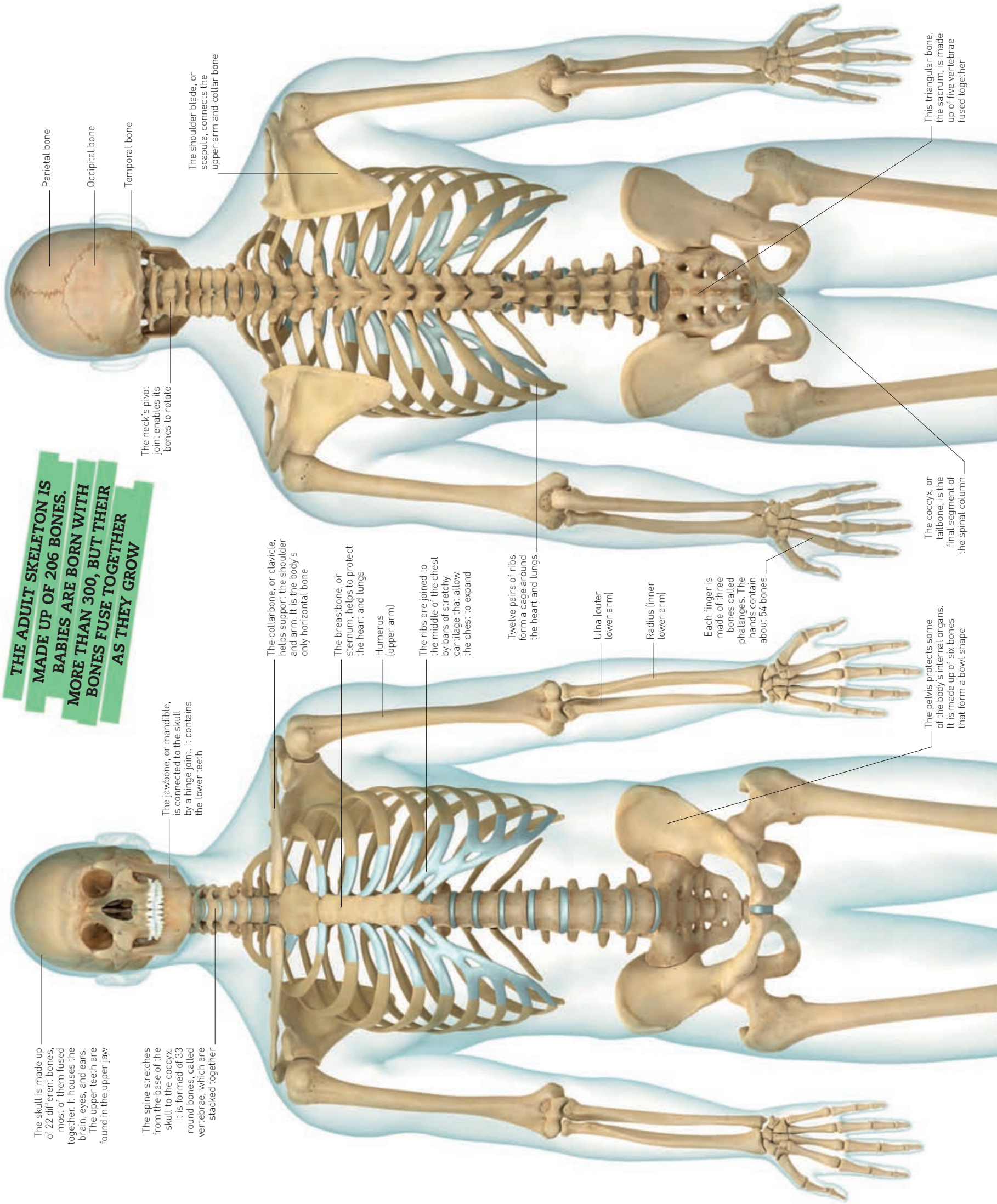
Parietal bone

Occipital bone

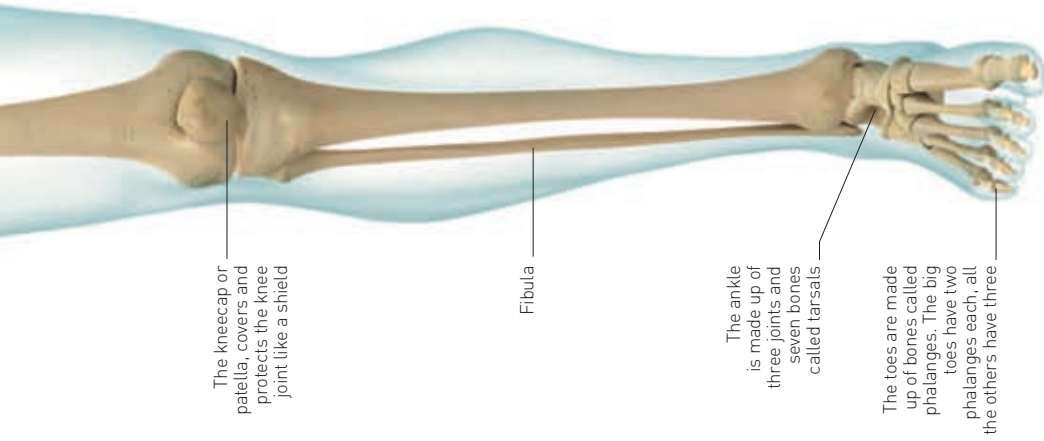
Temporal bone

The neck's pivot joint enables its bones to rotate

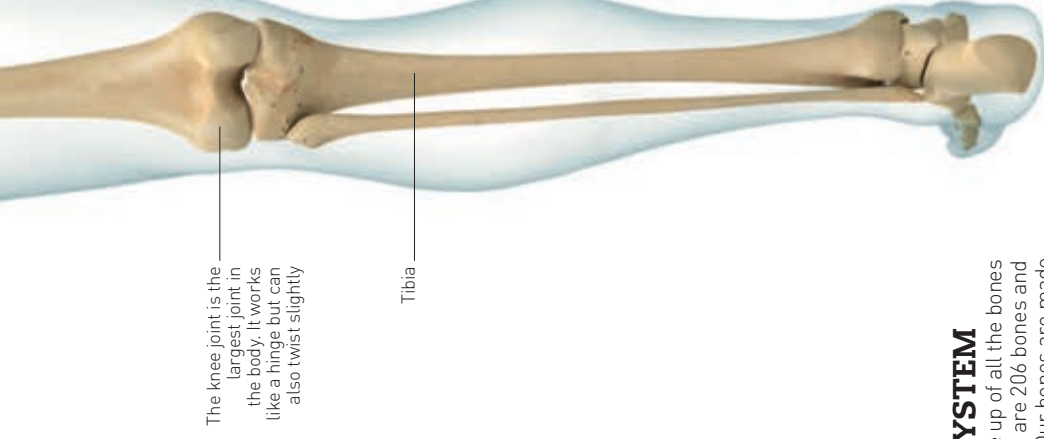
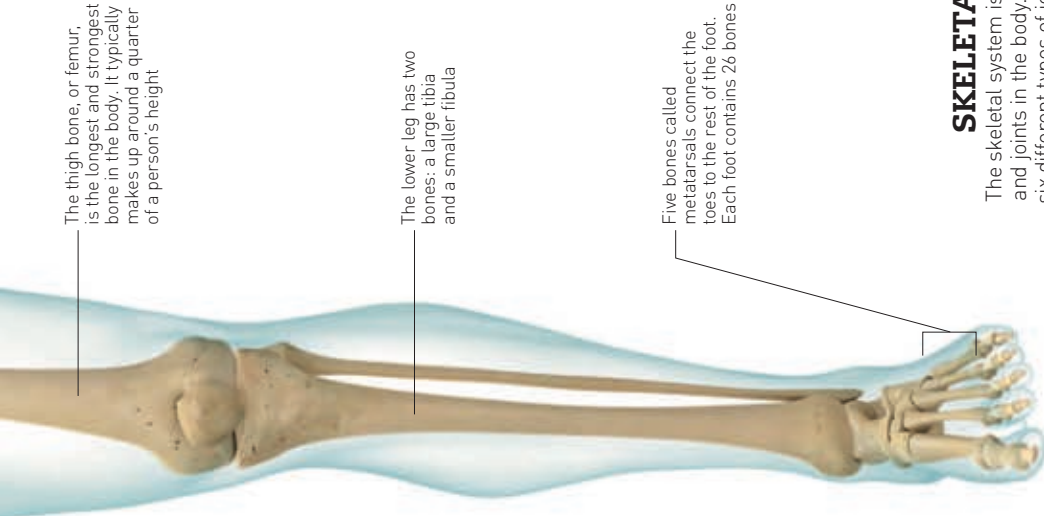
The shoulder blade, or scapula, connects the upper arm and collar bone







FRONT



BACK

## SKELETAL SYSTEM

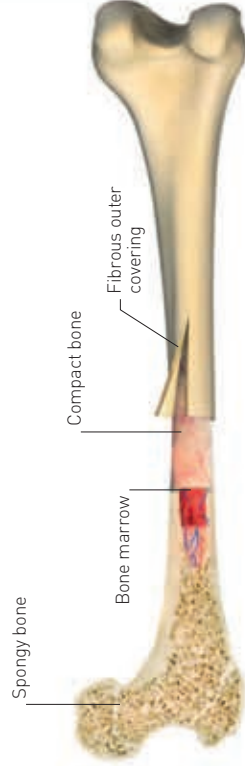
The skeletal system is made up of all the bones and joints in the body. There are 206 bones and six different types of joints. Our bones are made of living tissue, blood vessels, and nerves.

# 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.

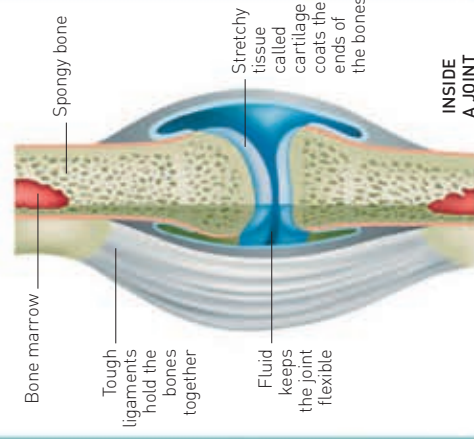
## INSIDE A BONE

Inside the solid outer bone is lighter, honeycomb-like spongy bone. In big bones the centre is filled with jelly-like marrow, which makes red blood cells.



## WHAT IS A JOINT?

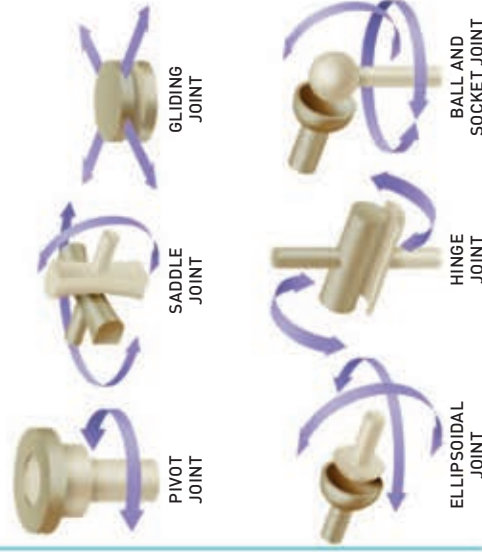
Where bones meet, they are held together by joints, tissues that allow them to move. Without joints we wouldn't be able to move our bodies. The movement a joint allows depends on the shape of the bones.



INSIDE A JOINT

## SYNOVIAL JOINTS

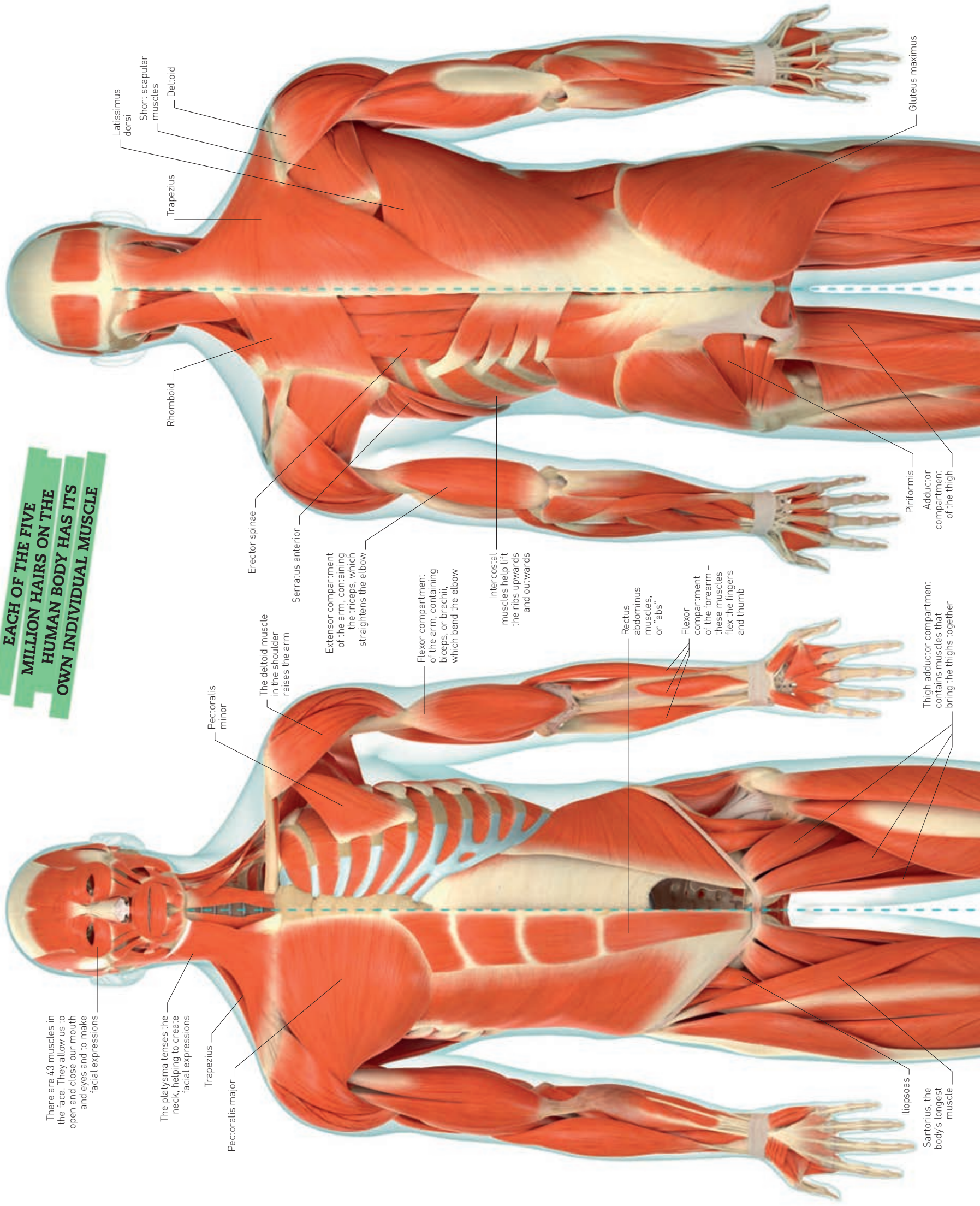
Synovial joints are the most common type of joints. There are six types of synovial joints, each allowing a different range of movement, depending on how the bones fit together.





ANTERIOR (FRONT)

POSTERIOR (BACK)



**EACH OF THE FIVE 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 to create facial expressions

Lattissimus dorsi  
Short scapular muscles  
Deltoid

Trapezius

Rhomboid

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 upwards and outwards

Rectus abdominus muscles, or 'abs'

Flexor compartment of the forearm - these muscles flex the fingers and thumb

Trapezius major

Iliopsoas

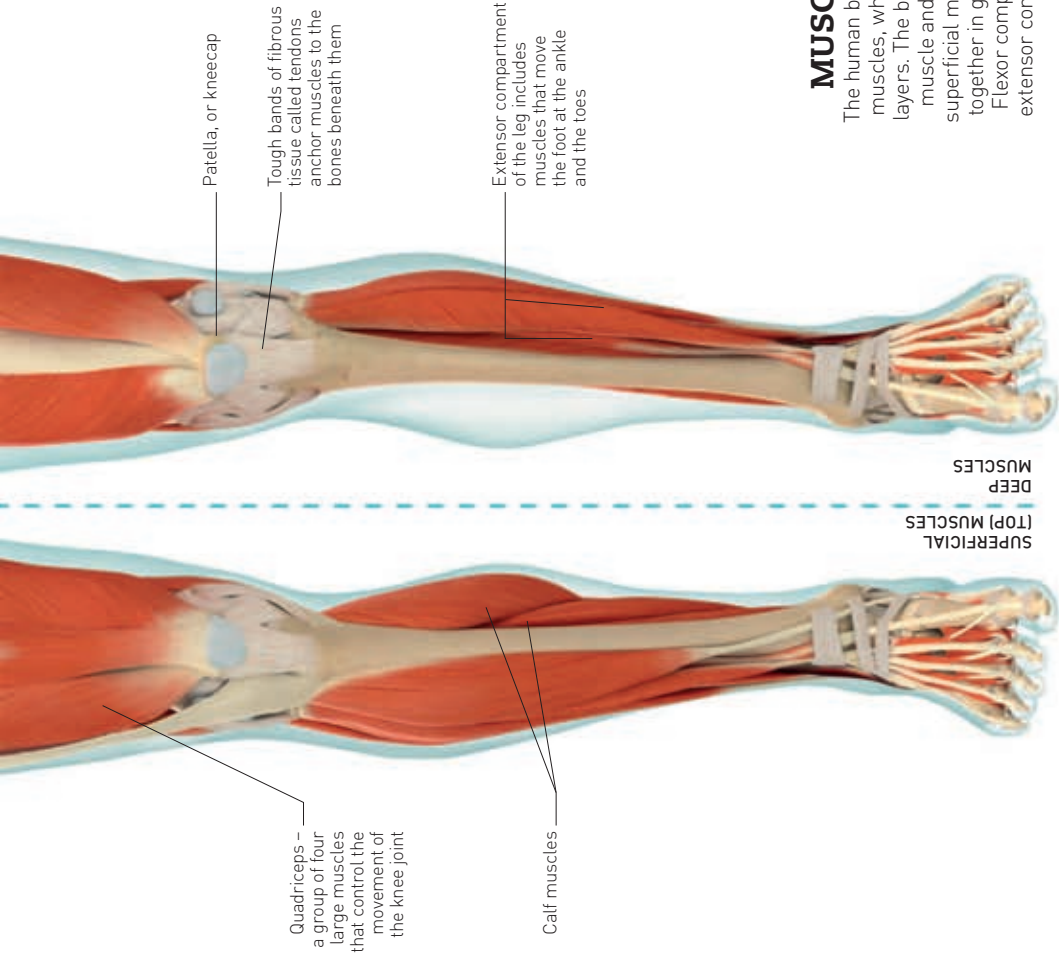
Sartorius, the body's longest muscle

Thigh adductor compartment contains muscles that bring the thighs together

Piriformis  
Adductor compartment of the thigh

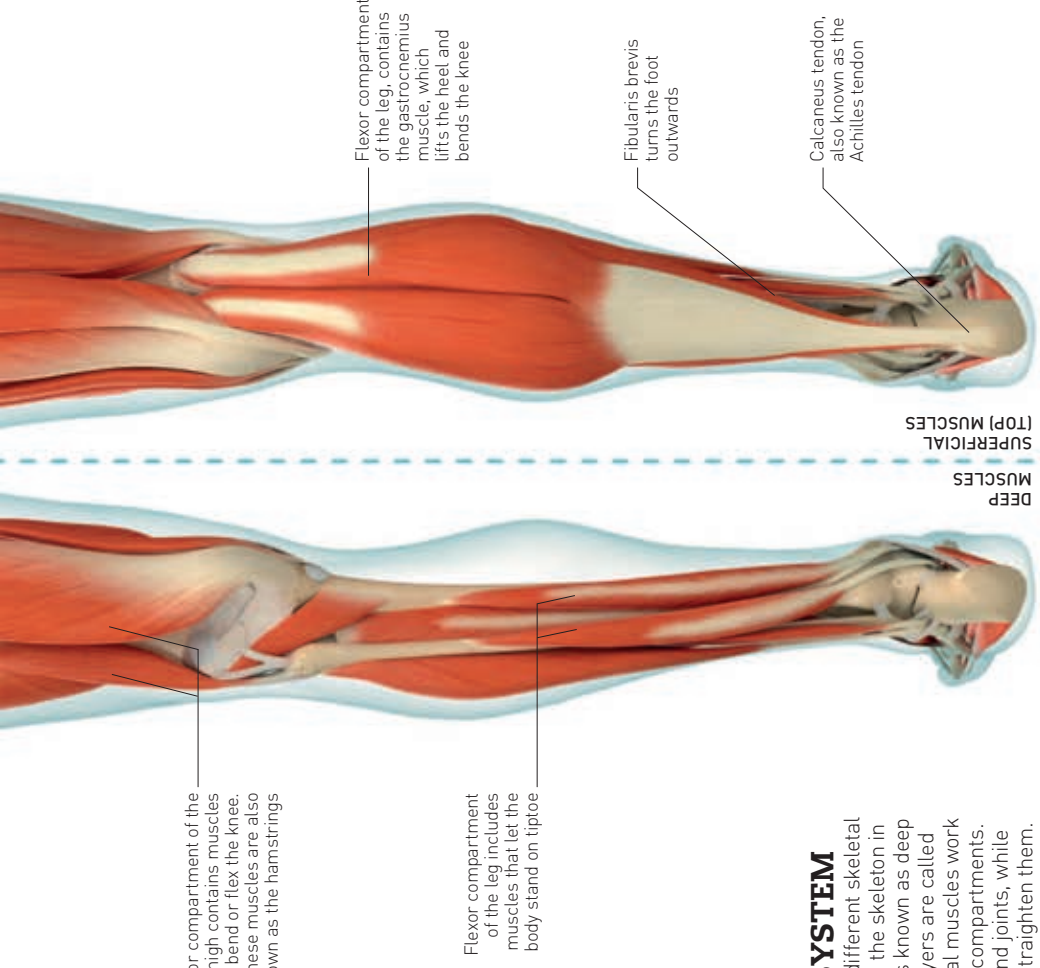
Gluteus maximus





SUPERFICIAL MUSCLES (TOP)

DEEP MUSCLES



DEEP MUSCLES

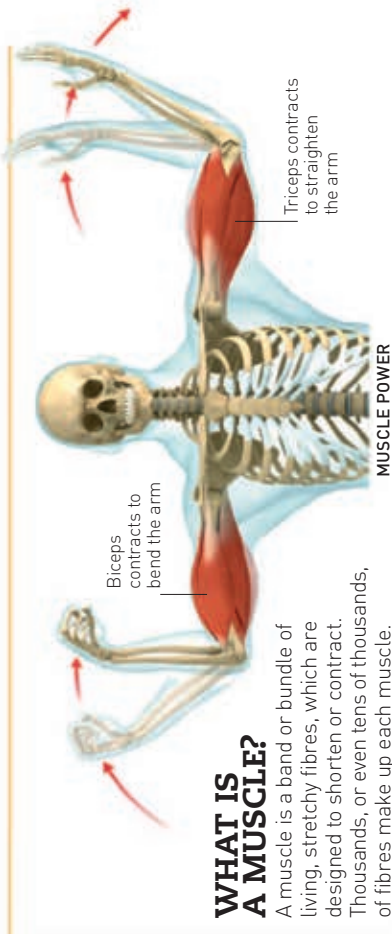
SUPERFICIAL MUSCLES (TOP)

### 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.



### WHAT IS A MUSCLE?

A muscle is a band or bundle of living, stretchy fibres, which are designed to shorten or contract. Thousands, or even tens of thousands, of fibres make up each muscle.

MUSCLE POWER

### 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)



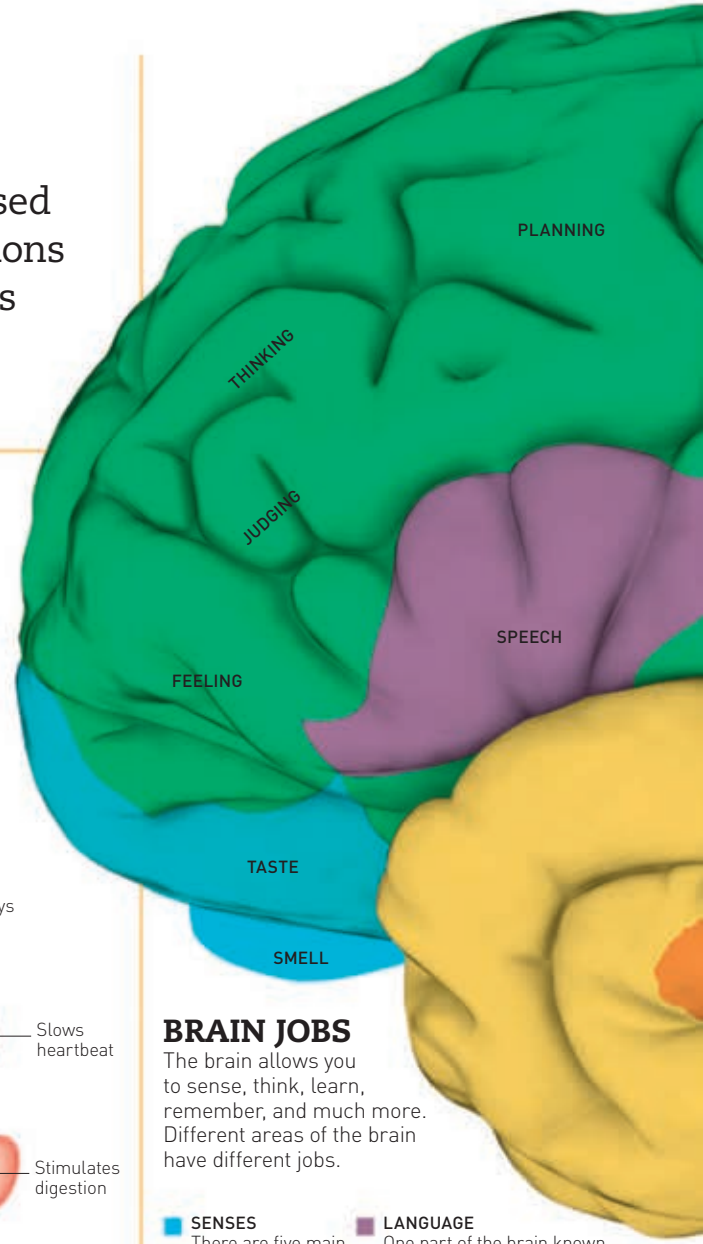
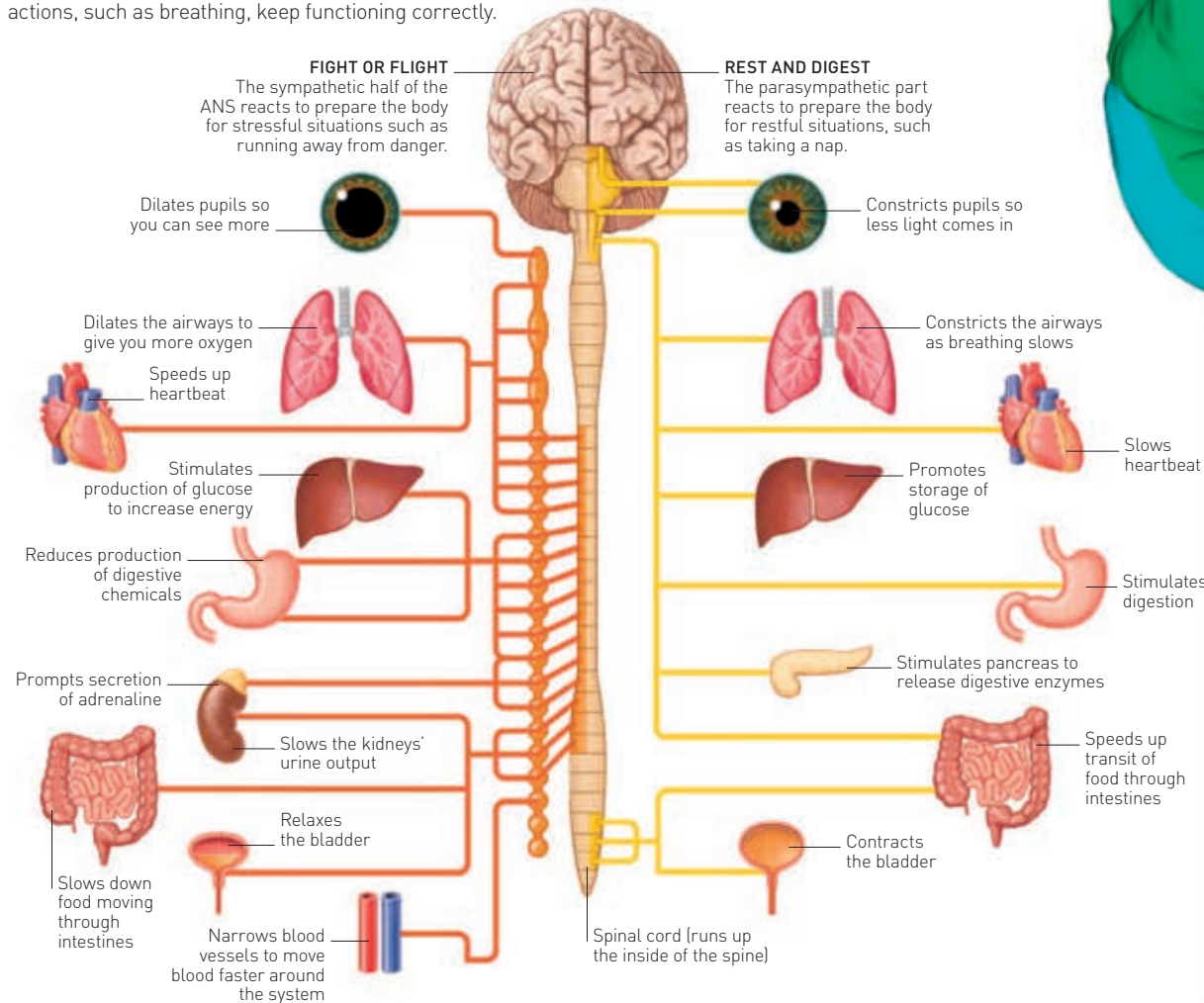
CIRCULAR (MOUTH)

# 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. Part of the system, known as the autonomic nervous system (ANS), makes sure all our "automatic" body actions, such as breathing, keep functioning correctly.



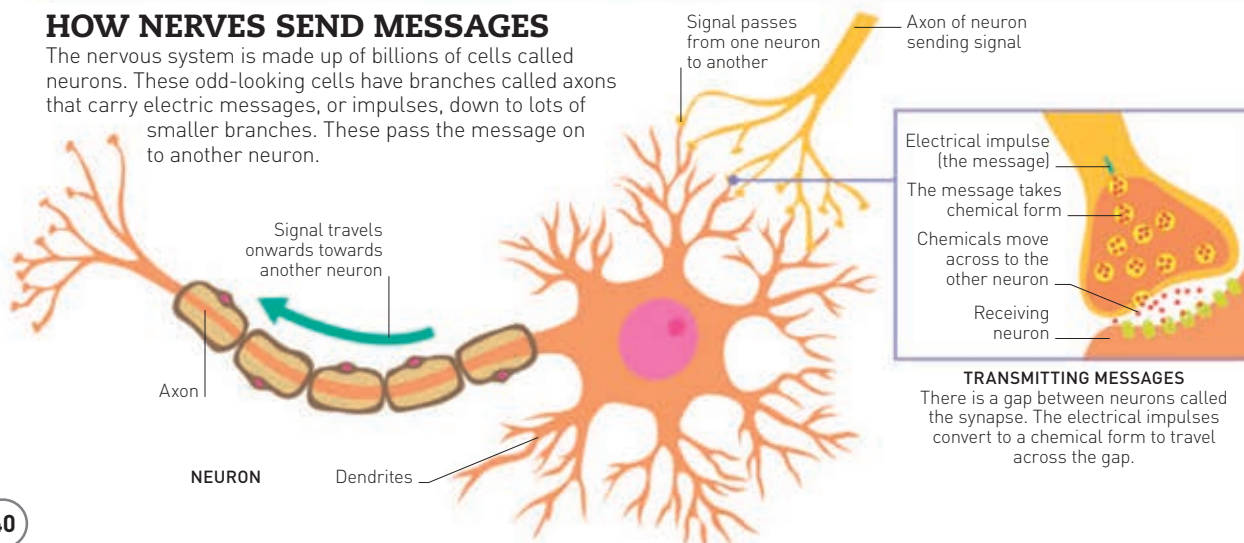
## BRAIN JOBS

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

- SENSES** There are five main sense areas in the brain. They process the 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 to 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, judgements, and ideas, and also helps you to understand other people's feelings.

## HOW NERVES SEND MESSAGES

The nervous system is made up of billions of cells called neurons. These odd-looking 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.



### TRANSMITTING MESSAGES

There is a gap between neurons called the synapse. The electrical impulses convert to a chemical form to travel across the gap.

## BRAIN AREAS

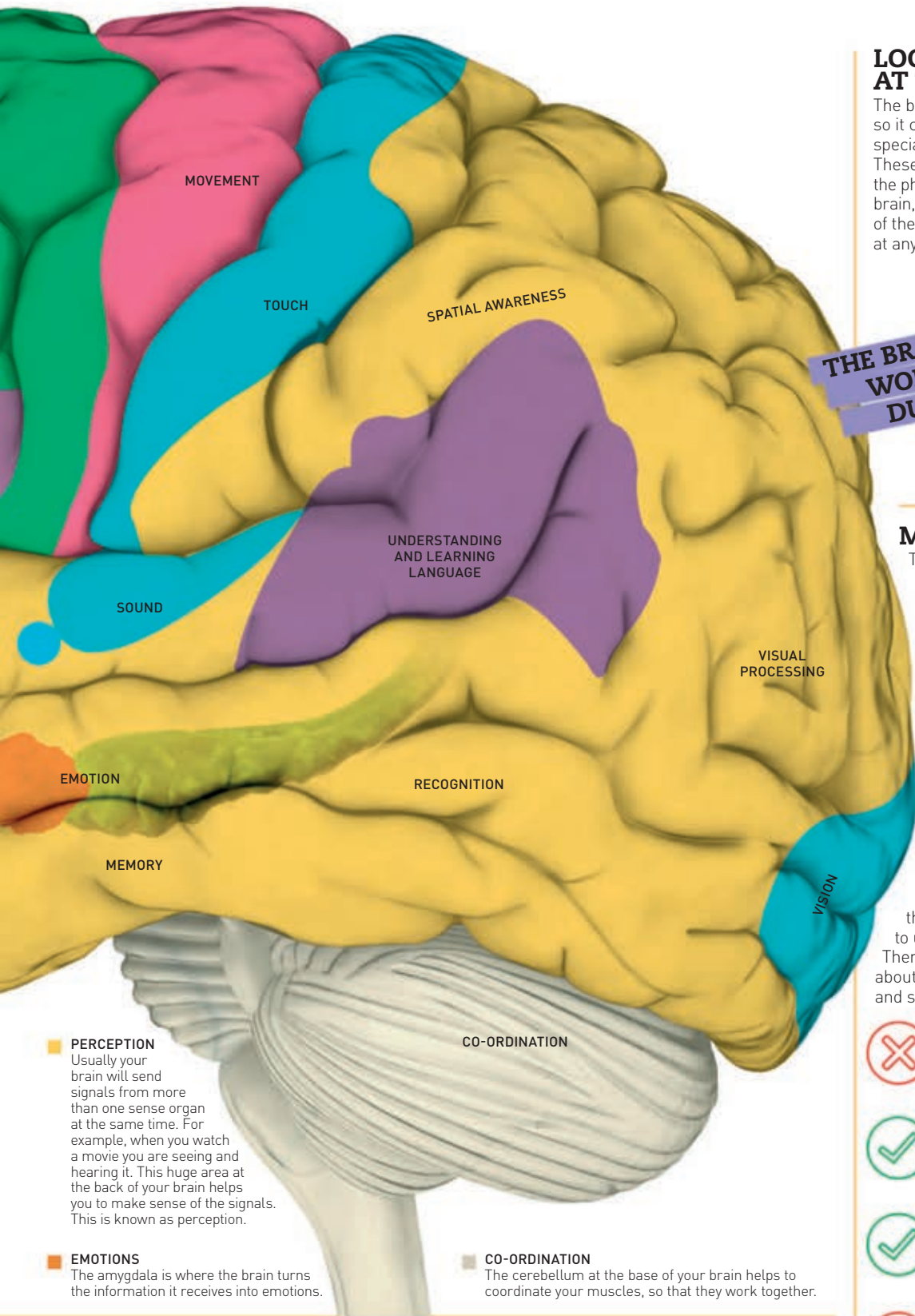
The human brain has many different parts, but it can be divided into three main areas. The large cerebrum deals with thoughts, language, and behaviour. The limbic system processes emotions, and the cerebellum coordinates movement.



### 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.





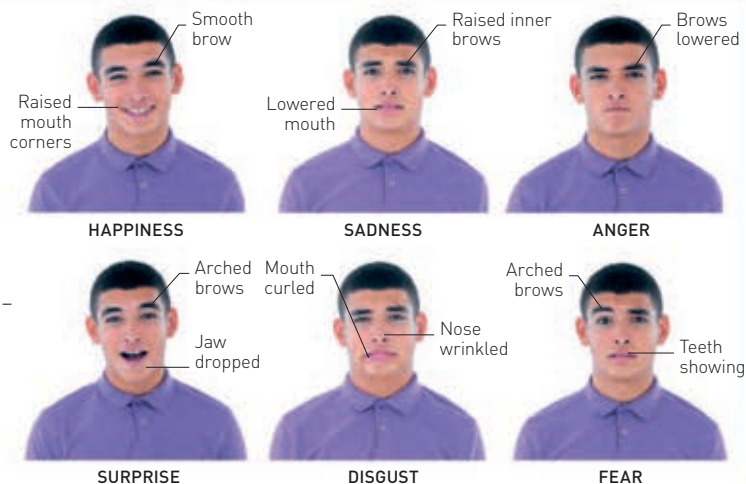
**PERCEPTION**  
Usually your brain will send signals from more than one sense organ at the same time. For example, when you watch a movie you are seeing and hearing it. This huge area at the back of your brain helps you to make sense of the signals. This is known as perception.

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

**CO-ORDINATION**  
The cerebellum at the base of your brain helps to coordinate your muscles, so that they work together.

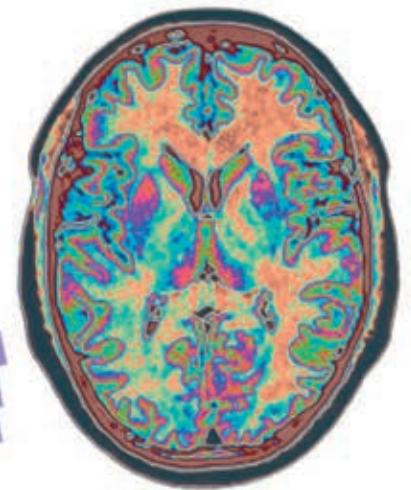
## EMOTIONS

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.

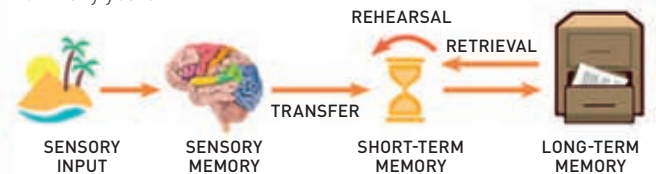


**MRI SCAN**  
An MRI scan uses magnetism to produce images of different sections of the brain.

**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 PER CENT 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.

## SOME UNUSUAL BRAINS

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

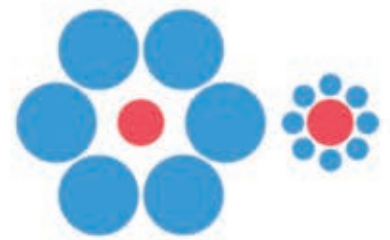
- AMNESIA**  
This is a loss of memory due to a physical or emotional trauma.
- SYNAESTHESIA**  
People with this disorder experience mixed-up senses. For example, some people see colours when they read or hear numbers.
- DEMENTIA**  
This is a set of problems, including difficulties with thinking, memory, problem-solving, and language. It usually affects older adults.
- 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.

**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.

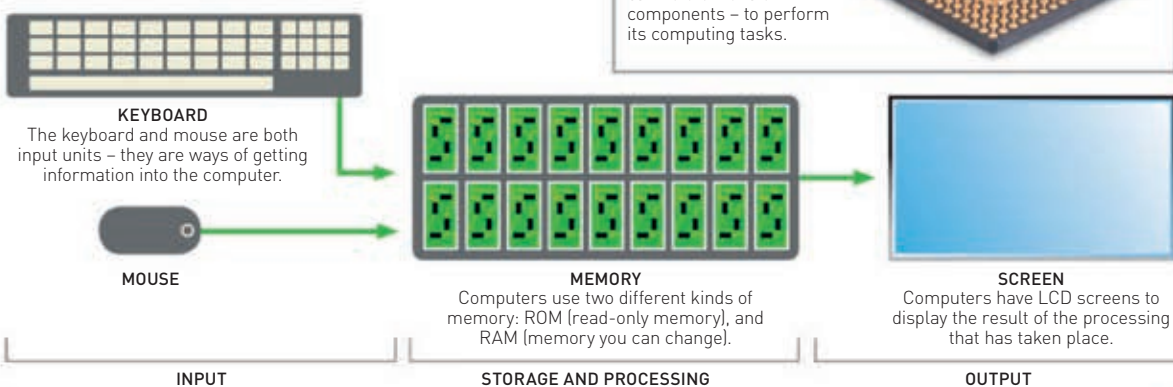
**1642**  
Blaise Pascal invents the Pascaline, a mechanical and automatic calculator.



Pascaline

## 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).



## 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.



**1 BINARY CODE**  
Computers only understand binary code, which is made up of 0s and 1s.

```

IDLE File Edit Shell Debug Window Help
# Ghost Game
from random import randint
print ("Ghost Game")
feeling_brave=True
Score=0
While feeling_brave:
    ghost_door=randint( 1,3 )
    print("Three doors ahead...")
    
```

**2 PROGRAMMING LANGUAGE**  
Programming languages are used to lay out sets of instructions for computers to follow.



**3 SOFTWARE**  
Programming languages are used to write computer programs (software).

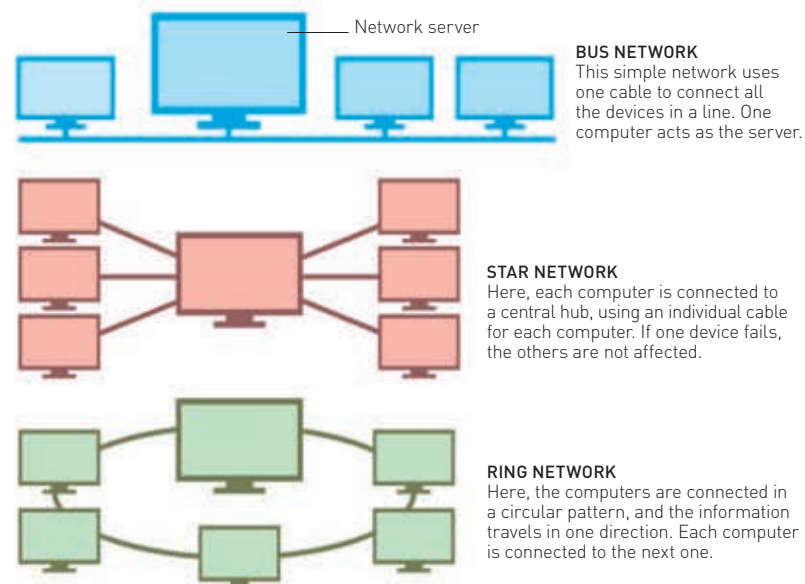
## SHRINKING SIZES

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.



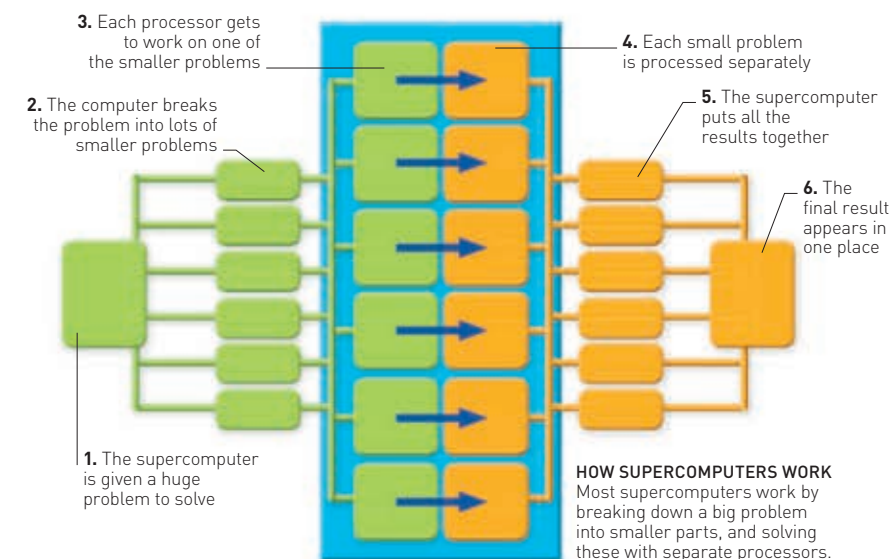
## NETWORKS

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



## 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.



Vacuum tube

**1906**  
The vacuum tube, an essential part of modern computers, is invented.

**1943**  
British engineer Thomas Flowers builds Colossus: the first electronic, digital computer.

**1946**  
ENIAC is created – the world's first general-purpose electronic computer. It weighs 100 tonnes and contains 18,000 electronic switches.

**1962**  
Computer company IBM sets up SABRE, a system that connects up 1,500 computer terminals.



Microchip

**1971**  
Intel 404, the first single-chip microprocessor, is invented.



USB

**1995**  
A USB is used for the first time to connect other devices to a computer.

**1822**  
Charles Babbage's engine has an input, a memory, and a number-cruncher (processor).



Babbage Engine

**1886**  
Herman Hollerith builds the first punched-card tabulating and sorting machine.



Herman Hollerith

**1941**  
German Konrad Zuse designs the Z3, the world's first working, programmable, fully automatic digital computer.

**1947**  
The transistor is invented. It would allow electronic devices to become much smaller.



Transistor

**1976**  
The world's first supercomputer, CRAY-1, is built.

**1981**  
IBM launches a PC that uses MS-DOS as an operating system.

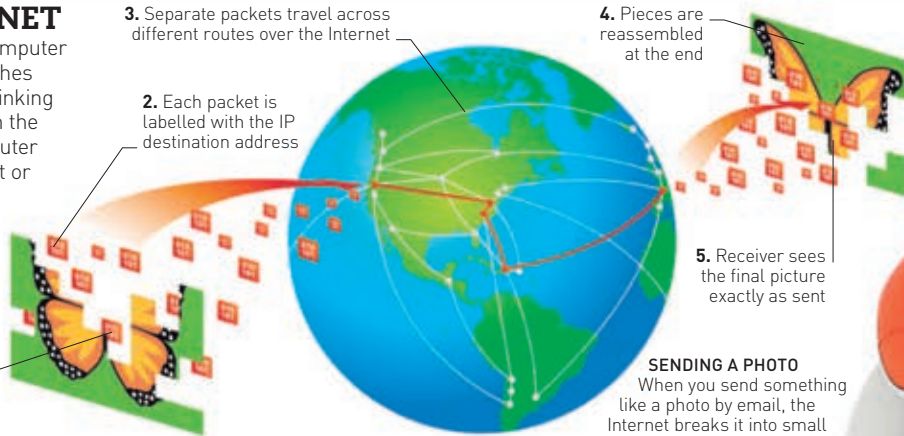
**1991**  
The World Wide Web is made publicly available.

**2014**  
The first 8-terabyte hard drive is released.

2015

## 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 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 then reassembles it.

## WHAT 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 NETWORKING**  
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 games console – 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 for ever. Others, such as the spear, have been replaced by newer, more effective models.

▶ 1,760,000 BCE



FLINT HAND AXE

## HAND AXE

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 axe, 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 ◀ 1862



ROTARY PHONE

## TELEPHONE

Early in the 19th century people found they could send signals through wires, but it was not until the invention 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.

## 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

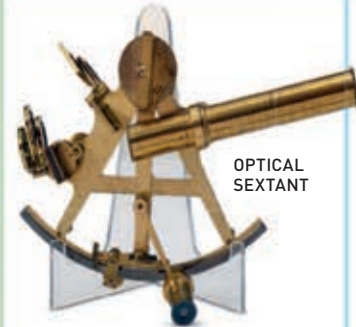
## REFRIGERATOR

Until 1834 people kept food cool in insulated boxes filled with ice, which was delivered to their door. Then Jacob Perkins of Philadelphia, USA, 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.

◀ 1712



▶ 1878 ▶ 1886



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 USA, who created a light bulb that could last for more than 1,200 hours. Light bulbs have since been redesigned to use less energy.

## CAR

Karl Benz of Germany built the first stationary petrol 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

## AEROPLANE

Orville Wright from the USA first took to the skies with an aeroplane powered by a small petrol engine in North Carolina in 1903. He flew for 12 seconds over a distance of 37 m (120 ft). 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 WRIGHTS' 1903 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 Philip 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 PLOUGH

### PLOUGH

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

▶ 3500 BCE

### WHEEL

The first wheels were solid wooden discs with a hole through the centre. People needed sharp metal tools to chisel the round shape, which explains why this major invention took a while to arrive. The wheels were connected by a rod called an axle.



WOODEN WHEEL

▶ 900 CE



GUNPOWDER BURNING

### GUNPOWDER

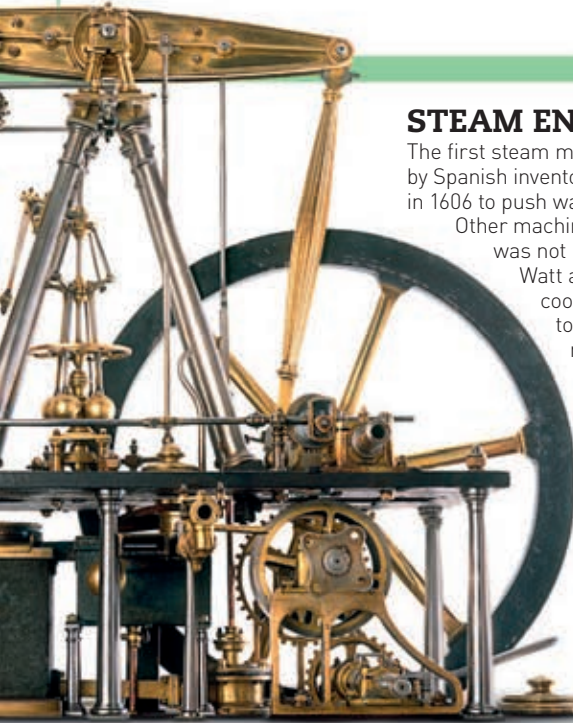
Chinese alchemists (early chemists) had been experimenting with chemicals for centuries when a group discovered that a mix of saltpetre, sulphur, and charcoal exploded into flame. The mix was used in fireworks to scare away evil spirits and later in weapons. The recipe was kept from the rest of the world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

◀ 1590

### 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, 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 transport.



REPLICA OF JAMES WATT'S STEAM ENGINE

### 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 the Englishman 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

Alexander Fleming's discovery that a mould 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 computers in the decades to come.



COMMODORE (PERSONAL) COMPUTER FROM 1977

▶ 1957

### SPACE SATELLITE

The Soviet Union put the first satellite into space on 4 October 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 USA, 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 ten years, but it marked the start of mobile personal communication systems.

▶ 1989

### WORLD WIDE WEB

In the 1970s Vinton Cerf developed a system that allowed mini-networks of computers all over the world to send files to each other. Then in 1991 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.

**2.4 BILLION OF THE  
7 BILLION PEOPLE  
ON EARTH USE  
THE INTERNET**

▶ 2010

### 3-D BODY PARTS

Invented in the USA, 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.



# 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.

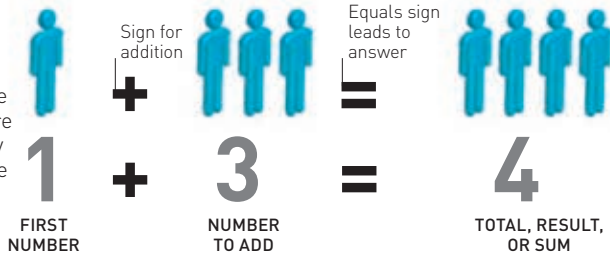
## NUMBER SYMBOLS

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	∩	∩∩	∩∩∩	∩∩∩∩	∩∩∩∩∩	∩∩∩∩∩∩	∩∩∩∩∩∩∩	∩∩∩∩∩∩∩∩	∩∩∩∩∩∩∩∩∩	∩∩∩∩∩∩∩∩∩∩

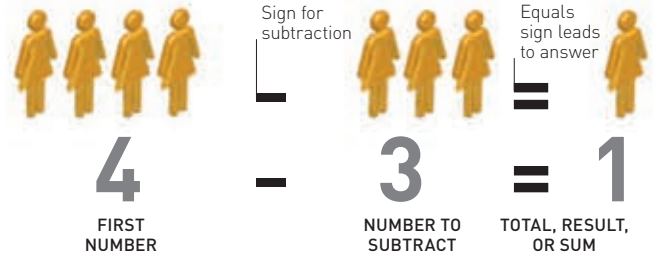
## ADDITION

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

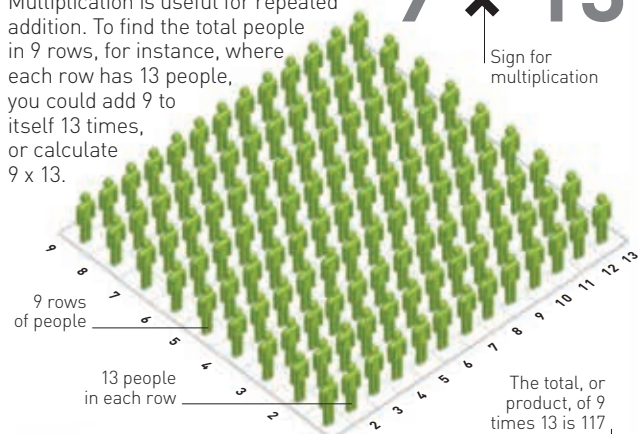
Subtraction is a mathematical way of working out how many are left if you take some of an original quantity away. It uses the "-" sign.



## 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  $9 \times 13$ .

$$9 \times 13$$



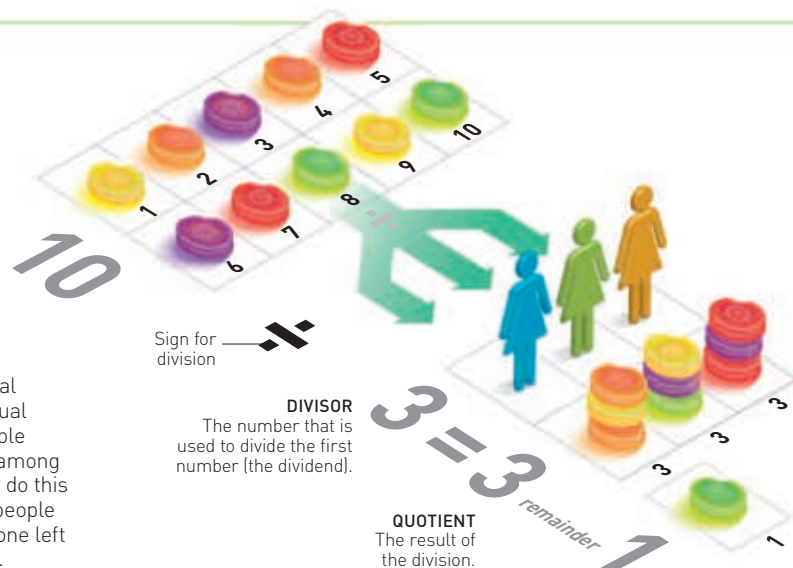
$$9 \times 13 = 13 + 13 + 13 + 13 + 13 + 13 + 13 + 13 + 13 = 117$$

$$10 \div 3$$

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

## DIVISION

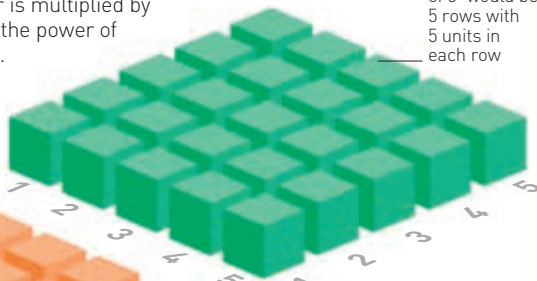
Division is used to divide up a total number of things into several equal bundles, or amounts. This example shows how to divide ten sweets among three people. It is not possible to do this evenly, so after giving the three people three sweets each, there is still one left over (known as the "remainder").



## POWERS

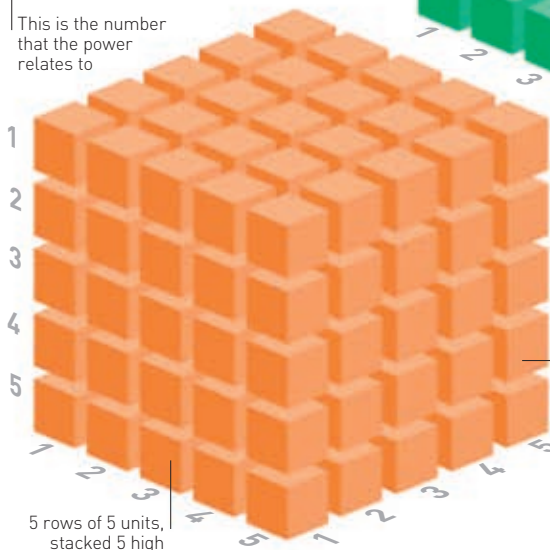
A "power" is the number of times a number is multiplied by itself. So "5 x 5 x 5 x 5" is said to be "five to the power of four" which is written mathematically as  $5^4$ .

**5<sup>3</sup>** This is the power, which shows how many times to multiply the number ( $5^3$  means  $5 \times 5 \times 5$ )  
 This is the number that the power relates to



$$5 \times 5 = 5^2 = 25$$

$5^2$  is called "5 squared"



$$5 \times 5 \times 5 = 5^3 = 125$$

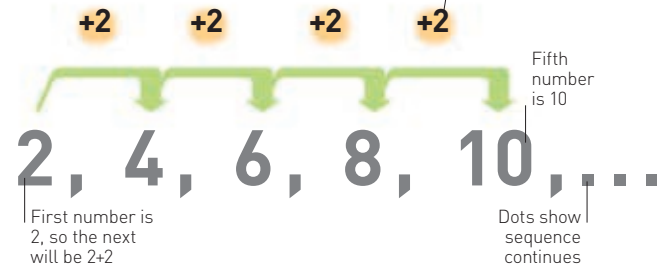
$5^3$  is called "5 cubed"

## 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.

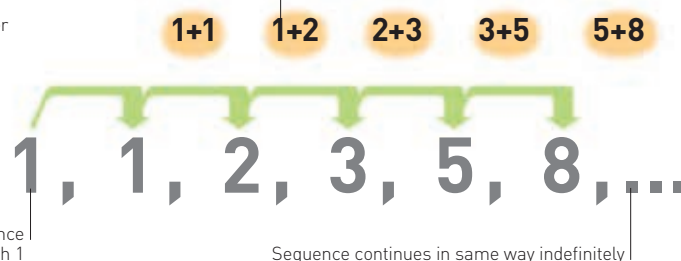
Each number in this sequence is 2 higher than the number before it

**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.

Each number in this sequence is the sum of the two numbers before it





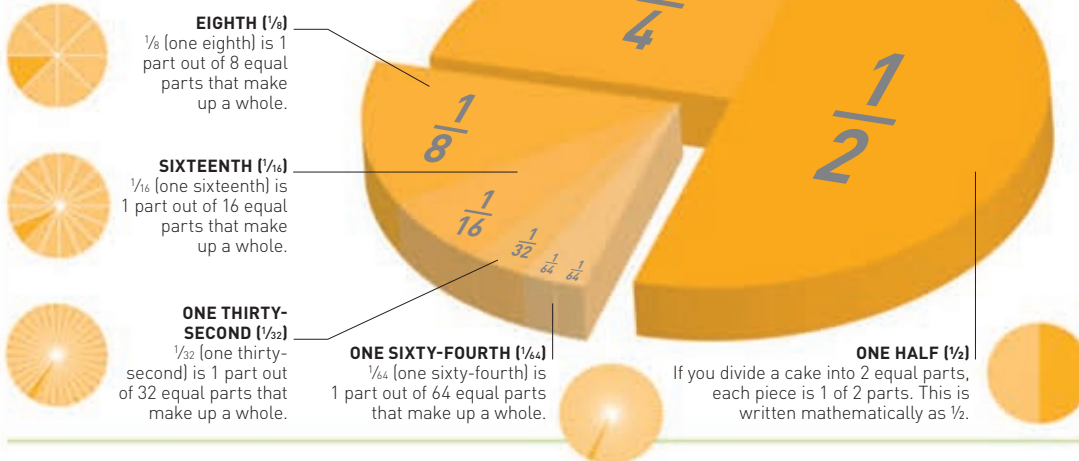
## POSITIVE AND NEGATIVE NUMBERS

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.



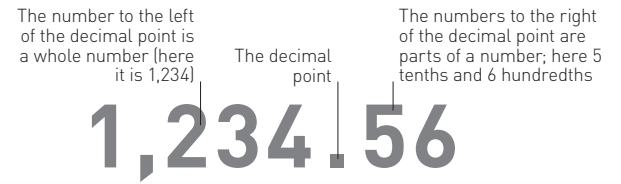
## FRACTIONS

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: "1/2".



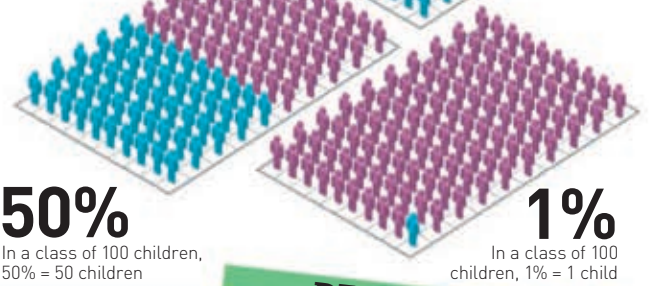
## DECIMALS

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



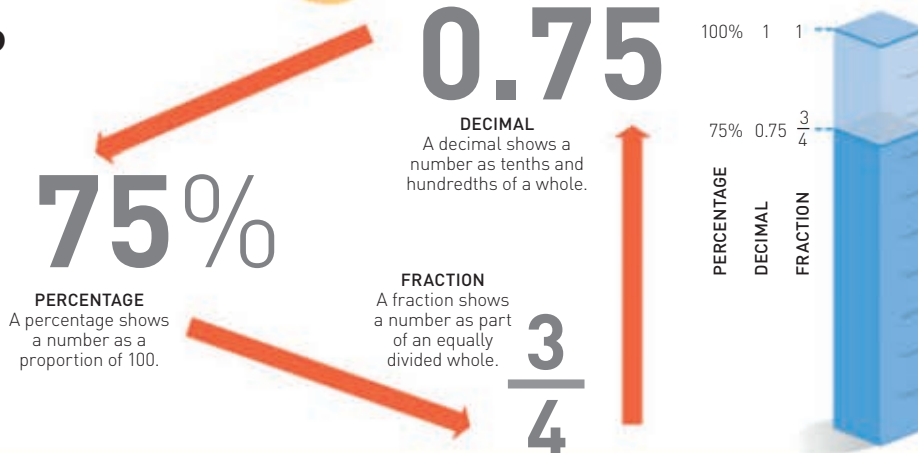
## PERCENTAGES

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 per cent, 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

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 metre). We can "translate" fractions, decimals, or percentages into each other. For instance, 3/4 is the same as 75% or 0.75.



**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	1/10	10%	0.625	5/8	62.5%
0.125	1/8	12.5%	0.666	2/3	66.7%
0.25	1/4	25%	0.7	7/10	70%
0.333	1/3	33.3%	0.75	3/4	75%
0.4	2/5	40%	0.8	4/5	80%
0.5	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.

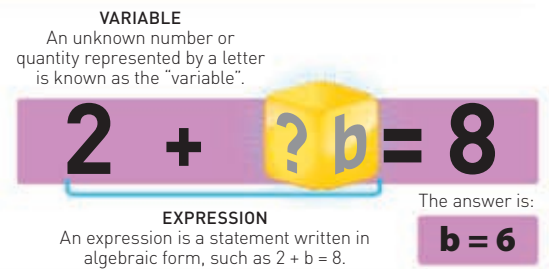
**42**  
COMPOSITE NUMBER

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

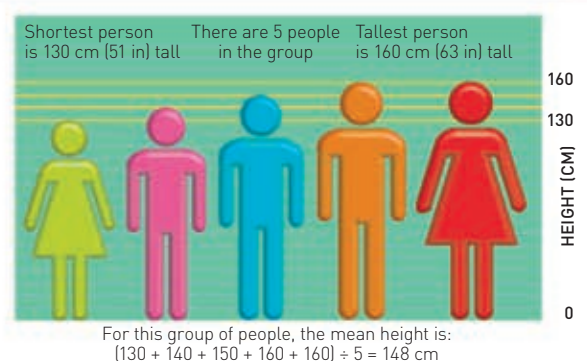
## ALGEBRA

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.



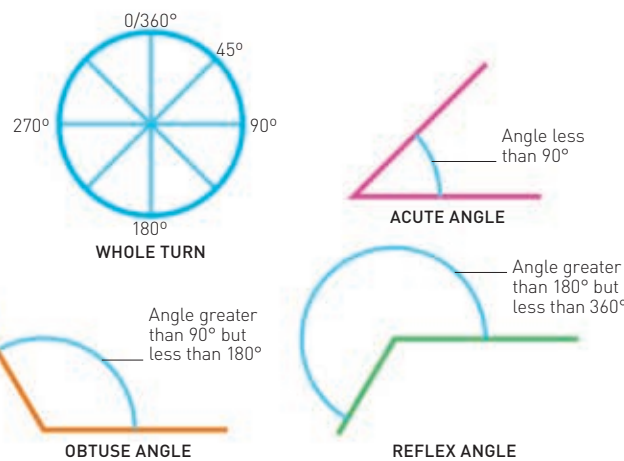


# Geometry

Geometry is the part of maths 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.

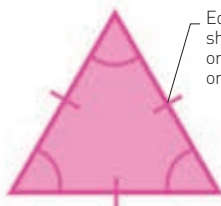
## COMMON ANGLES

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

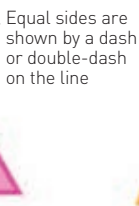


## TRIANGLES

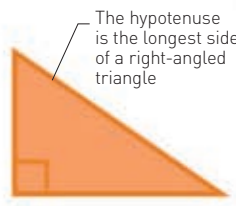
Shapes made of straight lines are called polygons. Triangles are the simplest polygons, because they are made from three straight lines joined at three corners. All three angles inside a triangle always add up to  $180^\circ$ . There are several different types of triangles.



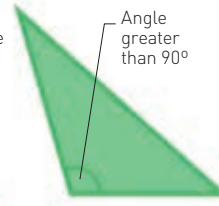
**EQUILATERAL TRIANGLE**  
This triangle has three equal sides and three equal angles (each  $60^\circ$ ).



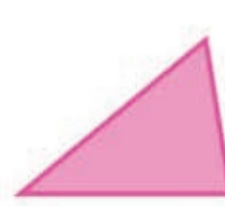
**ISOSCELES TRIANGLE**  
This triangle has two equal sides. The angles opposite these sides are equal.



**RIGHT-ANGLED TRIANGLE**  
This triangle has one angle that is  $90^\circ$  (a right angle). It also has a hypotenuse.



**OBTUSE TRIANGLE**  
This triangle has one angle that is greater than  $90^\circ$  (more than a right angle).



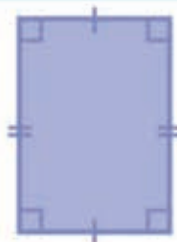
**SCALENE TRIANGLE**  
This triangle has sides of different lengths and three different-sized angles.

## 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  $360^\circ$ . There are several different types of quadrilaterals.



**SQUARE**  
This quadrilateral has four equal sides and four equal angles (right angles). The opposite sides of a square are parallel.



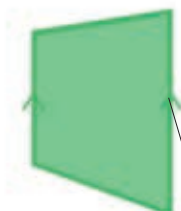
**RECTANGLE**  
This is like a long version of the square: it has four right angles and two pairs of sides, but one pair is longer than the other. Opposite sides are parallel.



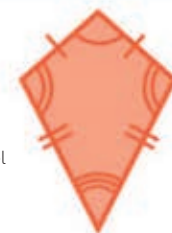
**RHOMBUS**  
This quadrilateral has four sides of equal length, and two pairs of opposite angles that are also equal.



**PARALLELOGRAM**  
This has two pairs of equal-length sides and two pairs of equal angles. The opposite sides are parallel.



**TRAPEZIUM**  
A trapezium (or trapezoid) has one pair of opposite sides that are parallel but not equal in length.



**KITE**  
A kite has two pairs of adjacent sides (sides that are next to each other) that are equal in length, and one pair of equal angles.

## 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.



**TRIANGLE**  
3 sides and angles



**SQUARE**  
4 sides and angles



**PENTAGON**  
5 sides and angles



**HEXAGON**  
6 sides and angles



**HEPTAGON**  
7 sides and angles



**OCTAGON**  
8 sides and angles



**NONAGON**  
9 sides and angles



**DECAGON**  
10 sides and angles



**HENDECAGON**  
11 sides and angles



**DODECAGON**  
12 sides and angles



**PENTADECAGON**  
15 sides and angles



**ICOSAGON**  
20 sides and angles

## CIRCLES

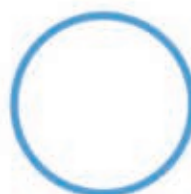
A circle is a closed curved line surrounding a central point, where every point along the curved line is the same distance from the centre point. In maths, the parts of a circle all have their own names.



**RADIUS**  
A straight line that runs from the centre point of a circle to any point on its edge.



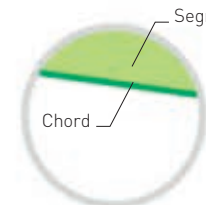
**DIAMETER**  
A straight line that runs from one side of a circle to the other, through the centre point.



**CIRCUMFERENCE**  
The circumference is the total length of the outside edge of a circle.



**ARC AND SECTOR**  
A sector is a space enclosed by two radii (the plural of radius). An arc is a section of the circumference.



**CHORD AND SEGMENT**  
A chord is a straight line linking two points on a circle's circumference. A segment is the area between a chord and the arc of the circle.



**AREA**  
The total amount of space inside a circle's circumference.



## PI

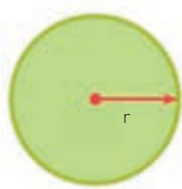
If you divide the circumference of a circle by its diameter, the answer is always 3 and a bit, or pi ( $\pi$ ). It is impossible to write pi precisely, because the numbers after the decimal point continue forever.

# $\pi = 3.141592653$

PI SYMBOL

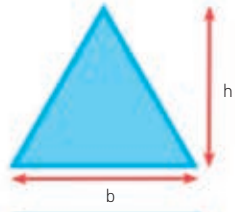
## FINDING AREA

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.



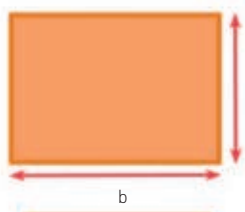
$$\text{area} = \pi r^2$$

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



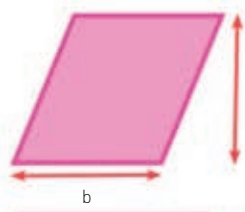
$$\text{area} = \frac{1}{2}bh$$

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



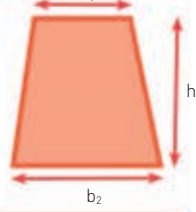
$$\text{area} = bh$$

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



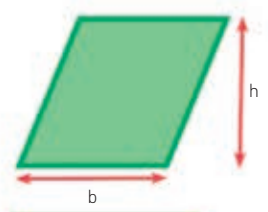
$$\text{area} = bh$$

**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.

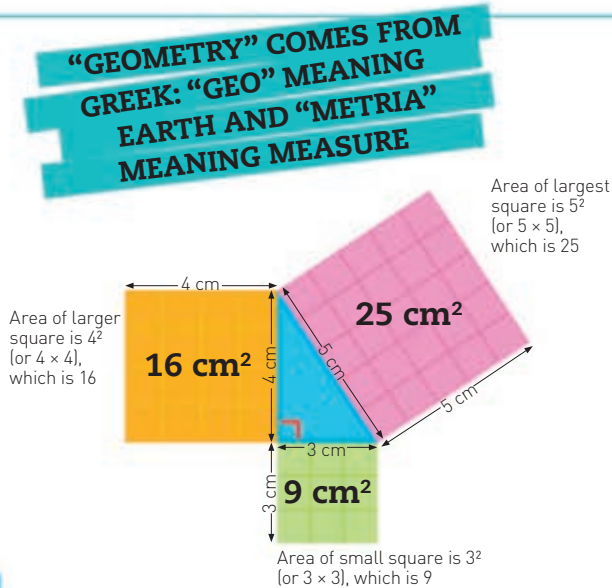


$$\text{area} = bh$$

**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).

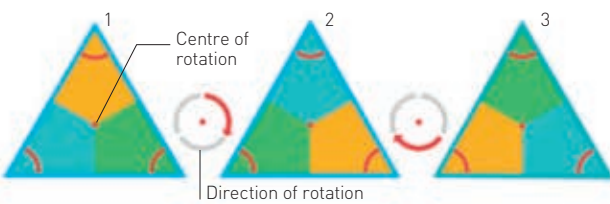
$$a^2 + b^2 = c^2$$

## ROTATIONAL SYMMETRY

If a shape can be moved around a centre 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 centre, a square fits its original outline in four different ways – its rotational symmetry is order 4.

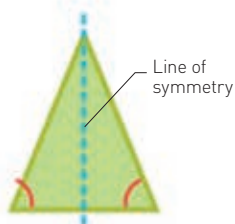


## REFLECTIVE SYMMETRY

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.



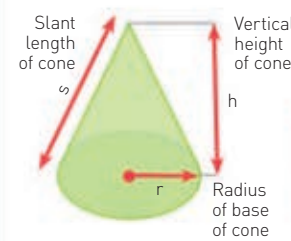
### EQUILATERAL TRIANGLE

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



## FINDING VOLUME AND SURFACE AREA

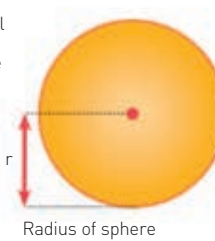
Volume is the amount of space enclosed within a three-dimensional (3-D) object. Surface area is the total area around the outside of a 3-D object.



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

### CONE

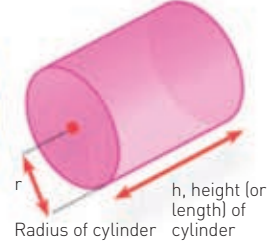
Find the surface area of a cone using the radius of its base, its height, and its slant length. Find the volume using the height and radius.



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

### SPHERE

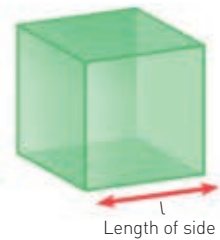
You can find the surface area and volume of a sphere using only its radius, because the other part of the equation, pi, is a constant number (3.14).



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

### CYLINDER

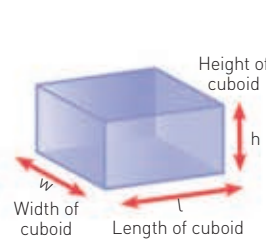
The surface area and volume of a cylinder can be found from its radius and height (or length).



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

### CUBE

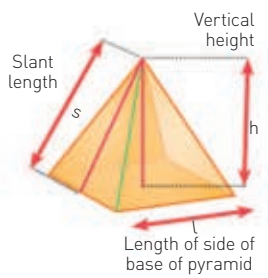
The surface area and volume of a cube can be found by using only the length of its sides. No other information is needed.



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

### 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 more than 130 years ago. Originally known as “horseless carriages”, these early models were slow, open-topped vehicles, but today’s cars are fast, stylish, and can be powered by petrol, diesel, or electricity.

## HOW A CAR WORKS

The power that turns a 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 petrol or diesel, compressed, and ignited with a spark.

### 1. INSIDE THE ENGINE

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

### 2. IN GEAR

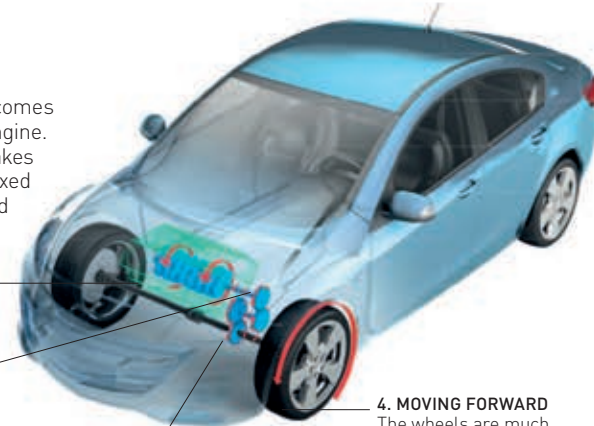
The pistons move very fast, but a car needs more force and less speed to start moving. Gears control the force and speed the car receives.

### 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. By 2014 yearly car sales had reached 71 million. Some models have sold in huge numbers, as shown below.

### 1 TOYOTA COROLLA

The world’s bestselling car, over 40 million of this Japanese model have been sold since 1966.

### 2 FORD F-SERIES

Ford have sold more than 35 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 – 27.5 million have been sold.

### 4 VOLKSWAGEN BEETLE

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



VOLKSWAGEN  
BEETLE 1948

### 5 FORD ESCORT

These family cars were produced from 1968. Sales eventually topped 20 million.

### 6 HONDA CIVIC

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

### 7 HONDA ACCORD

The first Japanese car produced in the USA, Honda has sold 17.5 million Accords since 1976.

### 8 FORD MODEL T

The original affordable car, Ford sold 16.5 million of these between 1908 and 1927.

### 9 VOLKSWAGEN PASSAT

Seven generations of Passat have seen total sales of above 15.5 million since 1973.

### 10 CHEVROLET IMPALA

Chevrolet have sold 14 million of these since the car was introduced in 1958.

CHEVROLET  
IMPALA 1960



**THE FERRARI LAFERRARI  
CAN REACH 100 KM/H  
(62 MPH) IN UNDER  
THREE SECONDS**



FERRARI  
LAFERRARI  
2013



MASERATI  
GRANTURISMO  
MC STRADALE  
2011

## 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. They are the cars that make onlookers say “Wow!”.



Benz  
Motorwagen

**1886**  
Benz Motorwagen is the first petrol-fuelled automobile.

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

**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 241 km/h (150 mph).

## 1886

### CARS THROUGH TIME

The first petrol-fuelled cars reached a top speed of 19 km/h (12 mph). Since then, technology has given us affordable, faster, and safer cars with speeds of up to 435 km/h (270 mph).

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



Mercedes Simplex 60HP

**1903**  
Mercedes Simplex 60HP can reach 120 km/h (75 mph).

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



Argyll Landulette

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



Citroën Traction Avant

**1948**  
Jaguar XK120 reaches 200 km/h (124.6 mph).



## 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 position.



WILLYS MB JEEP  
1941



LAND ROVER SERIES 1  
1949



MERCEDES-BENZ G300D  
1993



RANGE ROVER  
2002



HUMMER H3  
2008

## THE FUTURE IS GREEN

Hybrid cars have two kinds of energy sources: a petrol or diesel engine and an electric motor. When the car is using the petrol or diesel engine, it also charges up the electric motor, which can then be used to drive. These cars use less energy and cause less pollution than other cars.



FORD ESCAPE HYBRID  
2009

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



TESLA ROADSTER  
2007

This car is purely electric.



BMW i8  
2014

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



MCLAREN F1 GT  
1997



BUGATTI VEYRON  
2005



KOENIGSEGG  
AGERA RS  
2015



LAMBORGHINI  
HURACÁN  
2014



PORSCHE 918  
SPYDER  
2015

## RACING DEMONS

Racing 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 ten races in Germany's Touring Car Masters (DTM).



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



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



RALLYING: 2000 SUBARU IMPREZA  
Winner of the Safari Rally; driven by Richard Burns.

## 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 motoring, 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, USA, reaching 1,228 km/h (763 mph).



THRUST SSC

### SMALLEST ROADWORTHY CAR

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

### MOST EXPENSIVE CAR

In 2013 Lamborghini unveiled the world's most expensive car: the Veneno Roadster. It costs £3.3 million (US\$4.95 million) and has a top speed of 356 km/h (221 mph). Lamborghini said that only nine cars would ever be produced.

### FASTEST PRODUCTION CAR

The fastest series production car is the Hennessey Venom GT. It reached a speed of 435.31 km/h (270.49 mph) in 2014, and is powered by a 7.0-litre, twin-turbo V8 engine.

Mercedes-Benz  
300 SL "Gull Wing"



1959  
The space-saving, compact Mini changes thinking about 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

2014  
Hennessey Venom does 435 km/h (270.49 mph).

1958  
Aston Martin DB4 achieves 227 km/h (141 mph).



Aston Martin DB4

1966  
Lamborghini Miura reaches 275 km/h (171 mph).



Lamborghini Miura

1973  
Catalytic converter invented.



Catalytic converter

1997  
Toyota Prius is the first mass-produced hybrid car.



Toyota Prius

2010  
Bugatti Veyron 16.4 Super Sport does 434 km/h (269.86 mph).

2015

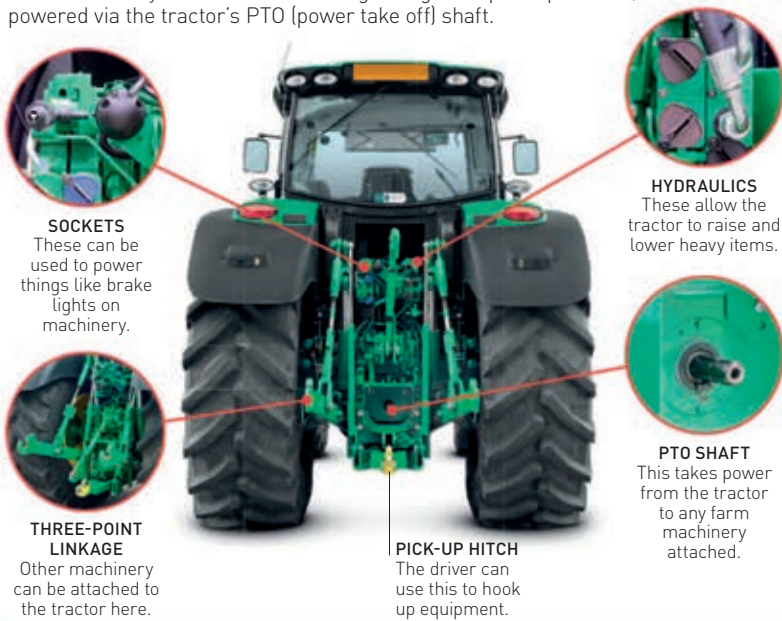


# Tractors

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 fuelled by coal, they now run on diesel.

## MODERN MACHINE ANATOMY

Modern tractors are very large and powerful. They have four huge wheels with grooved tyres 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 take off) shaft.



### SOCKETS

These can be used to power things like brake lights on machinery.

### HYDRAULICS

These allow the tractor to raise and lower heavy items.

### THREE-POINT LINKAGE

Other machinery can be attached to the tractor here.

### PICK-UP HITCH

The driver can use this to hook up equipment.

### PTO SHAFT

This takes power from the tractor to any farm machinery attached.

## 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 PLOUGHING AND CULTIVATING

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

### 2 PLANTING SEEDS

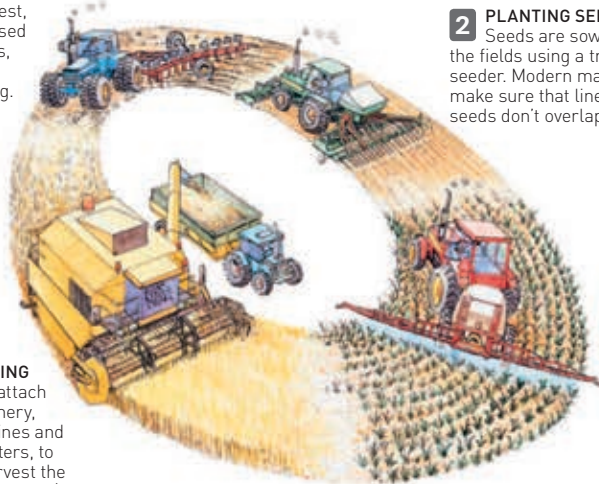
Seeds are sown on to the fields using a tractor seeder. Modern machines make sure that lines of seeds don't overlap.

### 4 HARVESTING

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

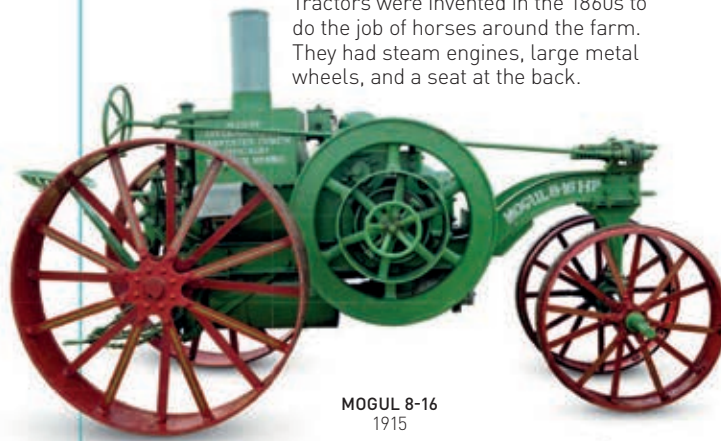
### 3 SPRAYING FERTILIZERS

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.



MOGUL 8-16  
1915



IVEL AGRICULTURAL MOTOR  
1903



MOLINE UNIVERSAL MODEL D  
1918

## FARM TRACTORS

Petrol 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.



ALLIS-CHALMERS MODEL U  
1933



JOHN DEERE B  
1935



THIEMAN  
1941



DAVID BROWN 850 1962



YTO 180  
2013



MASSEY FERGUSON  
MF941 LOADER  
2013



FELDERMAN MINI 16  
2014



SOLIS 20  
2014

## 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.



GEORGES VIDAL VINEYARD  
1925



INTERNATIONAL T20 TRAC-TRACTOR  
1933



CATERPILLAR D7  
1948



JOHN DEERE MC  
1950



BREDA 50Tcr  
1952





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 bonnet

Roll-bars over the cab area protect the driver should the tractor tip over

Thick treads, or grooves, provide grip on muddy ground



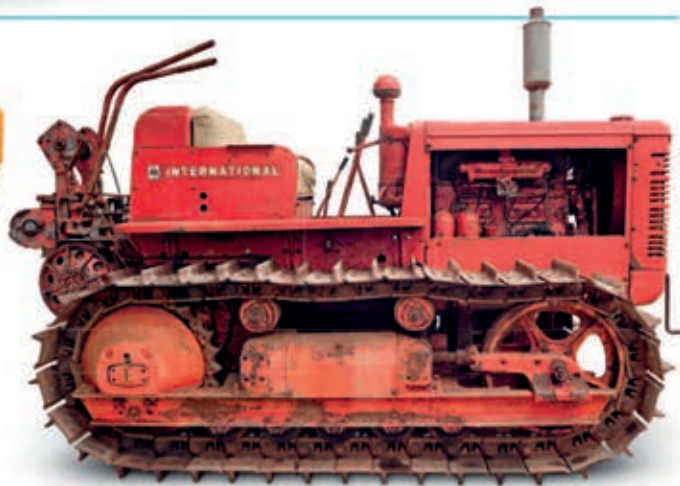
MASSEY FERGUSON 7619  
2013



CASE MODEL L ROADLESS  
1938



CATERPILLAR D2  
1942



INTERNATIONAL TD14  
1944



TRACK-MARSHALL  
1958



MINNEAPOLIS-MOLINE MOTRAC  
1960

1880

## TRACTOR HISTORY

Today's powerful tractors are the result of the gradual development of the tractor since its invention in the late 19th century.

1892 John Froelich builds first petrol engine that can move forwards and backwards.



Hornsby-Akroyd Tractor

1896 A Hornsby-Akroyd engine is used to power the first petrol tractor.

1908 Australia's tractor industry begins with the building of the first McDonald Imperial.



McDonald Imperial

1913-17 As Europe prepares for WWI, the Pavesi company realizes the demand for military tractors to replace horses for pulling heavy loads. The result is the US model known as Pavesi America.



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 WWII.

1958 Sir Edmund Hillary arrives at the South Pole on a tractor.



Doe Triple-D

1964 Doe Triple-D is the first double tractor; built by British farmer George Pryor.

1990 JCB launches the Fastrac, which has a top speed of 64 km/h (40 mph).



JCB Fastrac

2015 India becomes the world's largest tractor producer.

2015



# 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.



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

## LIGHT TRUCKS

While some light trucks may only be car-sized, they are hardwearing, 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 rubbish collection or breakdown recovery, are usually medium-sized.



STREET-SWEEPER VEHICLE



PICK-UP TRUCK WITH SMALL CRANE



DELIVERY TRUCK



REFUSE TRUCK

## HEAVY TRUCKS

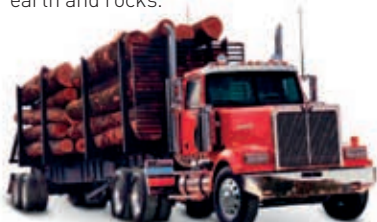
These huge vehicles have very powerful engines and strong structures to support their heavy cargoes. They are often "articulated", meaning a tractor unit pulls a trailer. The largest trucks are mining dump trucks, used to shift huge loads of earth and rocks.



MONSTER TRUCK



HAULAGE TRUCK



TIMBER TRUCK



CEMENT MIXER

Cars are loaded on to the transporter's decks



TRANSPORTER



TANKER



BIG RIG

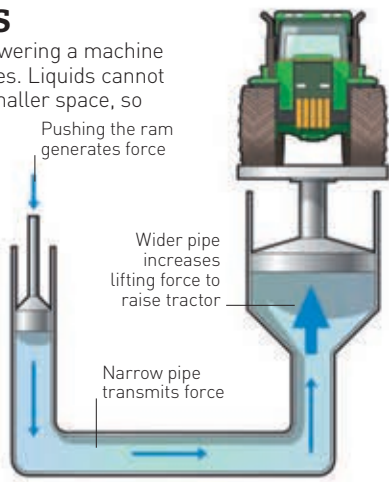


DUMP TRUCK



## 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

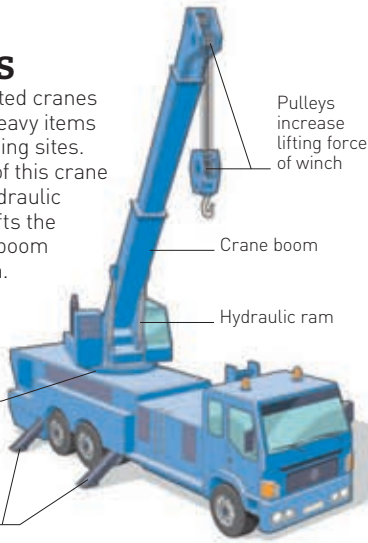
Since the lift pipe is wider than the ram pipe, the lifting force is multiplied.

## 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.

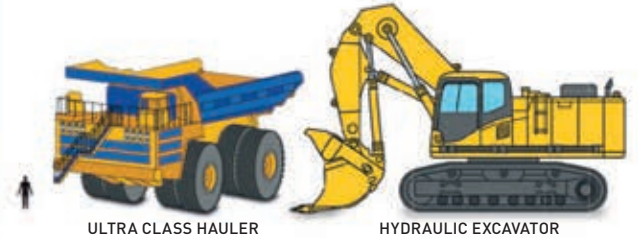
Turntable swings the boom over a large area

Hydraulic stabilizers stop the crane from tipping over



## MIGHTY MACHINES

The world's biggest dump trucks – or ultra class haulers – stand at around 8 m (26 ft) high. These mechanical monsters are used in mines and can carry a staggering 500 tonnes of debris – the weight of 38 elephants. At 10 m (33 ft) high, the largest hydraulic diggers weigh around 980 tonnes. They can shovel nearly 1,000 tonnes of material an hour.



ULTRA CLASS HAULER

HYDRAULIC EXCAVATOR



MOTOR HOME



AIRCRAFT TOW TRUCK

## EMERGENCY VEHICLES

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



AMBULANCE



POLICE VAN



SWAT TRUCK



FIRE CHIEF'S CAR



BOMB DISPOSAL TRUCK



FIRE ENGINE

## 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.



BACKHOE LOADER



FRONT LOADER



TRACKED LOADER



MINI DIGGER



WHEELED EXCAVATOR



TRACKED DIGGER

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



Cab where the driver sits

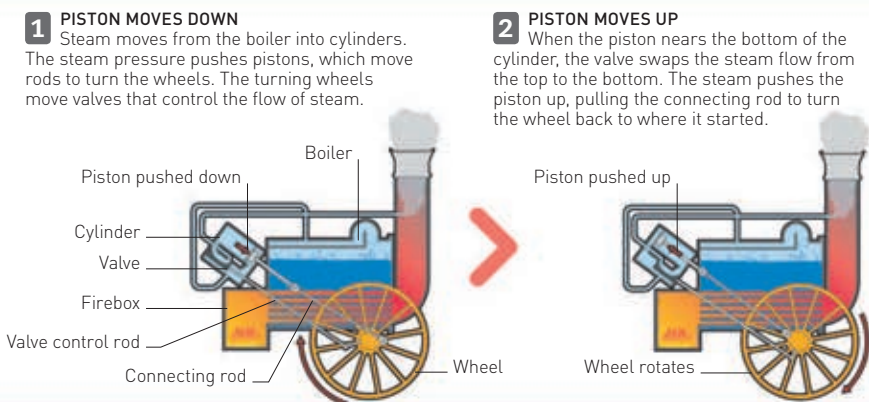


# Trains

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

## 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 backwards and forwards. The pistons are connected to the driving wheels, and push and pull them round.



## DIESEL TRAINS

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

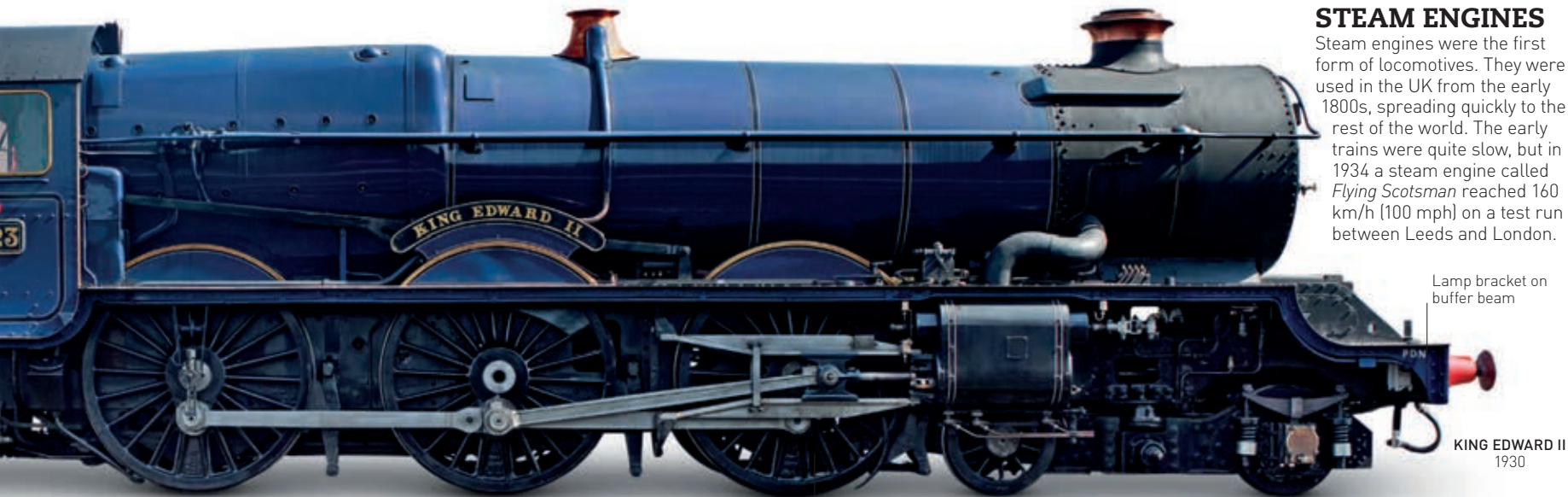


BOXLEY WHITCOMB 30-DM-31  
1941



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 quite slow, but in 1934 a steam engine called *Flying Scotsman* reached 160 km/h (100 mph) on a test run between Leeds and London.

Lamp bracket on buffer beam

KING EDWARD II  
1930

Wheels driven by pistons



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



HUNSLLET AUSTERITY  
1944



DR (CLASS 99.73-76)  
1954





**BUGATTI RAILCAR**  
1932/33

**DR (CLASS K6)**  
1934

**GHE T1**  
1934

**MA&PA GM EMD TYPE NWZ**  
1946



**BALDWIN S12 SWITCHER**  
1950



**BR CLASS 08**  
1953



**BR (CLASS 05)**  
1954



**NORFOLK AND WESTERN 41**  
1958



**DR V60 (CLASS 105)**  
1961



**CONRAIL NO.2233**  
1963



**BR D9500 (CLASS 14)**  
1964



**PRESTON DOCKS SENTINEL**  
1968



**DR V60 (CLASS 105)**  
1961



**CONRAIL NO.2233**  
1963



**BR D9500 (CLASS 14)**  
1964



**PRESTON DOCKS SENTINEL**  
1968

## 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.



**ENGLISH ELECTRIC, 0-4-0**  
1930



**READING MULTIPLE UNIT NO.800**  
1931



**DR E04**  
1933



**PRR (CLASS GG1)**  
1934



**DR (CLASS 243)**  
1982



**BR (CLASS 92)**  
1993



**GATWICK ADTRANZ C-100**  
1987



**EUROTUNNEL LE SHUTTLE**  
1994



**JAVELIN NO.395 017**  
2009

## FASTEST TRAINS

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



**MAGLEV: SHANGHAI METRO, CHINA**  
UP TO 430 KM/H (267 MPH)



**HARMONY CRH 380A: BEIJING TO SHANGHAI, CHINA**  
UP TO 380 KM/H (236 MPH)



**AGV ITALO: NAPLES TO MILAN, ITALY**  
360 KM/H (224 MPH)



**AVE S 103: BARCELONA TO MADRID, SPAIN**  
350 KM/H (217 MPH)



**TALGO 350: MADRID TO LLEIDA, SPAIN**  
350 KM/H (217 MPH)

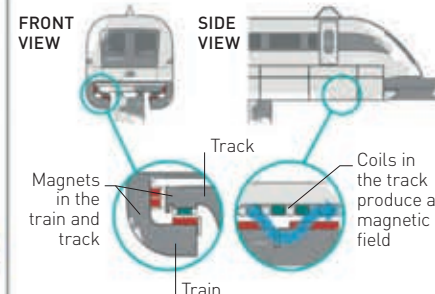
## MAGNETIC TRAINS

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**

*Stephenson's Rocket* becomes the fastest train when it reaches 46 km/h (29 mph).

**1869**

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

**1914-18**

Large armies are moved by train during World War I.

**1964**

Japan introduces a super-fast "bullet" train.



**Japanese bullet train**

## 1800

**1804**

Trevithick's Pen-y-darren locomotive is tried in South Wales.

**1812**

First successful commercial use of steam, in Yorkshire, England.

**1863**

Underground railway opens in London, UK.

**1913**

Sweden uses the first diesel-powered main line trains.

**1960s**

USA phases out steam engines.



**East German Battery shunter**  
1966

## 2000s

**2014**

Japan's Maglev trains run faster than 480 km/h (300 mph).

## 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.



**London Underground map**

**1890**

First use of electric locomotives on London's underground.

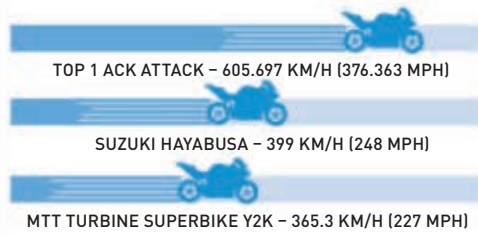


# Motorbikes

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

## FASTEST BIKES

Some specially built motorcycles can travel at more than 560 km/h (350 mph). 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.



HONDA VFR700F INTERCEPTOR 1987



YAMAHA YZF600R THUNDERCAT 1998

## 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.



STOPPIE



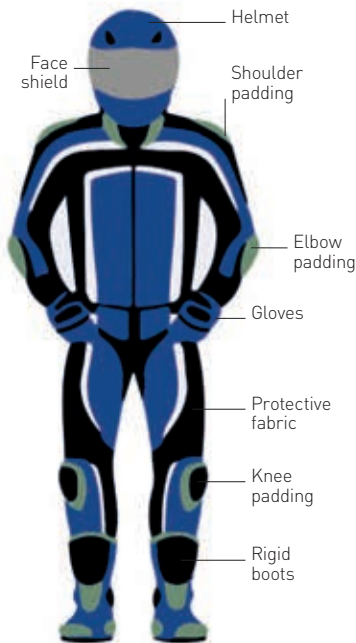
ONE-HAND STOPPIE



STAND-UP WHEELIE

## 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 well ahead. This improves safety, especially in busy towns. Standard bikes are often the first choice for new riders.



BMW R32 1923



COVENTRY EAGLE FLYING 8 1925



NORTON INTERNATIONAL 1948



TRIUMPH TROPHY TR6 1958



ROYAL ENFIELD INTERCEPTOR 1965



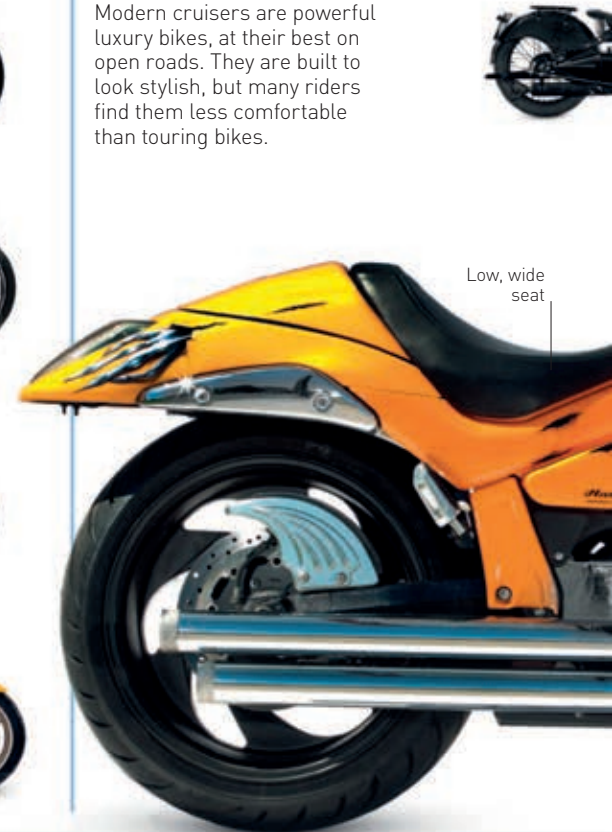
HONDA CB250 K4 1972



DUCATI M900 MONSTER 1994

## 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.



Low, wide seat

## TOURERS

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



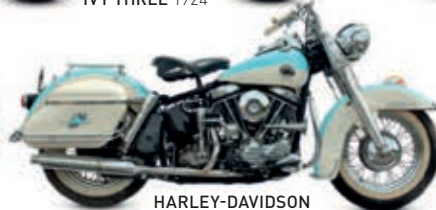
ROYAL ENFIELD CONSTELLATION AIRFLOW 1959



IVY THREE 1924



SUNBEAM S7 DE LUXE 1949



HARLEY-DAVIDSON FLH DUO-GLIDE 1960



SUZUKI T500 1975

## 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.



ZUNDAPP KS750 WEHRMACHT SIDECAR 1940



## HISTORY OF MOTORBIKES

The motorbike 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.



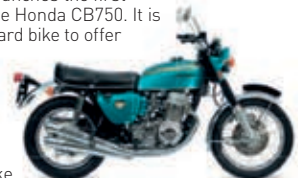
**NLG Peugeot**

1936 The first scooters are made in the USA. 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 disc brake.



**Honda CB750**



**Mighty Mouse**

1977 Raced by builder Brian Chapman, "Mighty Mouse" is the first dragster to cover 400 m (1,312 ft) 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 biggest production motorcycle engine ever built.



**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**

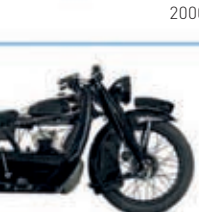


**TRIUMPH DAYTONA 675 2006**



**DUCATI 1098S 2007**

**A SPECIAL EDITION OF THE DUCATI 1098S WAS MADE IN THE COLOURS OF THE ITALIAN FLAG**



**FRANCIS-BARNETT CRUISER 1933**



**HONDA VF500C MAGNA 1983**

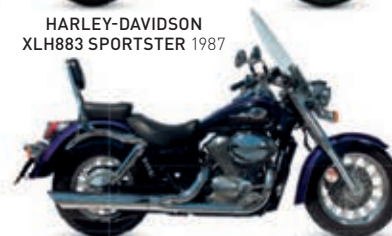


**HARLEY-DAVIDSON XLH883 SPORTSTER 1987**



**SUZUKI M1800R INTRUDER 2007**

Brake disc



**HONDA VT 750C2 SHADOW 1998**



**MOTO GUZZI CALIFORNIA EV 2001**



**TRIUMPH AMERICA 2012**

## 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 34 kg (75 lb) and fitted into a small canister.



**SCOOTER FOLDED INTO CANISTER**



**WELBIKE SCOOTER 1942**



**KIRBY BSA RACING SIDECAR 1968**



**BMW R50 COMBO 1957**



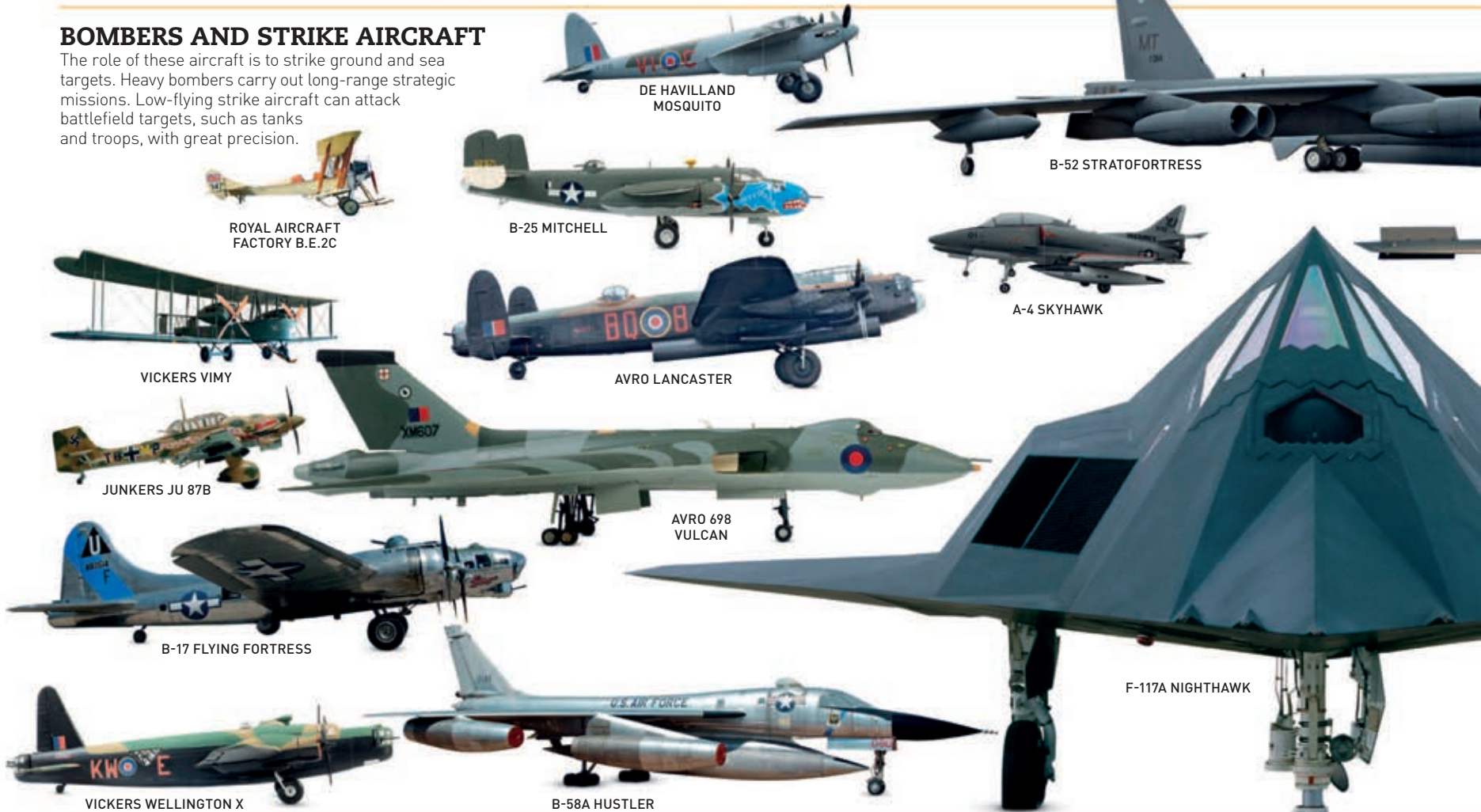
## FIGHTER PLANES

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.



## 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.

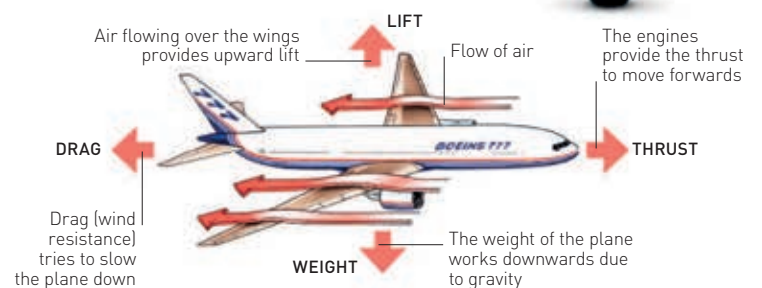


# Aircraft

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 aeroplanes 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 transport. Some business travellers use private, often luxurious jets as air taxis.



BOEING STEARMAN MODEL 75



AUSTER J/1 AUTOCRAT



GIPSY MOTH



PITTS S1-S



CESSNA F177RG CARDINAL



BOMBARDIER LEARJET 45

## 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



WESTLAND WESSEX



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.

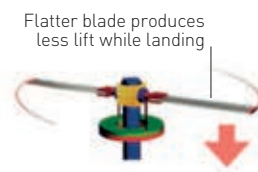
## HOW HELICOPTERS FLY

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".



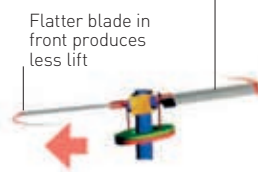
Tilted blade produces more lift for takeoff

**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 forwards, the resulting thrust propels the helicopter forwards.



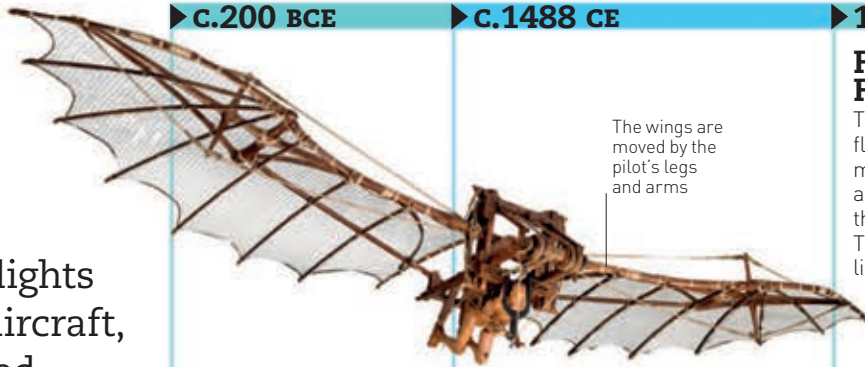
# The story of flight

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 to shape the modern world.

▶ C.200 BCE

▶ C.1488 CE

▶ 1783



The wings are moved by the pilot's legs and arms

ORNITHOPTER

## KONGMING LANTERN

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

## LEONARDO DA VINCI

An ornithopter – a wing-flapping aircraft – is designed by Leonardo da Vinci. He also sketches flying machines such as helicopters and parachutes (although he does not build them), and studies airflows and streamlined shapes.

## FIRST MANNED FLIGHT

The first recorded manned flight – lasting about 25 minutes – takes place in a hot-air balloon built by the Montgolfier brothers. The balloon is 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 becomes the first pilot to travel faster than the speed of sound in the Bell X-1. This rocket-powered aircraft does not take off from the ground but is launched from the belly of a Boeing B-29 at an altitude of 7000 m (23,000 ft).

## FIRST COMBAT JET

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

## FIRST HELICOPTER FLIGHT

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

## AMELIA EARHART

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



AMELIA EARHART

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



GLOSTER METEOR F MK8

▶ 1952

▶ 1967

▶ 1969

▶ 1976



DE HAVILLAND DH106 COMET 4C

## FIRST JETLINER

The de Havilland Comet 1, the world's first ever jetliner, enters service. There are 36 passengers on the maiden flight between London and Johannesburg, South Africa. The journey, including stops, takes 23 hours, 38 minutes, and the return fare costs £315.



X-15

## FASTEST MANNED AIRCRAFT

An experimental rocket-powered aircraft, the X-15, achieves 7273 km/h (4520 mph) – nearly seven times the speed of sound. This remains the record for a manned aircraft.

## FIRST SUPERSONIC AIRLINER

Concorde, the world's first supersonic airliner, makes its maiden flight. The jet will enter 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 will make the price of tickets very expensive.

CONCORDE

## FASTEST JET AIRCRAFT

The Lockheed SR-71 Blackbird sets the official air speed record for a manned jet aircraft with a speed of 3530 km/h (2193 mph).

SR-71 BLACKBIRD





▶ 1853

### FIRST MANNED GLIDER

English engineer Sir George Cayley is the first person to understand the forces acting upon an aircraft wing. In 1853 he transports his coachman across a small valley in what he calls a "governable parachute" – the first man-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 dies in hospital after his glider stalls and he crashes from a height of 15 m (50 ft). His scientific data on flight would inspire many others.



OTTO LILIENTHAL'S HANG-GLIDER

▶ 1900



1928 ZEPPELIN

### FIRST AIRSHIP

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

▶ 1903

### FIRST POWERED FLIGHT

The first controlled, powered aeroplane flight is achieved by American inventors the Wright brothers. It lasts just 12 seconds and covers 36.5 m (120 ft).



WRIGHT FLYER

▶ 1909

### FIRST CHANNEL CROSSING

Flying his Type XI monoplane, Frenchman Louis Blériot crosses the English Channel for the first time in a heavier-than-air aircraft. He crash-lands 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 makes the journey in a Gipsy Moth named "Jason". With only experience of flying from London to Hull in England, Amy Johnson makes her epic 18,000 km (11,000 miles) trip in a small, low-powered biplane more suited to club flying.



GIPSY MOTH

◀ 1927

### FIRST TRANSATLANTIC SOLO FLIGHT

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

◀ 1919

### FIRST TRANSATLANTIC FLIGHTS

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



CURTISS NC-4

◀ 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 – serves throughout World War I in the French Flying Corps. He is awarded the Legion of Honour.

◀ 1910

### FIRST TAKEOFF FROM A SHIP

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

**FOR PROTECTION, ELY WORE A PADDED AMERICAN FOOTBALL HELMET AND A LIFE JACKET MADE FROM PARTS OF BICYCLE TYRES**

▶ 1988

### HEAVIEST AIRCRAFT

Designed to transport the Soviet Union's 250-tonne Buran space shuttle, the six-engined Antonov An-225 takes the record for the world's biggest and heaviest aircraft. It also has the largest wingspan of any aircraft in operational service.

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



ANTONOV AN-225

▶ 1991



F-117 NIGHTHAWK

### FIRST STEALTH FIGHTER

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

▶ 2005



AIRBUS A380

### LARGEST MASS-PRODUCED AIRCRAFT

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

### SOLAR IMPULSE 2 SETS OFF

Using only energy from the Sun, Solar Impulse 2 leaves on an epic round-the-world flight. Its wingspan is larger than a Boeing 747's, though the aircraft weighs no more than a small van.

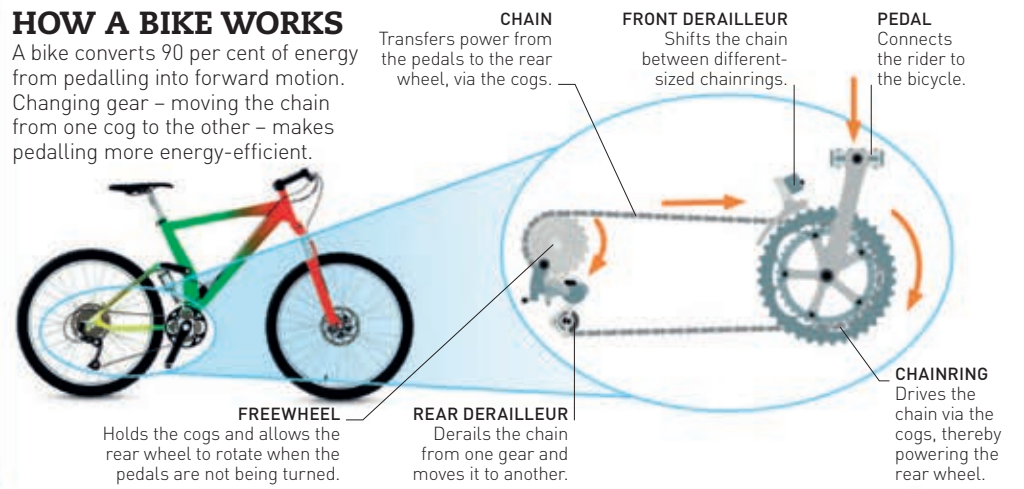


# Bicycles

Millions of people around the world use bicycles as an efficient means of transport. 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 per cent of energy from pedalling into forward motion. Changing gear – moving the chain from one cog to the other – makes pedalling more energy-efficient.



## OFF-ROADERS

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



## SPECIALIST BIKES

Like any great invention, the bicycle has been adapted over the years. Recumbent bikes 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.



Pedals assisted by an electric motor





## 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 tyres, and wheels of roughly the same size greatly improved bicycle design.

**VELOCIPEDS WERE SO BUMPY TO RIDE, THEY WERE CALLED "BONESHAKERS"**



DANDY HORSE  
1817



MICHAUX VELOCIPEDE (BONESHAKER)  
1869



PENNY FARTHING  
1871



SWIFT SAFETY BICYCLE  
1887



FACILE DWARF SAFETY BICYCLE  
1888

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 tyres. 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



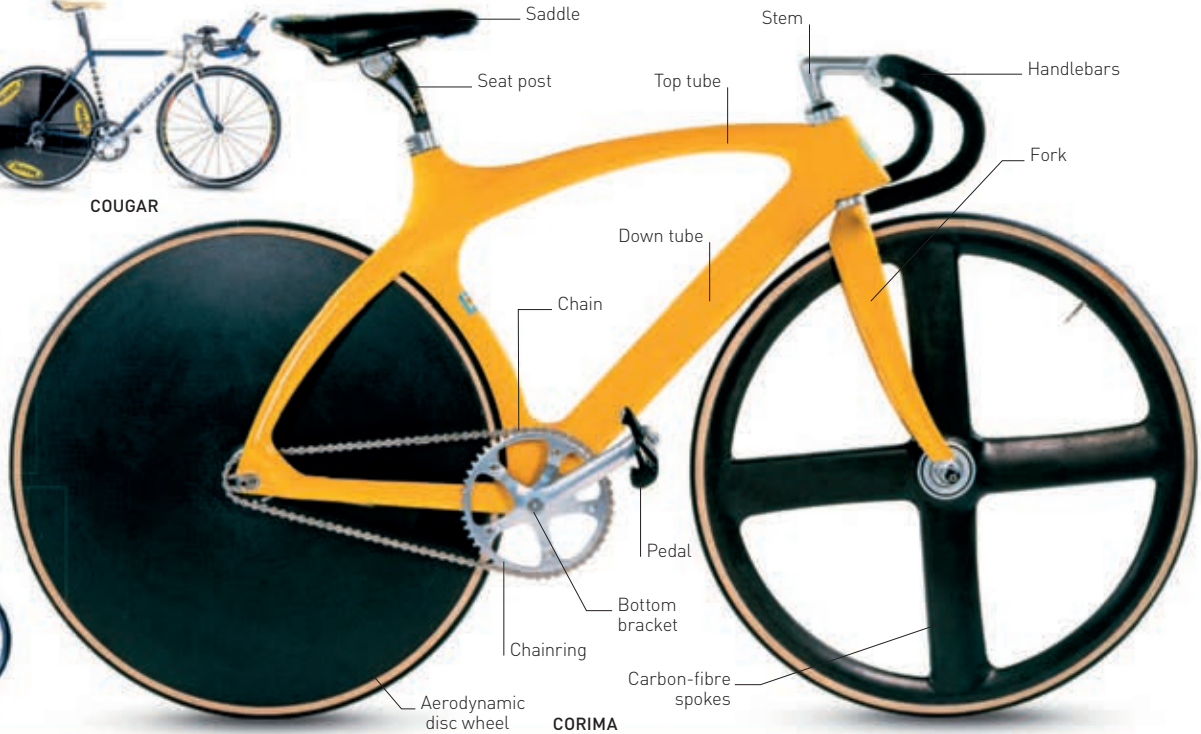
PINARELLO PRINCE



CANNONDALE ST1000



TREK 1000



CORIMA

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



UNICYCLE



SANTANA TRIPLET

### BROMPTON FOLDING BICYCLE

Made from more than 1,200 parts, this small-wheeled bike folds up into a compact, portable package. It is ideal for commuters travelling 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.





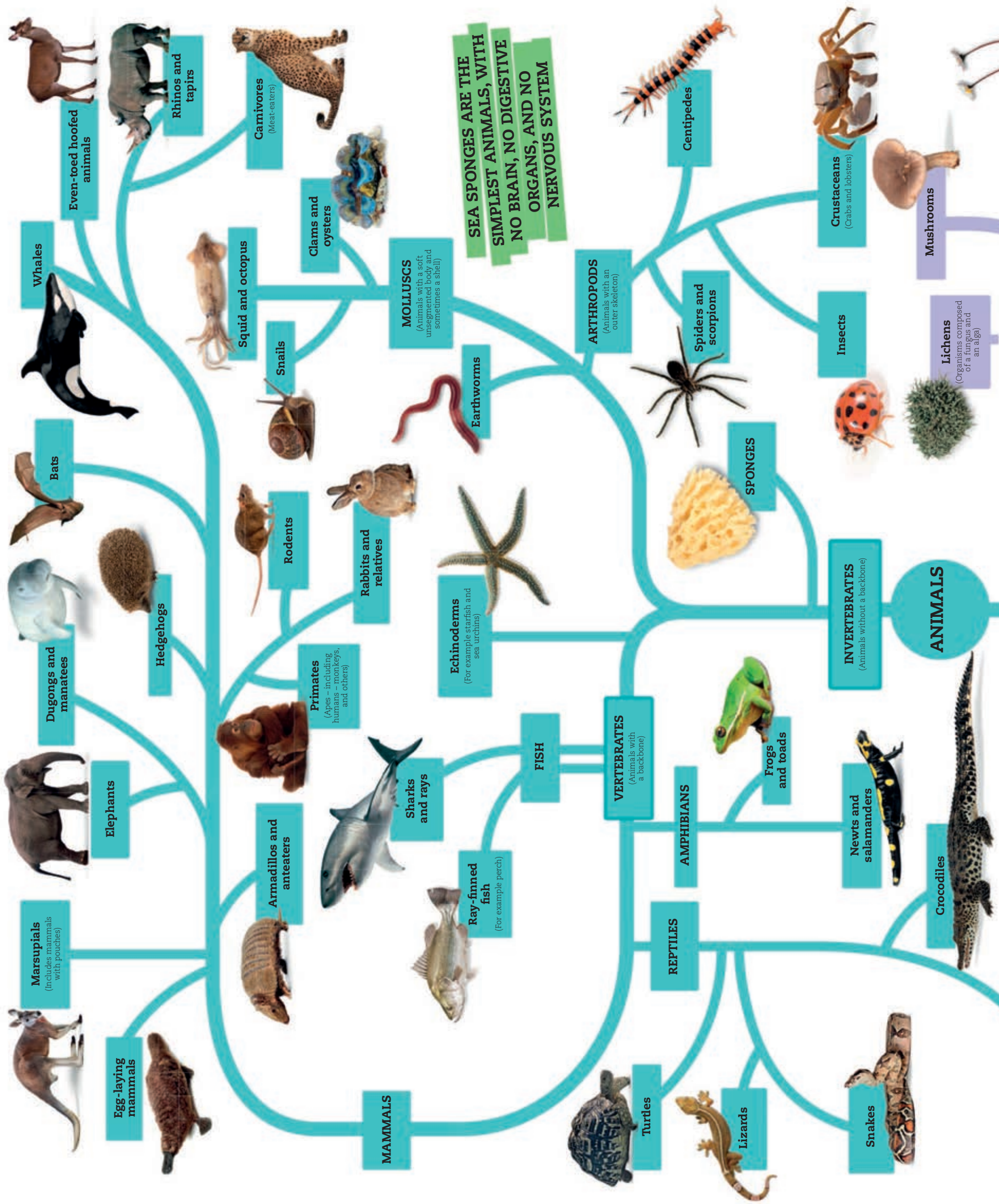




# Nature







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



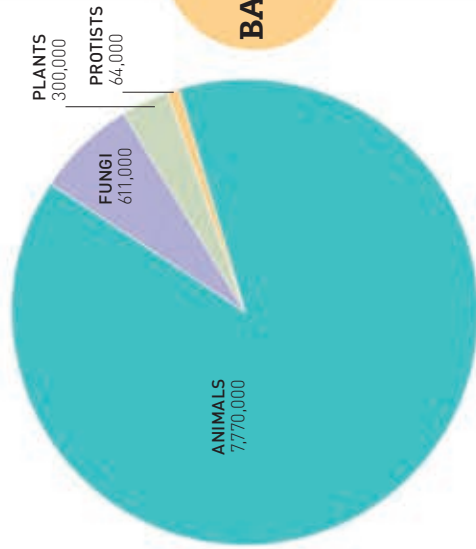
### Birds



### 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 dinosaurs, are not included.

### ESTIMATED NUMBER OF SPECIES



### 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

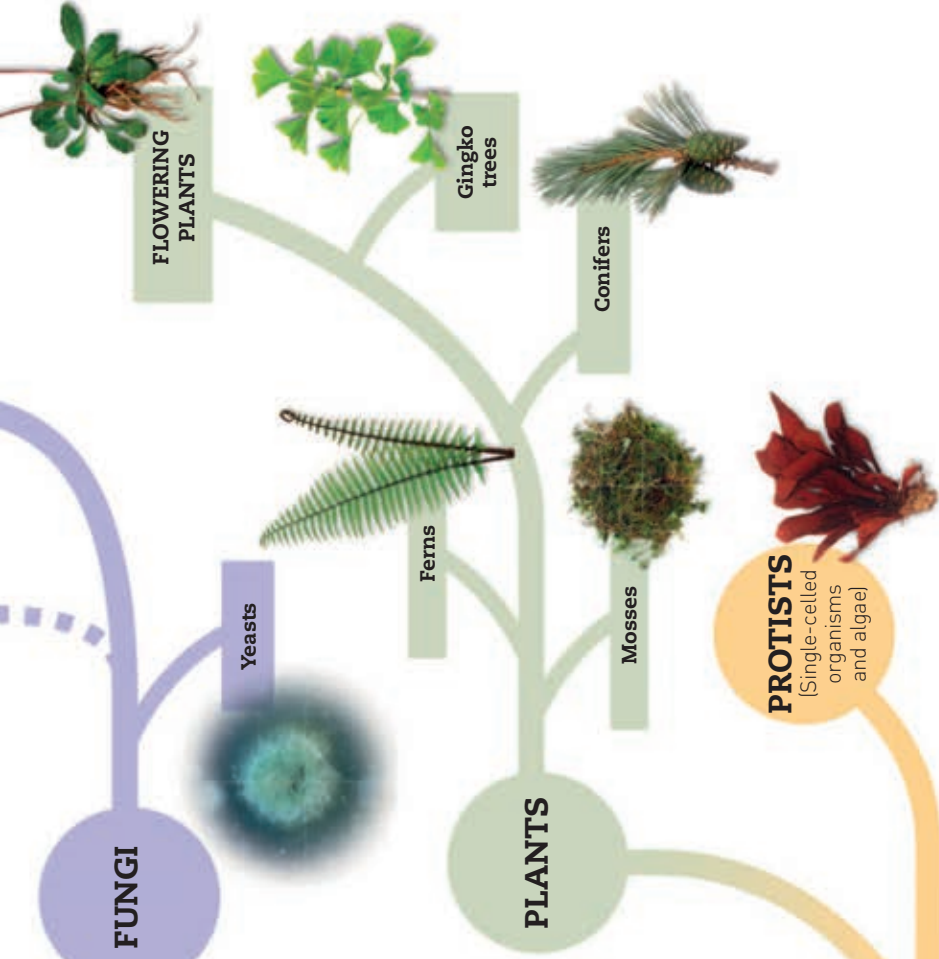
The first living things that appeared on Earth, billions of years ago, were tiny organisms made of just one cell. This "tree" shows how such simple beginnings led to the development of the wonderful variety of life we know today.

### 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.

KINGDOM	PHYLUM	CLASS	ORDER	FAMILY	GENUS	SPECIES
<b>1 ANIMALS</b> Multi-celled living things that feed on other organisms. Most are able to move around.	<b>2 CHORDATES</b> Animals with a rod-like structure in their bodies. Includes vertebrates, which have a backbone.	<b>3 MAMMALS</b> Warm-blooded vertebrates with hair whose females feed their young on milk.	<b>4 CARNIVORES</b> Mostly mammals that hunt other animals for food and have special teeth for cutting through meat.	<b>5 CATS</b> Agile, specialized hunters. Many have sheathed toes into which their claws can disappear.	<b>6 BIG CATS (PANTHERA)</b> The largest and most powerful members of the cat family, including lions, tigers, and leopards.	<b>7 TIGER (TIGRIS)</b> 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.



#### PROTISTS

Single cells with a nucleus. Some make their own food; others must feed on other organisms.



#### PLANTS

From tiny mosses to big trees, all plants use sunlight to make food and release oxygen into the air.



#### BACTERIA

Cells similar to archaea but not suited to their extreme habitats. Many are vital to life; others cause diseases.



#### FUNGI

Some are single-celled, but the best known are mushrooms. They break down organic matter.



#### 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 years ago. Fossils preserved in rock help us chart the story of life from the first single-celled bacteria to the modern humans who 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.

- PRE-CAMBRIAN**  
4.6 BYA–541 MYA
- PALAEOZOIC ERA**  
541–252 MYA
- MESOZOIC ERA**  
252–65 MYA
- CENOZOIC ERA**  
65 MYA–PRESENT DAY

BYA = Billion years ago  
MYA = Million years ago

## 4.6 BYA–541 MYA

### PRE-CAMBRIAN

This represents 80 per cent 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 molluscs, 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, flying reptiles, and dinosaurs such as the long-necked *Plateosaurus* appeared.



PLATEOSAURUS (DINOSAUR)

PTEROSAUR (REPTILE)

HEXAGONOCAULON (PLANT)

CRINOID (MARINE ANIMAL)

DICROIDIDIUM (PLANT)

AMMONITE

MORGANUCODON (MAMMAL)



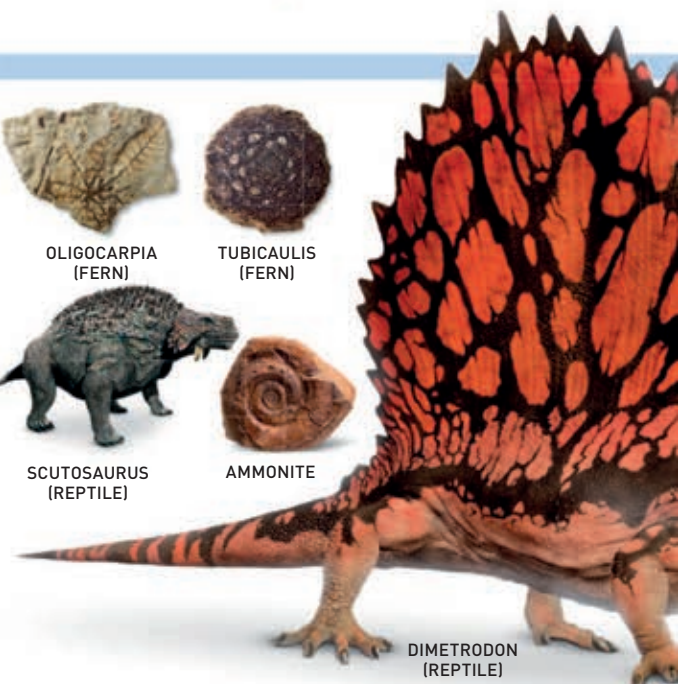
OLIGOCARPIA (FERN)

TUBICAILIS (FERN)



SCUTOSAURUS (REPTILE)

AMMONITE



DIMETRODON (REPTILE)

## 201–145 MYA

### JURASSIC

Reptiles began to dominate the land and sea, and some took to the air. Many different dinosaurs roamed Earth, from giant plant-eaters to fierce predators.



PTERODACTYL (REPTILE)

EOCAECILIA (AMPHIBIAN)

WILLIAMSONIA (PLANT)

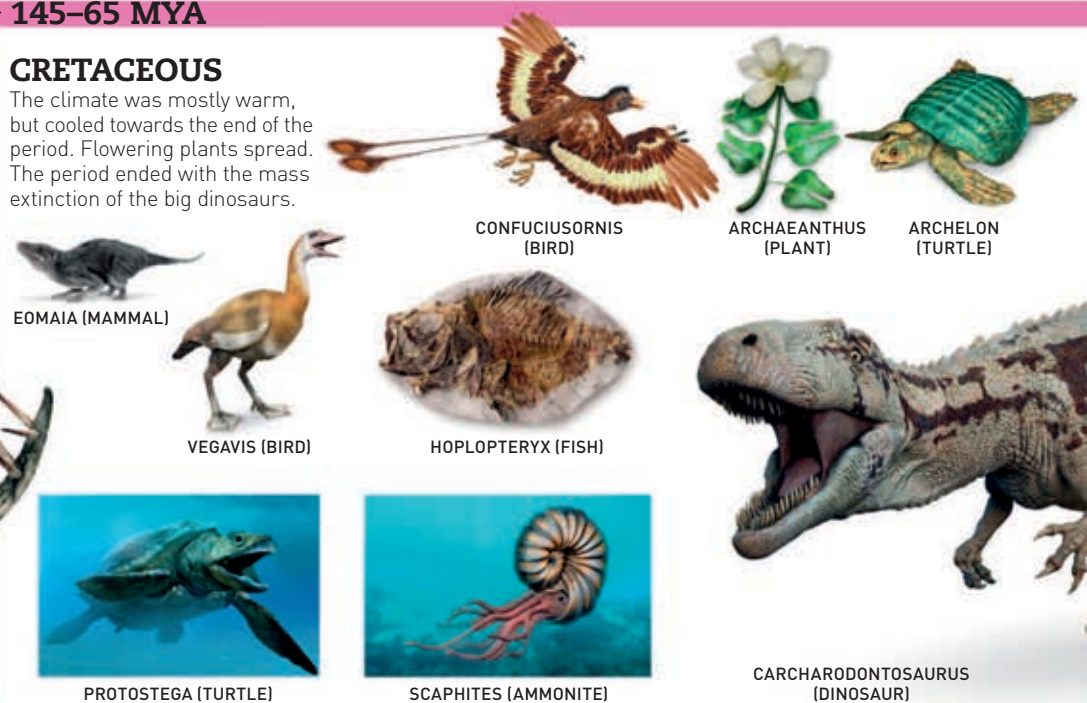
DAKOSAURUS (REPTILE)

KENTROSAURUS (DINOSAUR)

## 145–65 MYA

### CRETACEOUS

The climate was mostly warm, but cooled towards the end of the period. Flowering plants spread. The period ended with the mass extinction of the big dinosaurs.



CONFUCIUSORNIS (BIRD)

ARCHAEANTHUS (PLANT)

ARCHELON (TURTLE)

EOMAIA (MAMMAL)

VEGAVIS (BIRD)

HOPLOPTERYX (FISH)

PROTOSTEGA (TURTLE)

SCAPHITES (AMMONITE)

CARCHARODONTOSAURUS (DINOSAUR)



▶ 485–443 MYA

**ORDOVICIAN**

The first fish appeared, such as the scaly, jawless *Astraspis*. Molluscs and corals dominated the oceans. The period ended with mass extinctions.



SPONGE



TRILOBITE



BRACHIOPOD (SHELL)



FALSE MUSSEL



SEA MAT



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 scorpions may have left the oceans for land.



COOKSONIA (PLANT)



ECHINODERM



CORAL



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)

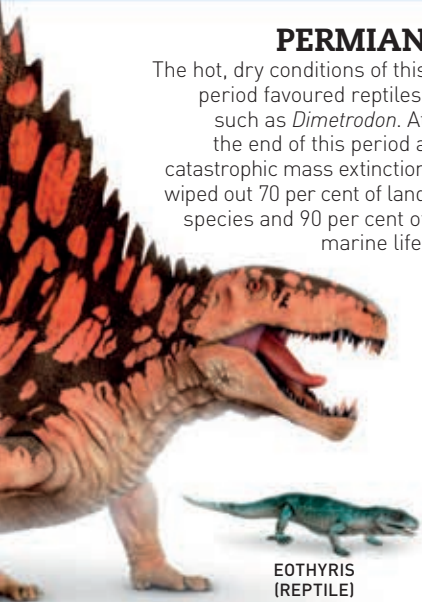


DISCALIS (PLANT)

◀ 298–252 MYA

**PERMIAN**

The hot, dry conditions of this period favoured reptiles, such as *Dimetrodon*. At the end of this period a catastrophic mass extinction wiped out 70 per cent of land species and 90 per cent of marine life.



EOTHYRIS (REPTILE)



ECHINODERM



CORAL



SPINOAEQUALIS (REPTILE)



OPHIACODON (REPTILE)



CLUB MOSS



AMPHIBAMUS (AMPHIBIAN)



ODONTOPTERIS (FERN)



COCKROACH

◀ 358–298 MYA

**CARBONIFEROUS**

As lush swamp forests grew, life on Earth flourished. Reptiles such as *Spinoaequalis* and *Ophiacodon* evolved.

▶ 65–23 MYA

**PALEOGENE**

With the dinosaurs extinct, mammals and birds evolved rapidly. Most of the main groups of mammals had their beginnings in this period.



AMMONITE



CHAMA AND XENOPHORA (MOLLUSCS)



OSMUNDA (FERN)



ICARONYCTERIS (BAT)



ROTULARIA (WORMS)



UINTATHERIUM (MAMMAL)

▶ 23–2 MYA

**NEOGENE**

The first humans, or hominins, evolved in this era. More modern 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 two 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.



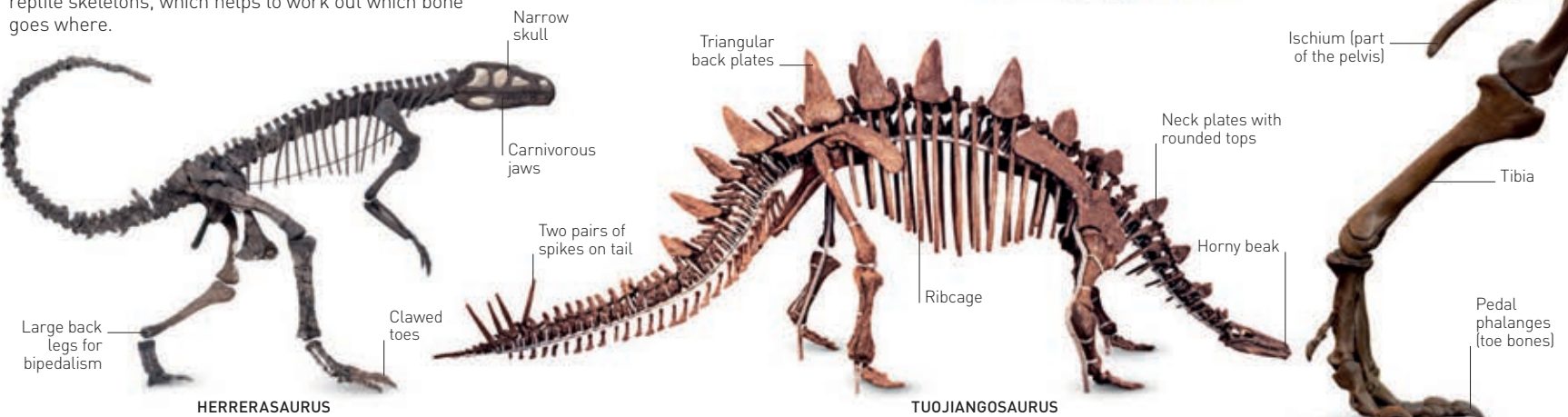
## INVERTEBRATES

Fossils of animals without backbones have been found in large numbers and from a wide range of animal types.



## PUTTING IT TOGETHER

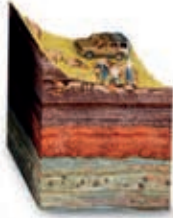
Dinosaur bones can be found scattered over a large area and scientists then work out how they are pieced together. Dinosaur skeletons are very like bird and reptile skeletons, which helps to work out which bone goes where.







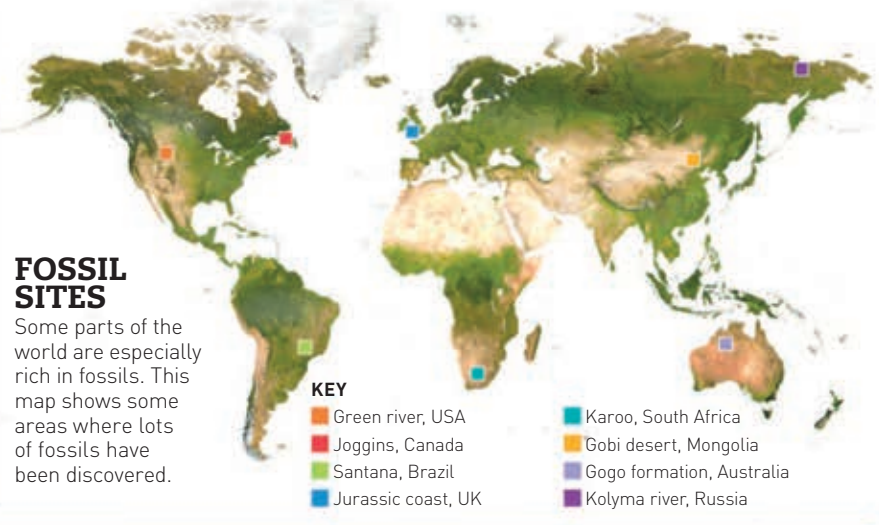
**5 SURFACE EROSION**  
Fossilized remains of creatures begin to be revealed as the land is eroded slowly over thousands of years.



**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

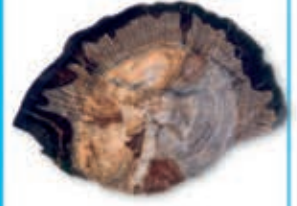
Fossils may be formed from the remains of plants or animals, or from traces of their activities during life.



**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

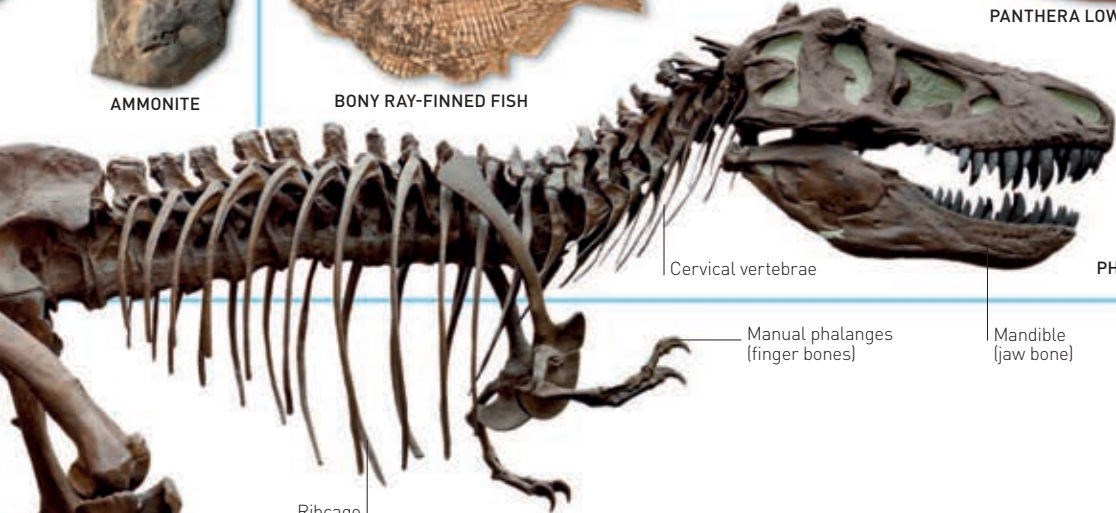
Fossils of vertebrate animals are some of the most exciting fossils ever found. They reveal species – such as dinosaurs and flying reptiles – that existed millions of years ago.



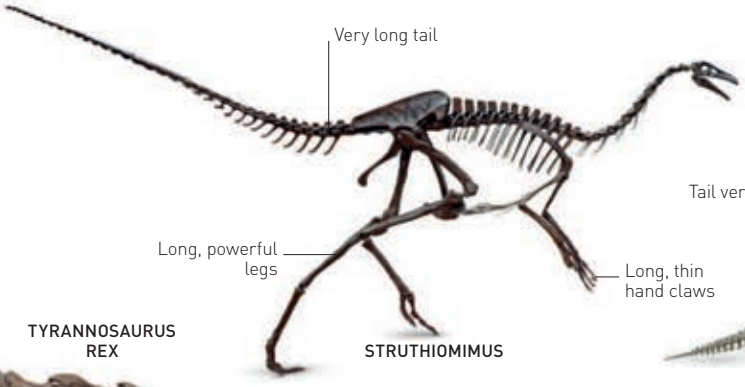
AMMONITE



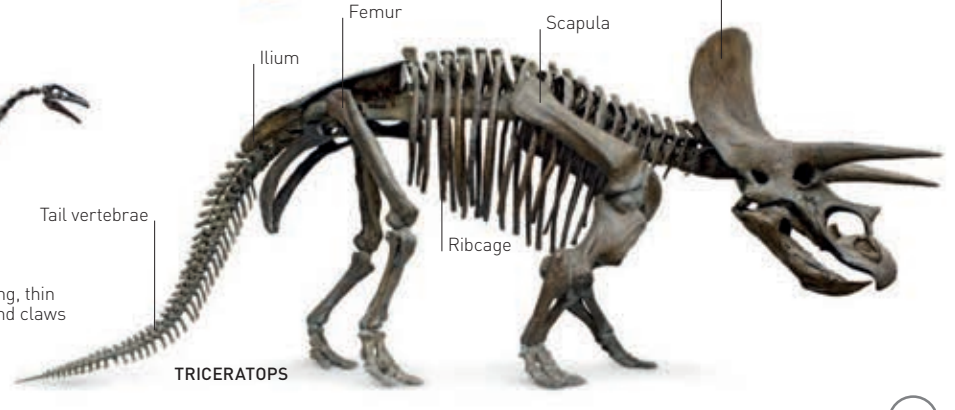
DINOSAUR VERTEBRA



TYRANNOSAURUS REX



STRUTHIOMIMUS



TRICERATOPS

**DINOSAUR FOSSILS HAVE BEEN DISCOVERED ON EVERY CONTINENT, INCLUDING ANTARCTICA**

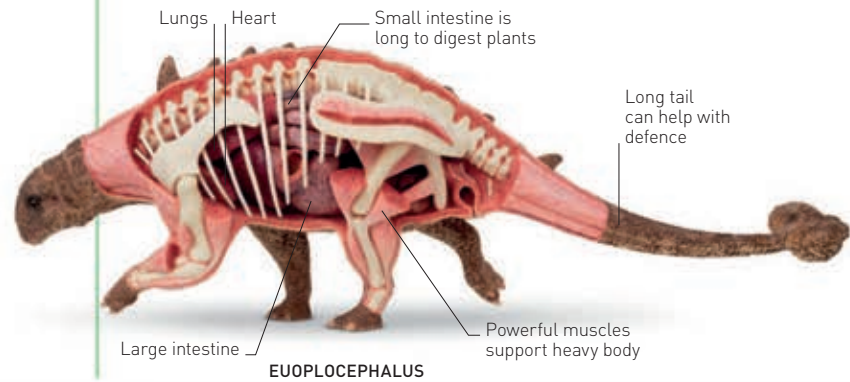


# Plant-eating dinosaurs

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.

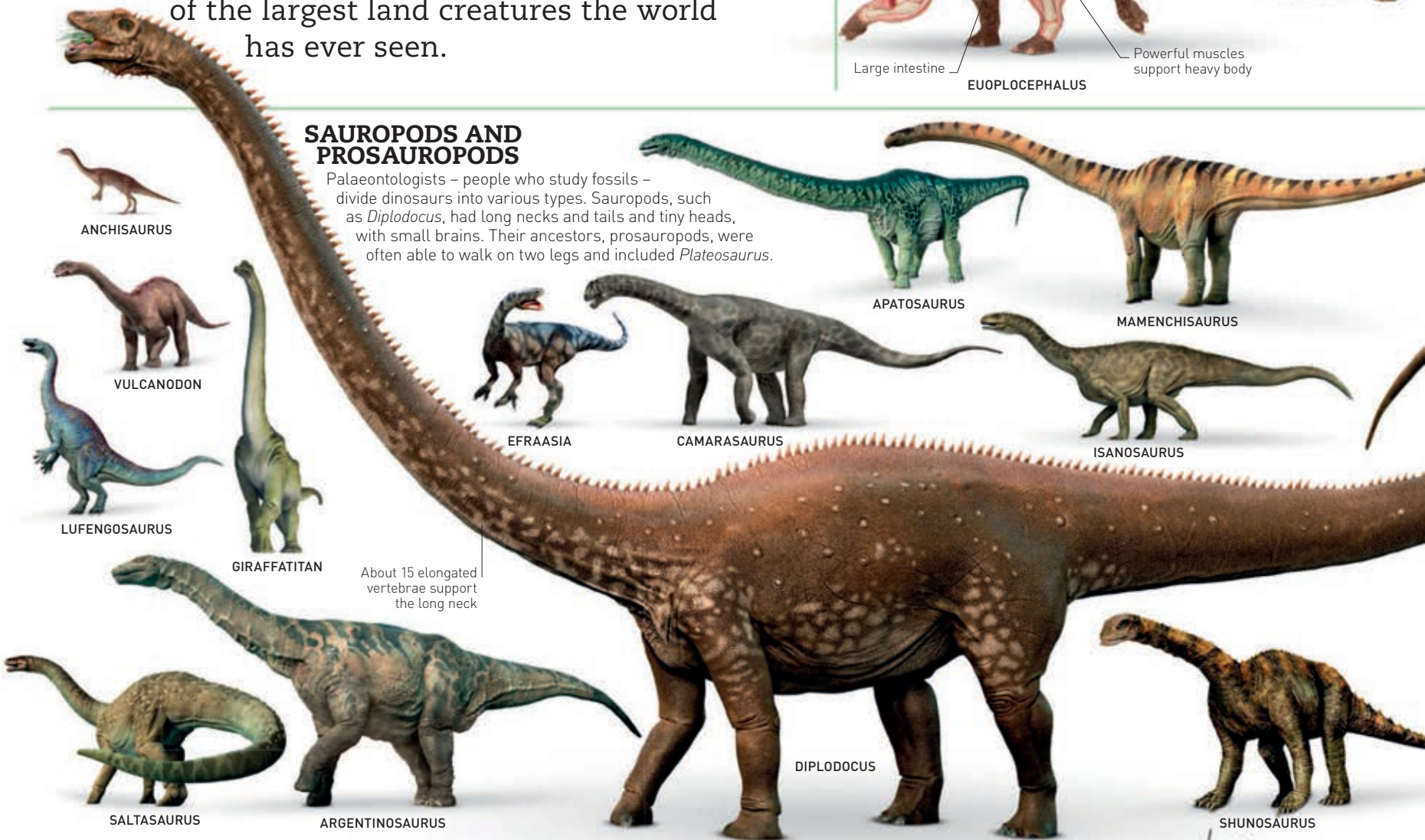
## HERBIVORE ANATOMY

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.



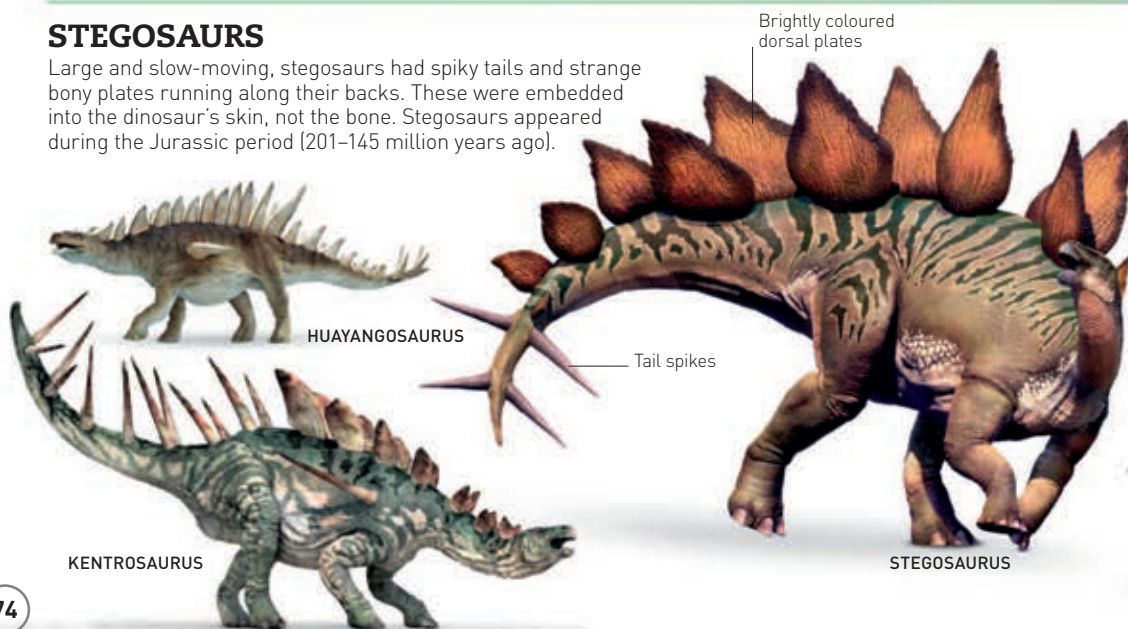
## SAUROPODS AND PROSAUROPODS

Palaeontologists – 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*.



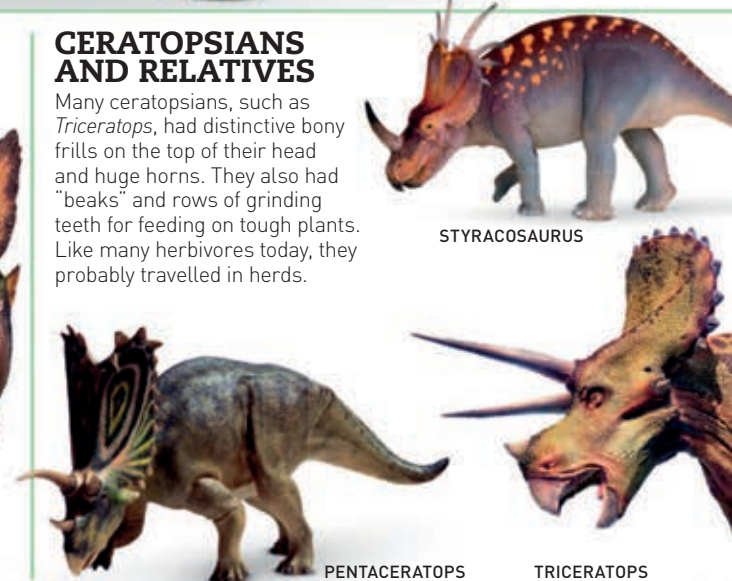
## STEGOSAURS

Large and slow-moving, 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).



## CERATOPSIANS AND RELATIVES

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 travelled in herds.





## SELF-DEFENCE

Even the largest plant-eating dinosaurs risked being hunted and killed by meat-eating dinosaurs. Over time herbivores developed specialized body defences for survival. These included horns, spikes, spines, and heavy tails that could inflict terrible injuries.



### BONY PLATES

Covering the head of *Euplocephalus*, 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.



### 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*.



### TAIL CLUB

Some plant-eaters, particularly ankylosaurs, had heavy, club-like tails made of fused bone that could break a predator's leg.



### SPIKY TAIL

The *Stegosaurus* had very sharp spikes on the end of its tail that could inflict terrible injuries on an opponent.



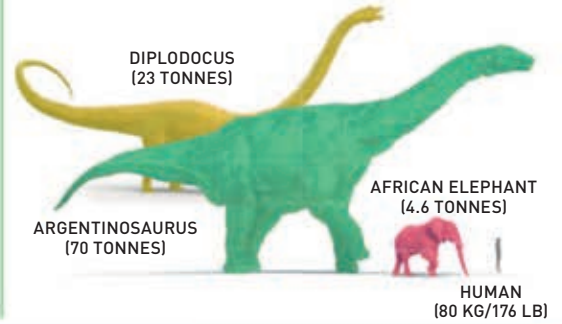
### WHIP-LIKE TAIL

It is suggested that the mighty *Diplodocus* used its long tail like a whip to defend itself against attackers.

## THE HORNS OF TRICERATOPS WERE AN AMAZING 1 M (3 FT) IN LENGTH

## HEAVYWEIGHTS

Like humans, elephants, and other animals, dinosaurs were vertebrates: they had an internal skeleton with a backbone to support their bodies. Many, though, were much heavier. At 70 tonnes, *Argentinosaurus* was 15 times heavier than an elephant.



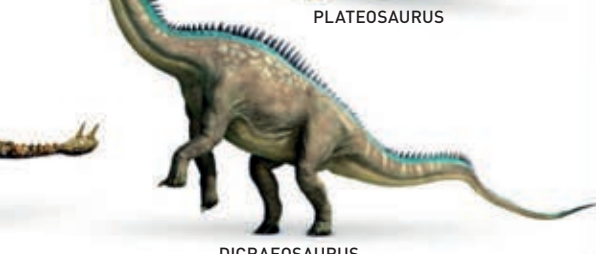
TITANOSAURUS



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.



LESOTHOOSAURUS



LEAELLYNASAURA



HETERODONTOSAURUS



DRYOSAURUS



HYPSILOPHODON



MUTTABURRASAUURUS



CORYTHOSAURUS



LESOTHOOSAURUS



LEAELLYNASAURA



HETERODONTOSAURUS



DRYOSAURUS



EDMONTOSAURUS



PARASAUROLOPHUS



IGUANODON



TENONTOSAURUS



MAIASAURA

## ANKYLOSAURS AND RELATIVES

Looking rather like prehistoric armoured 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



EUPOLOCEPHALUS



GARGOYLEOSAURUS



GASTONIA



SAUROPELTA



ANKYLOSAURUS



EDMONTONIA

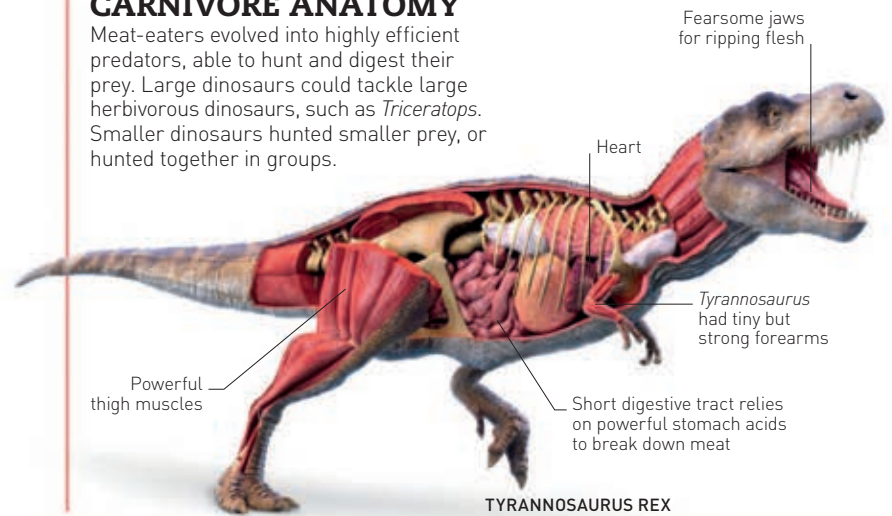


# Meat-eating dinosaurs

Dinosaurs appeared on Earth about 245 million years ago. They spread to every continent and dominated Earth for millions of years before dying out. Many were powerful meat-eating predators, with bodies built for attack.

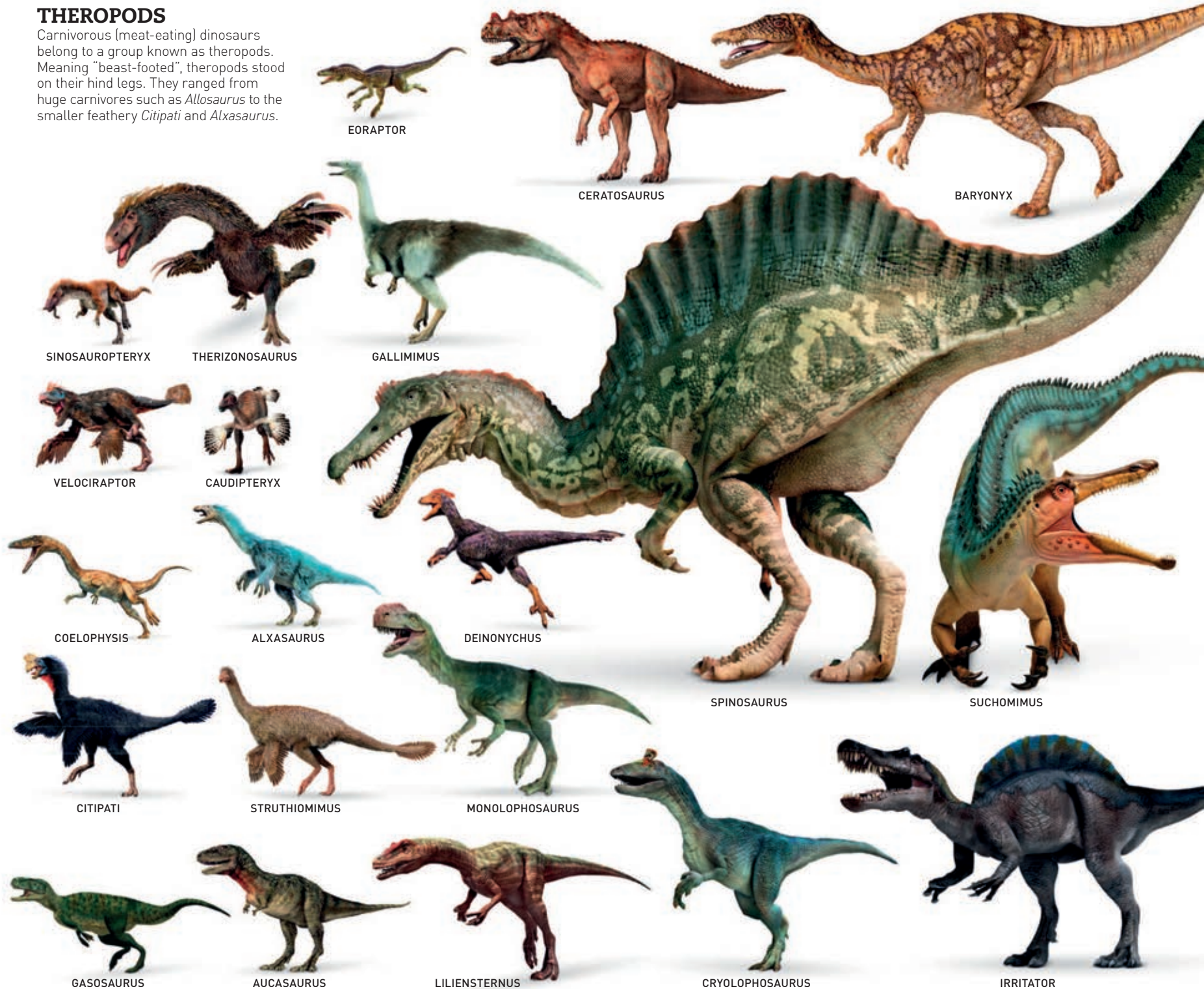
## CARNIVORE ANATOMY

Meat-eaters evolved into highly efficient predators, able to hunt and digest their prey. Large dinosaurs could tackle large herbivorous dinosaurs, such as *Triceratops*. Smaller dinosaurs hunted smaller prey, or hunted together in groups.



## THEROPODS

Carnivorous (meat-eating) dinosaurs belong to a group known as theropods. Meaning "beast-footed", theropods stood on their hind legs. They ranged from huge carnivores such as *Allosaurus* to the smaller feathery *Citipati* and *Alxasaurus*.





**DIET**

Theropods were the most powerful predators on land. They fed on insects, fish, other dinosaurs, small mammals, and bird-like creatures.



**INSECTS**

Insects evolved more than 350 million years ago.



**FISH**

Oceans and rivers teemed with fish.



**DINOSAURS**

Plant-eating dinosaurs provided food.



**EARLY MAMMALS**

Rodent-like mammals existed with dinosaurs.



**EARLY BIRDS**

Birds evolved from earlier theropod dinosaurs.

**TEETH**

Scientists can learn about dinosaurs from their fossilized skulls and teeth, which are often the only remaining parts. Carnivorous dinosaurs had lethal claws and sharp teeth.



**SHARP POINTS**

*Baryonyx* and other fish-eating theropods had pointed needle-like teeth that pierced fish skin.



**KNIFE-LIKE**

Theropods such as *Allosaurus* had sharp teeth that they used to slice meat from the bone.



**CRUSHING BONES**

The large teeth of *Tyrannosaurus rex* crushed straight through bone.

**PACK HUNTING**

A pack of *Deinonychus* attacks a large plant-eating *Tenontosaurus*. Evidence from fossilized dinosaur footprints suggests that some dinosaurs hunted in packs. Probably they did not herd prey but worked together to bring down larger dinosaurs.



DUBREUILLOSAAURUS

CARCHARODONTOSAURUS

ALBERTOSAURUS

ALLOSAURUS

TYRANNOSAURUS REX

Stiff, pointed tail counterbalances huge head and allows dinosaur to turn quickly

Powerful legs with four clawed toes, only three of which are weight-bearing

**DEEP BITES FROM TYRANNOSAURUS HAVE BEEN FOUND IN FOSSILIZED TRICERATOPS BONES**



# 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 *Megalodon* and *Hybodus* look a lot like the fish and sharks around today.



## TYPES OF PREHISTORIC ANIMALS

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 fish, invertebrates (animals without backbones), reptiles, amphibians, and mammals.



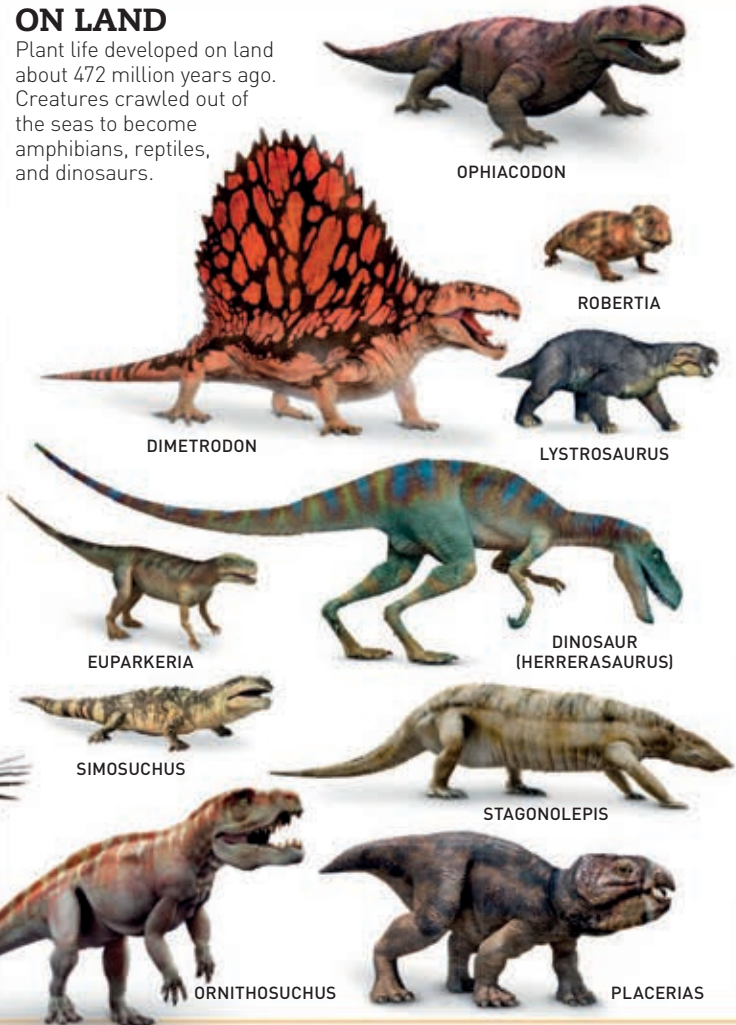
### INVERTEBRATES

This squid-like belemnite lived in the prehistoric oceans some 200 million years ago.

**SCIENTISTS THINK THAT EITHER AN ASTEROID STRIKE OR ERUPTING VOLCANOES CAUSED A MASS EXTINCTION OF PREHISTORIC ANIMALS**

## ON LAND

Plant life developed on land about 472 million years ago. Creatures crawled out of the seas to become amphibians, reptiles, and dinosaurs.







**FISH**

The very first vertebrates (animals with backbones) to evolve were fish.



**AMPHIBIANS**

Like frogs today, prehistoric amphibians could breathe air but bred in fresh water.



**REPTILES**

The earliest reptiles evolved from amphibians about 315 million years ago. They had scaly skin.



**MAMMALS**

The first mammals appeared on Earth about 220 million years ago.

**TRANSITION TO MODERN ANIMALS**

About 65 million years ago a huge catastrophe wiped out many prehistoric creatures. Birds and some animals 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 4.5 m (14.8 ft) 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 downwards



PROTOSUCHUS



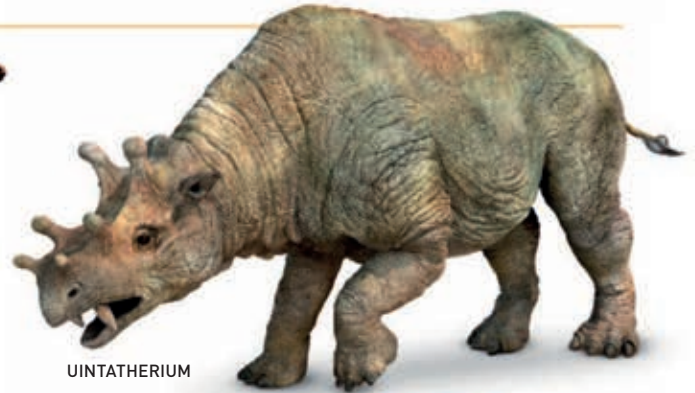
SPHENOSUCHUS



PLIOHIPPIUS



NEMEGTBAATAR



UINTATHERIUM



DIRE WOLF



SMILODON



WOOLLY MAMMOTH



GLYPTODON



WOOLLY RHINOCEROS



PLIOPATECARPUS



HYBODUS



LEEDSICHTHYS



ISCHYODUS



MOSASAURUS



ELASMOSAURUS



MEGALODON

KRONOSAURUS



# 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.

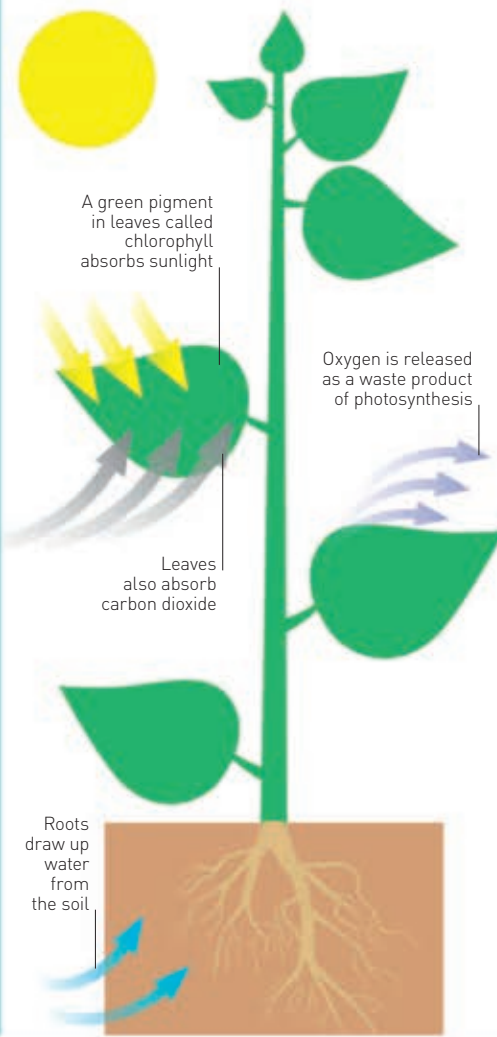
## HOW PLANTS GROW

In spring, seeds get warm, absorb water, and start to sprout (germinate). Roots begin to grow downwards to get water and nutrients from the soil, while shoots grow upwards, towards the light.



## PHOTOSYNTHESIS

Plants make their own food (glucose) through a process called photosynthesis. They soak up water from the soil and take in carbon dioxide from the air. They then use the Sun's energy to produce glucose.



## 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.

## NON-FLOWERING PLANTS

These evergreen plants tend to like damp, shady places. They reproduce by releasing spores. Spores from coniferous plants are carried by the wind to special cones, where seeds develop.



EUROPEAN YEWE



CALIFORNIA NUTMEG

AUSTRIAN PINE



GOLDEN LARCH

## FLOWERING PLANTS

The colourful and often fragrant flowers of these plants attract insects. The insects pick up pollen and transport it to other plants of the same type, helping it to reproduce.



MAGNOLIA



WINTER'S BARK



BOTTLEBRUSH



TULIP TREE



CAROLINA ALLSPICE



PEARL OF THE POOL WATER LILY

## 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.



**CONIFERS**  
Coniferous plants stay green all year round. They have long, thin needles that need less water and can withstand freezing weather.



**MANGROVES**  
These grow near the sea, but their leaves are able to get rid of (secrete) excess salt. If the salt levels become too high, the leaves just fall off.



**CACTI**  
Cacti live in very hot places, so they have small spines instead of leaves, which do not allow so much water to evaporate. Their stems also store water.



**SCIENTISTS THINK THAT SOME SPECIES OF FERNS HAVE BEEN ON EARTH FOR OVER 350 MILLION YEARS**



ALPINE WOODFERN

TONGALAND CYCAD

MEXICAN HORNCONE

MOORE'S MACROZAMIA CYCAD

FLOATING FERN

HORSETAIL

EASTERN CAPE BLUE CYCAD

ADDER'S TONGUE FERN

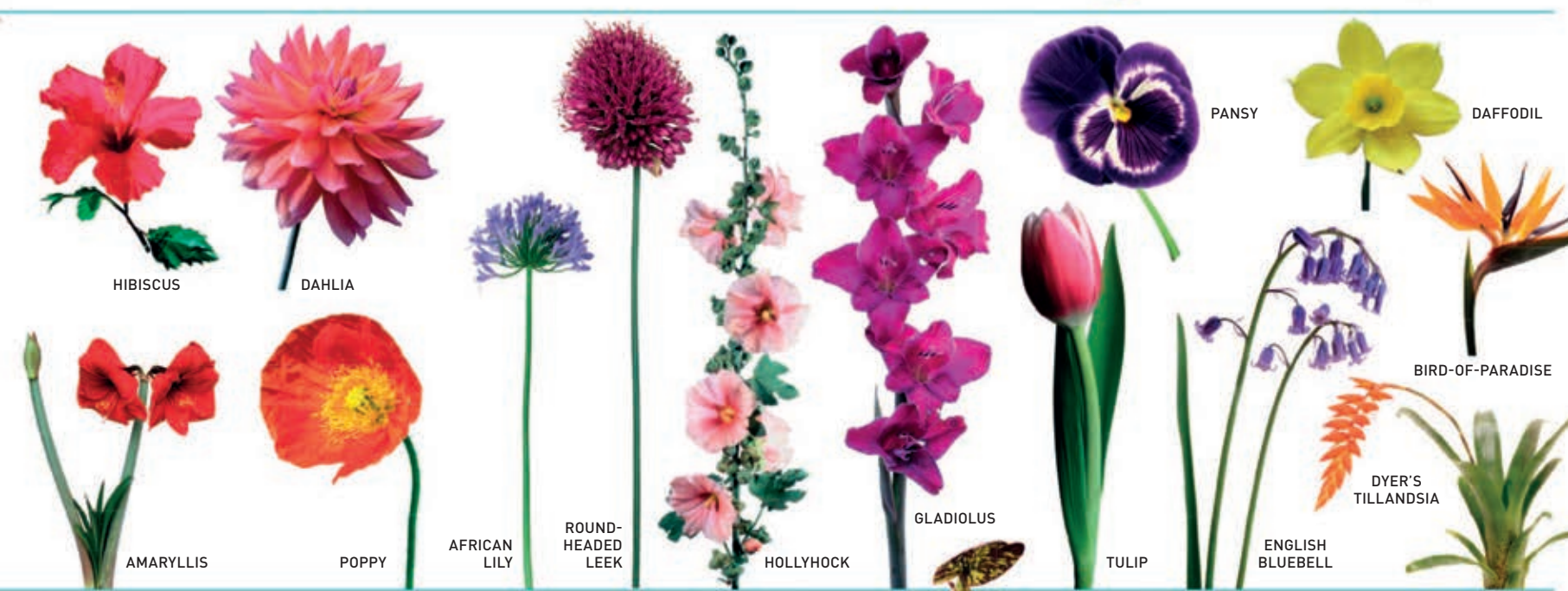
SILVER LIP FERN

GINKGO

COMMON LIVERWORT

SPHAGNUM

HORNWORT



HIBISCUS

DAHLIA

AMARYLLIS

POPPY

AFRICAN LILY

ROUND-HEADED LEEK

HOLLYHOCK

GLADIOLUS

TULIP

PANSY

DAFFODIL

BIRD-OF-PARADISE

ENGLISH BLUEBELL

DYER'S TILLANDSIA

## 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 colour 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

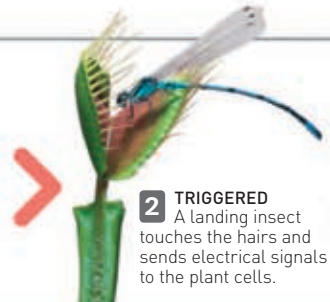
This tropical plant has cups (pitchers) that hang from trees and contain water to attract prey. Thirsty insects fall in – and become plant food.

### 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.

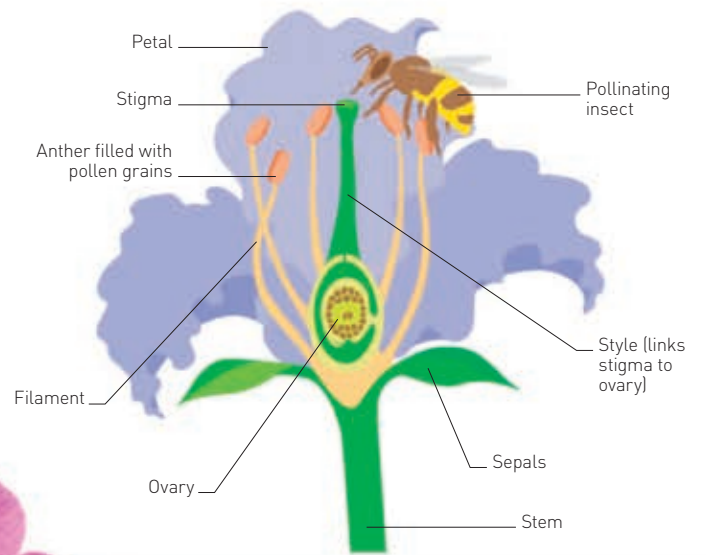


# Flowers

Flowers, often colourful 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 centred 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.



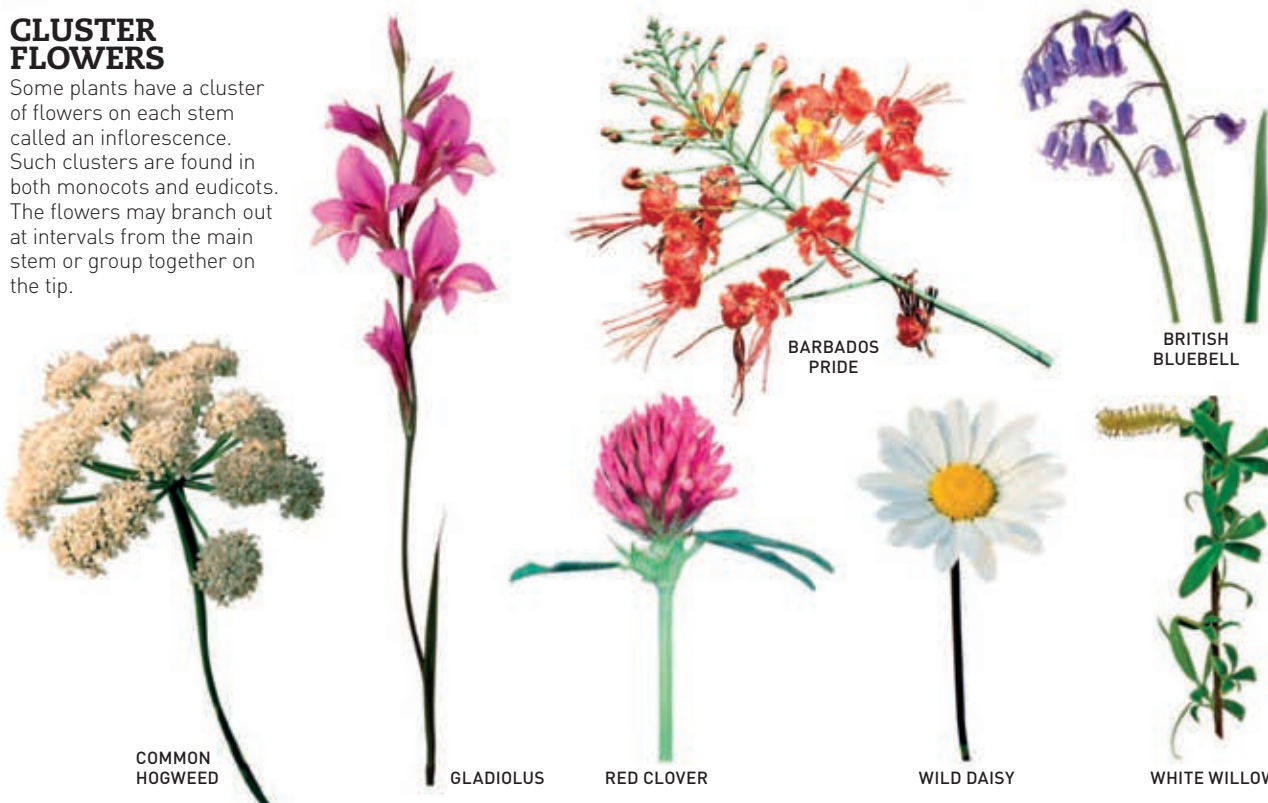
## MONOCOTS

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 with green flowers use wind pollination, as they are less attractive to insects. The flowers also tend to be small and not always 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 colour 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.



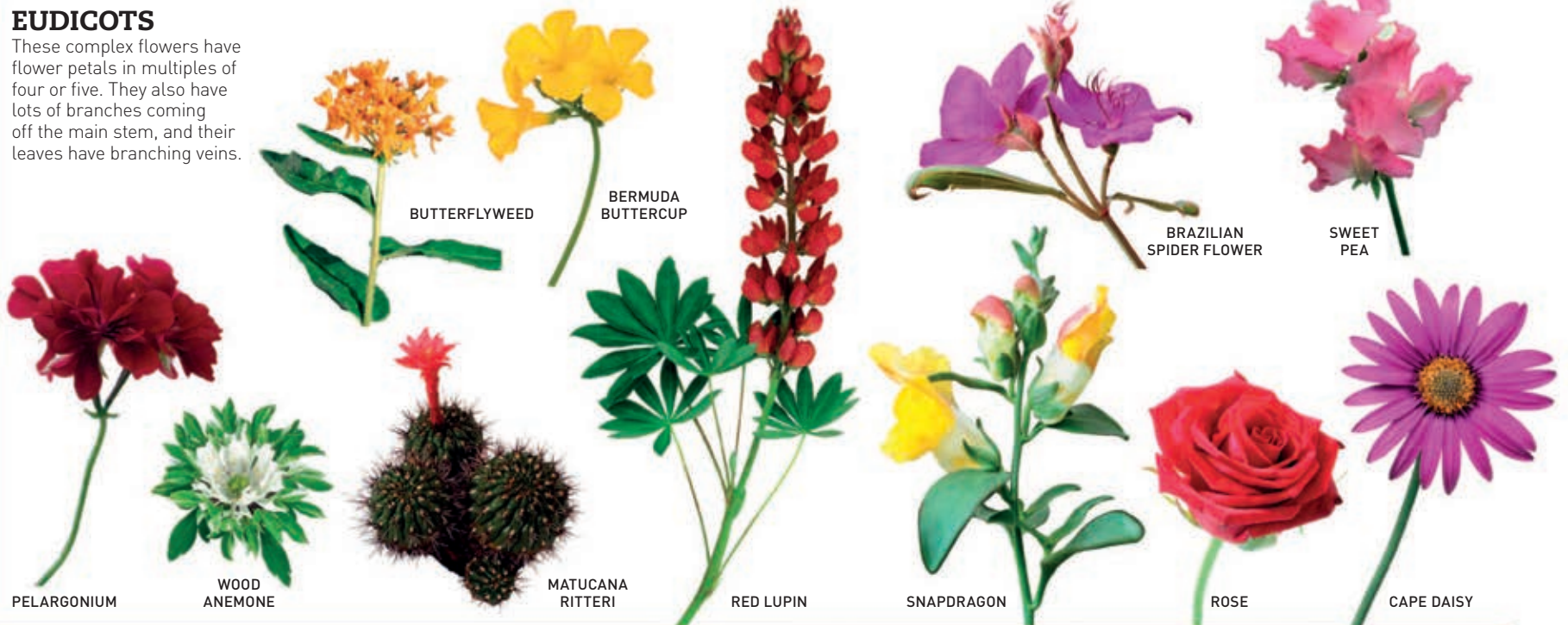
**4 RIPENING**  
Over the growing season, the fruit gets bigger and ripens.



**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.



PELARGONIUM

WOOD ANEMONE

BUTTERFLYWEED

MATUCANA RITTERI

BERMUDA BUTTERCUP

RED LUPIN

SNAPDRAGON

BRAZILIAN SPIDER FLOWER

ROSE

SWEET PEA

CAPE DAISY

**PLANTS WITH GREEN FLOWERS ARE A MAJOR CAUSE OF HAY FEVER BECAUSE THEY PRODUCE LOTS OF POLLEN AT CERTAIN TIMES OF THE YEAR**



GREEN BRISTLEGRASS

GRASS FLOWERS

SEA BEET

NAVELWORT

## 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.



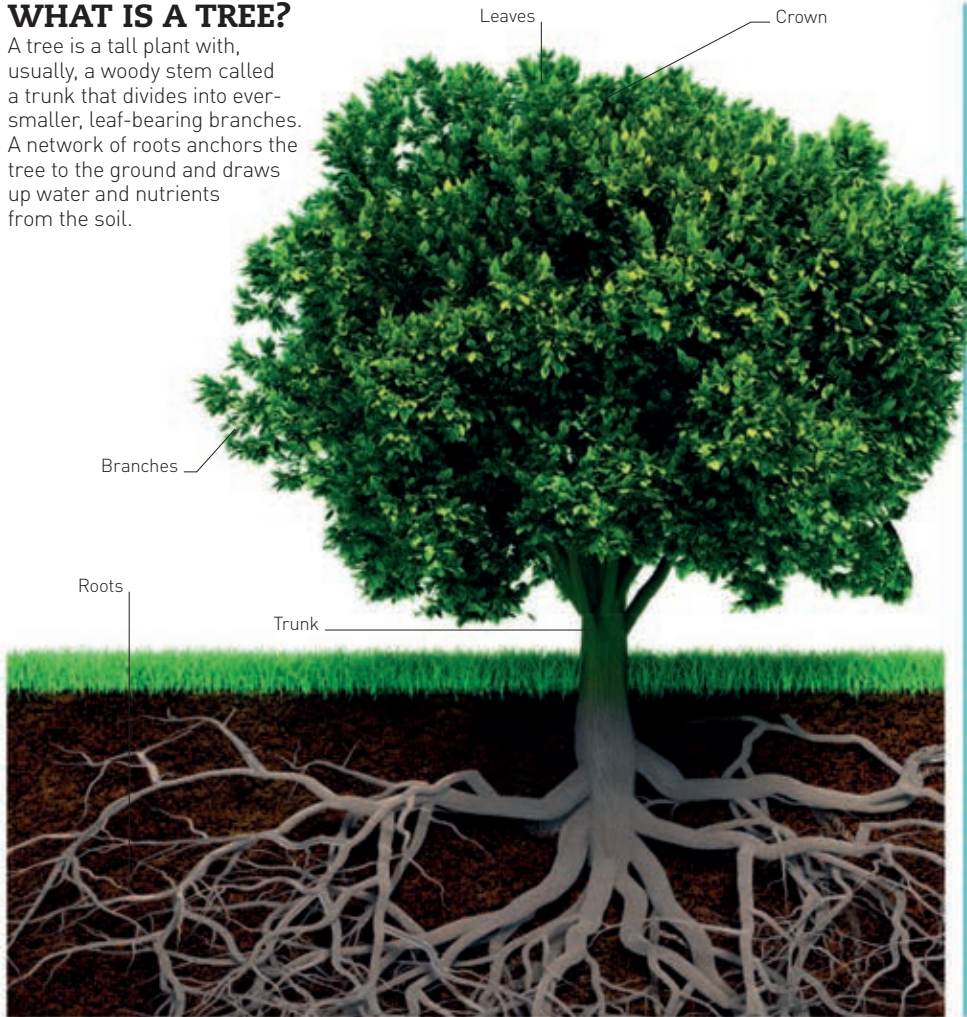
# Trees

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 to 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.



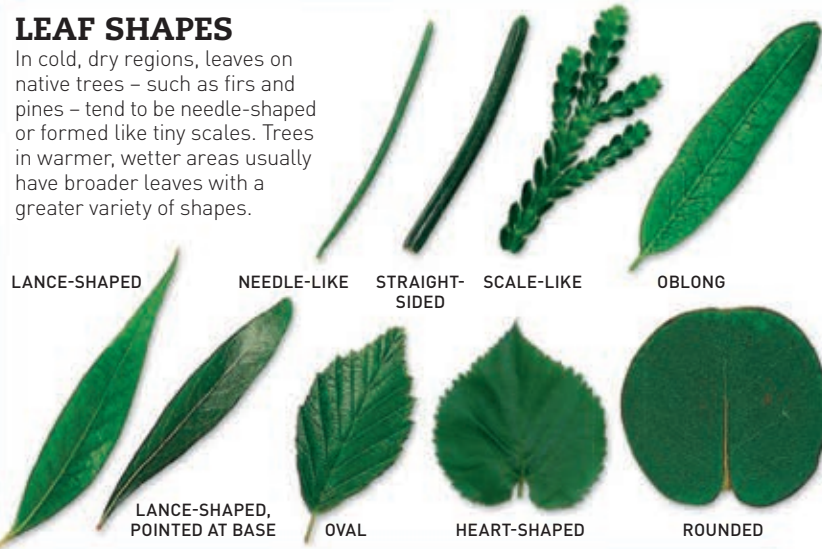
## TYPES OF BARK

Bark is the outer layer of a tree. It protects the trunk and branches from damage and keeps in water. The colour 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.



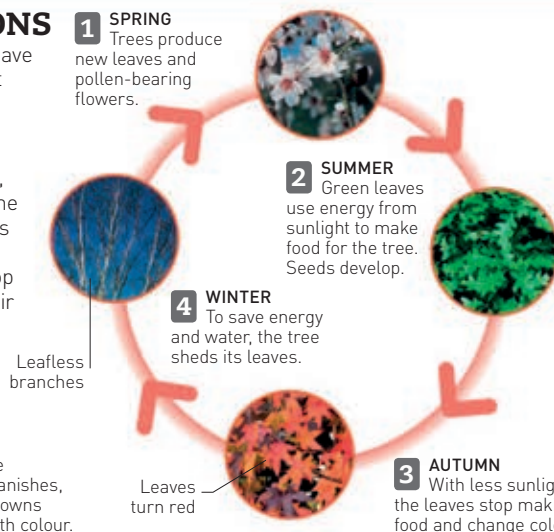
## TREE RINGS

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

Many types of 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 autumn, the trees stop growing and drop their leaves. In winter, the trees have a period of rest.



### LEAF CHANGE

In autumn, leaves change appearance. The green vanishes, and reds, yellows, and browns make woodlands glow with colour.

## 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, USA. The very tallest redwood is an amazing 116 m (380 ft) high. Named Hyperion, its exact location is secret.

**HYPERION REDWOOD**  
116 m (380 ft)





## 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 4,789  
YEARS OLD**

## ANCIENT TREES

The first tree-like 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.

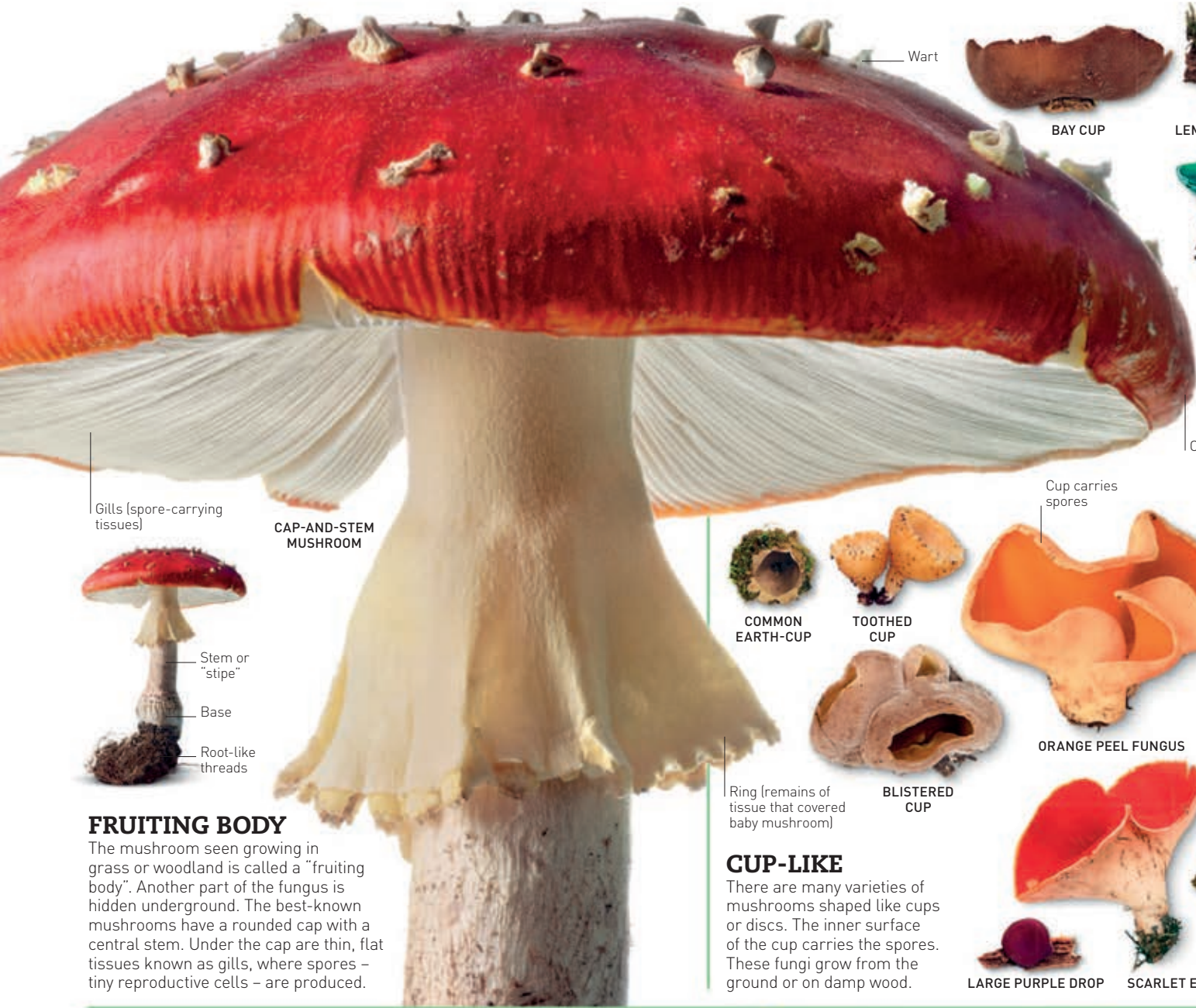


JAPANESE MAPLE



DWARF CRAB APPLE





**CAP-AND-STEM MUSHROOM**

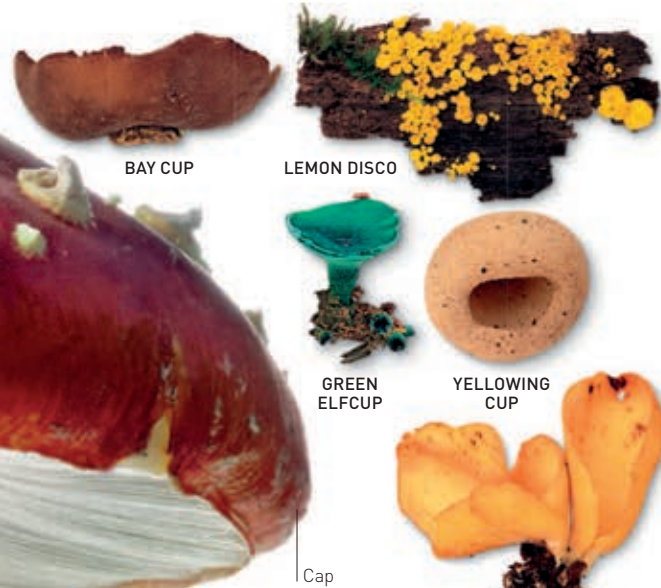
Gills (spore-carrying tissues)



Stem or "stipe"  
Base  
Root-like 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.



**BAY CUP**

**LEMON DISCO**

**GREEN ELFCUP**

**YELLOWING CUP**

**LEMON PEEL FUNGUS**



**COMMON EARTH-CUP**

**TOOTHED CUP**

**BLISTERED CUP**

Ring (remains of tissue that covered baby mushroom)



**ORANGE PEEL FUNGUS**

Cup carries spores

Deeply cup-shaped fruiting body



**LARGE PURPLE DROP**

**SCARLET ELFCUP**



**ANEMONE CUP**

**JELLY EAR**

Spore-producing tissue



**BEECH JELLYDISC**

**CUP-LIKE**

There are many varieties of mushrooms shaped like cups or discs. The inner surface of the cup carries the spores. These fungi grow from the ground or on damp wood.

**BALL-SHAPED**

Some fungi are round like balls. They range in size from tiny ones clustering on stems to giants as large as a football. The type called puffballs split open to release the spores stored inside.



**COMMON EARTHBALL**

**STUMP PUFFBALL**

**SPINY PUFFBALL**

**MEADOW PUFFBALL**

**SUMMER TRUFFLE**

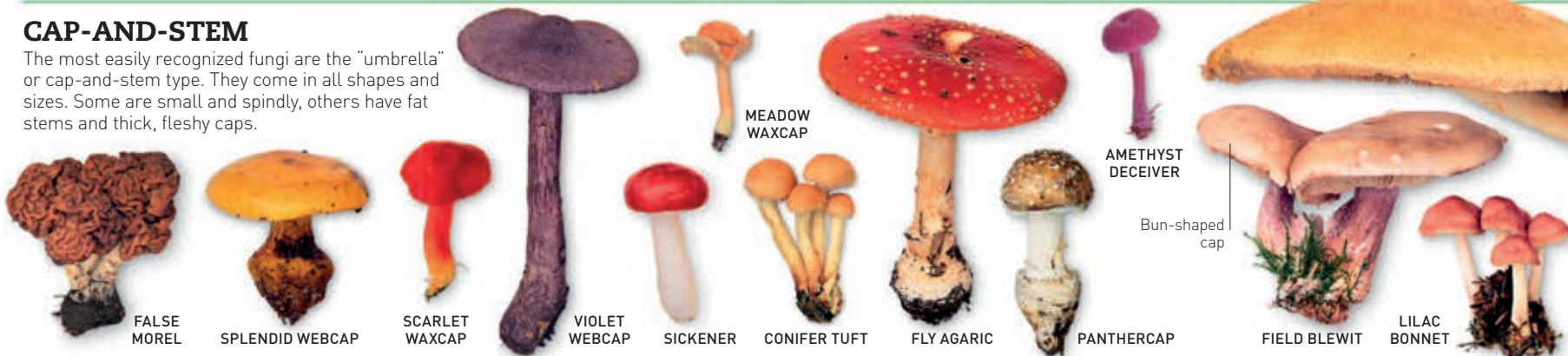
**GIANT PUFFBALL**

**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, others have fat stems and thick, fleshy caps.



**FALSE MOREL**

**SPLENDID WEBCAP**

**SCARLET WAXCAP**

**VIOLET WEBCAP**

**SICKENER**

**CONIFER TUFT**

**FLY AGARIC**

**PANTHERCAP**

**FIELD BLEWIT**

**LILAC BONNET**

Bun-shaped cap

**AMETHYST DECEIVER**

**MEADOW WAXCAP**

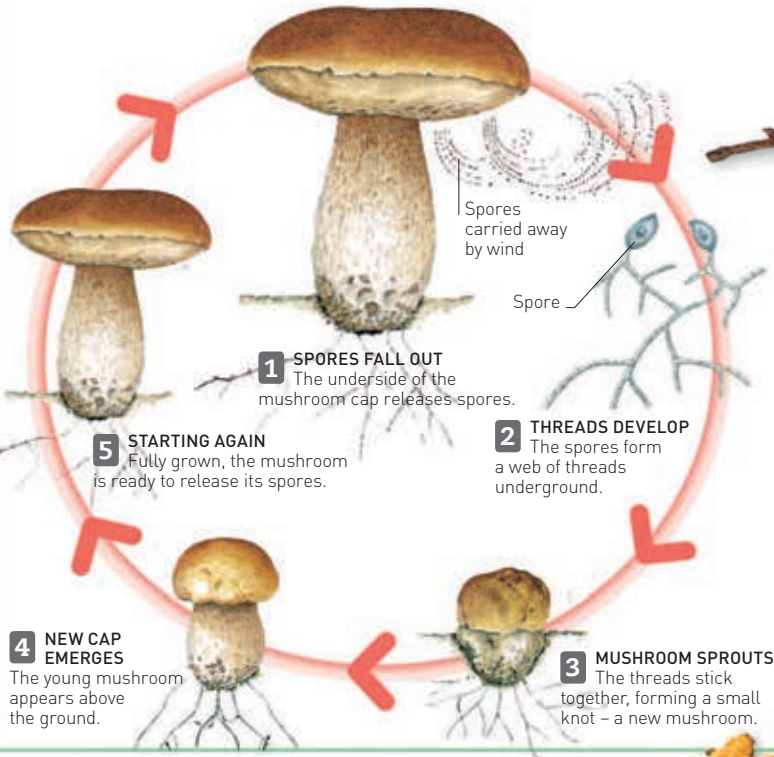


# Mushrooms

Although they look like plants, mushrooms are quite different and belong to a separate scientific group – the fungi. They come in many shapes and colours, and all of them feed on organic matter. Some mushrooms 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.



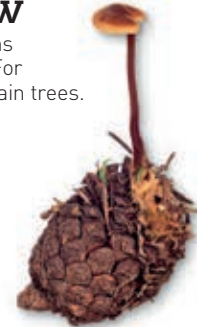
**FALLEN BRANCHES**  
The common brown cup mushroom grows on oak bark.



**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

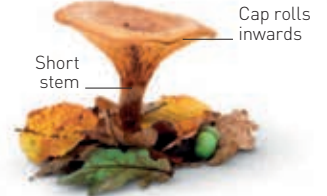
Some poisonous mushrooms look very like the ones used in cooking. No one should pick a mushroom without being quite sure what type it is.

### 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-coloured 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.

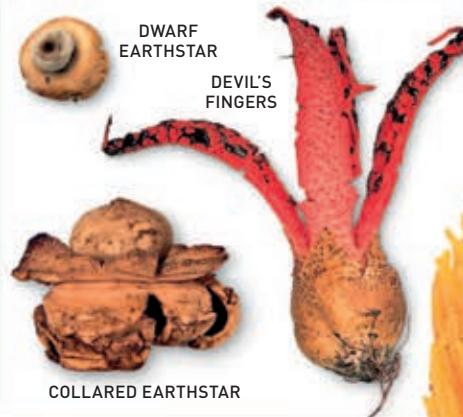
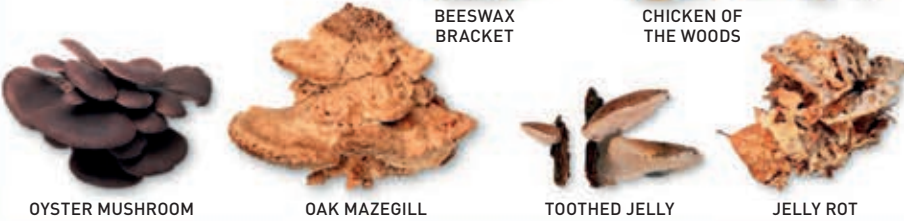
### DEADLY WEBCAP

This is very dangerous because it looks like the edible chanterelle mushroom. If eaten, the webcap damages the liver and kidneys.



## BRACKET-LIKE

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.



## 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.



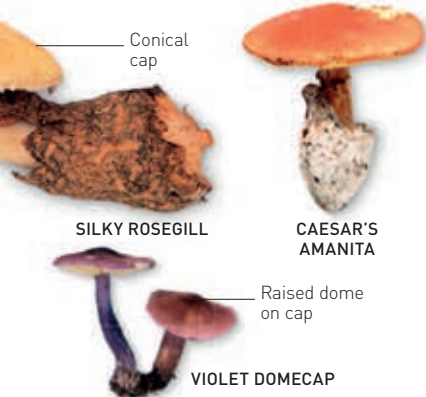
## CLUB-SHAPED

With their upright shapes and no noticeable cap, club fungi can be hard to recognize as mushrooms. Some types grow in clumps.



## CORAL-LIKE

Often brightly coloured, the clustered, branching stalks of coral fungi look very similar to the corals found in tropical seas.





## SPIDERS

There are about 4,200 species of spiders. They have eight legs, and six or eight eyes. Most spiders can live for up to one year, if they avoid disease and predators. Some big spiders, such as the tarantula, 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



AMERICAN GOLDEN SILK ORB-WEAVER



CHACO TARANTULA



NORTHERN BLACK WIDOW SPIDER



FUNNEL-WEB SPIDER



EUROPEAN WOLF SPIDER

# Spiders and scorpions

Spiders and scorpions are part of the arachnid family – invertebrate animals with eight legs. They are alike in many ways, but a scorpion has a venomous stinger in its tail, while spiders have venomous fangs.



## 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.

YELLOW THICK-TAIL SCORPION



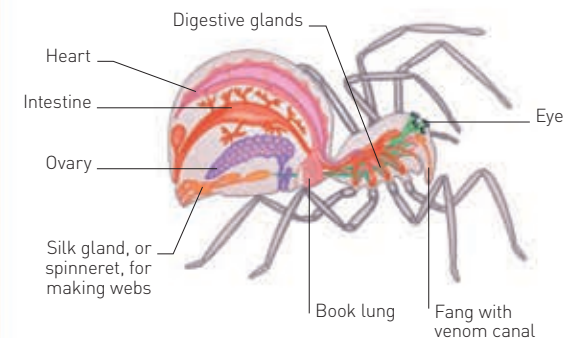
IMPERIAL SCORPION



CHILEAN BURROWING SCORPION

## ANATOMY OF A SPIDER

A spider's body is divided into two parts. The first part includes the eyes, fangs, stomach, and legs, while the second 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 moults for the first time.



Scorplings

External skeleton will be shed five to seven times before adulthood





CRAB-LIKE SPINY ORB-WEAVER



ORANGE BABOON TARANTULA



MEXICAN RED-KNEED TARANTULA



RAFT SPIDER



WHIP SPIDER



COMMON HARVESTMAN



BROAD-HEADED PSEUDOSCORPION

## OTHER ARACHNIDS

The arachnid family 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.

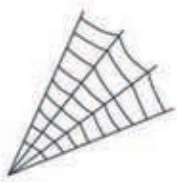
## WEB TYPES

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 non-venomous 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 non-sticky 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 28 cm (11 in).



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, and 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 bite with flesh-eating venom for which there is no cure.

### ○ BLACK WIDOW SPIDER

This spider's venom is very poisonous, but its bite is small.

**THE OLDEST WEB IS A 110-MILLION-YEAR-OLD FOSSIL**

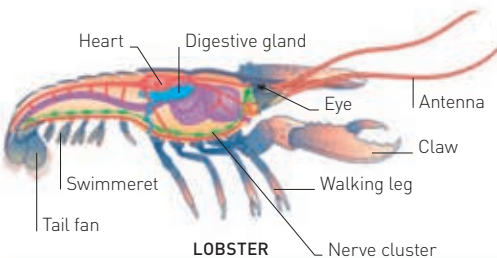


# Crustaceans

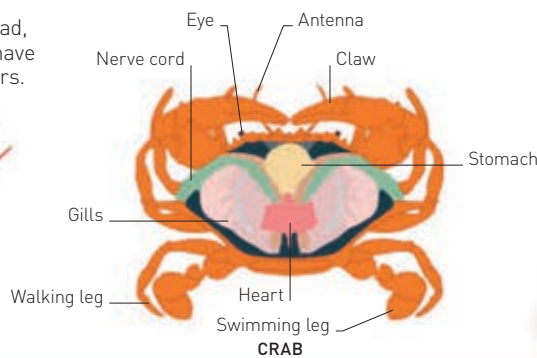
The animals called crustaceans are a varied group that includes crabs, lobsters, prawns, and shrimps. Most of them live in water. Among the few found on land are tiny woodlice. Crustaceans have an outer skeleton that does not grow when their bodies do, so they shed it regularly to allow a new, larger one to develop.

## THE BODY OF A CRUSTACEAN

Lobsters and crabs have three body regions: the head, the thorax or mid-section, and the abdomen. They have five pairs of legs, which in some species form pincers.



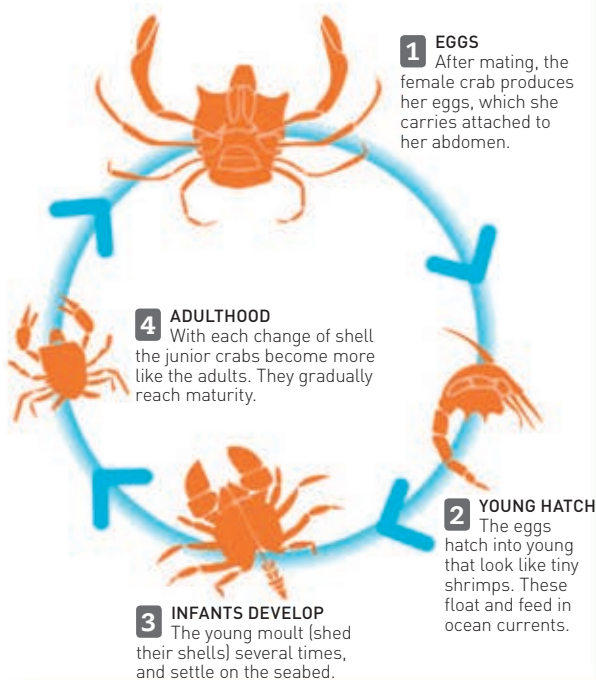
LOBSTER



CRAB

## 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 5 cm (2 in) 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 FAMILIES

Like most crabs, lobsters live in the sea. These large animals have a hard upper shell and powerful tails. Smaller crustaceans include numerous shrimps, both marine and freshwater. Sea slaters and woodlice belong to a large family 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



FURROWED CRAB



ANEMONE HERMIT CRAB



DUNGENESS CRAB



VELVET SWIMMING CRAB



PANAMIC ARROW CRAB



PORCELAIN ANEMONE CRAB



RED REEF HERMIT CRAB



ORANGE FIDDLER CRAB



WHITE-SPOTTED HERMIT CRAB

COMMON EUROPEAN CRAB



ATLANTIC BLUE CRAB



PEACOCK MANTIS SHRIMP



SCULPTURED SLIPPER LOBSTER



COMMON MARBLE SHRIMP



COMMON SHRIMP



HAIRY SQUAT LOBSTER



NORWAY LOBSTER



MORETON BAY BUG LOBSTER



STRIPED-LEG SPINY LOBSTER



SEA SLATER



ANTARCTIC KRILL



WHITE-CLAWED CRAYFISH



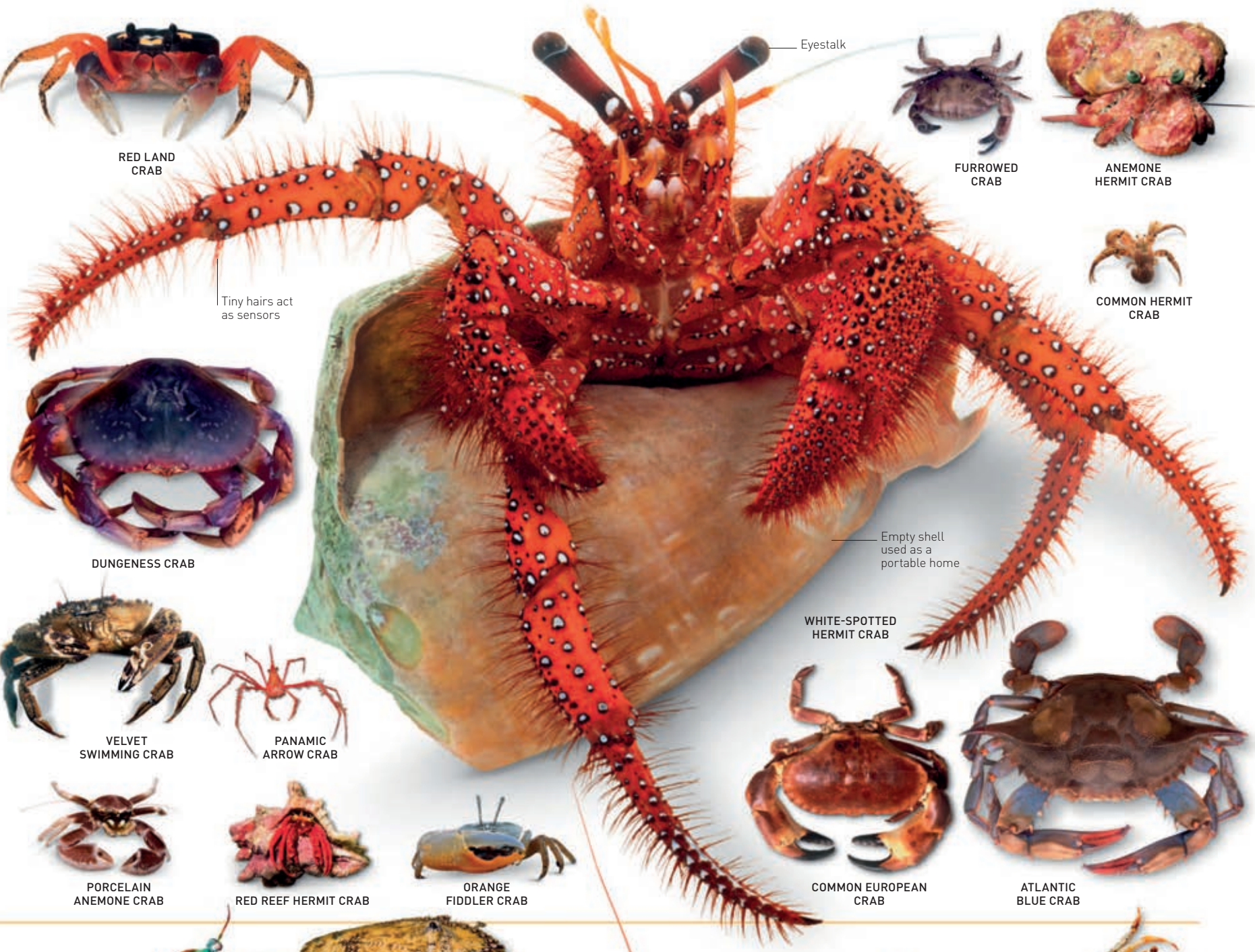
PILL WOODLOUSE



SPINY SQUAT LOBSTER



TIGER PRAWN



Eyestalk

Tiny hairs act as sensors

Empty shell used as a portable home



## 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



FEELERS



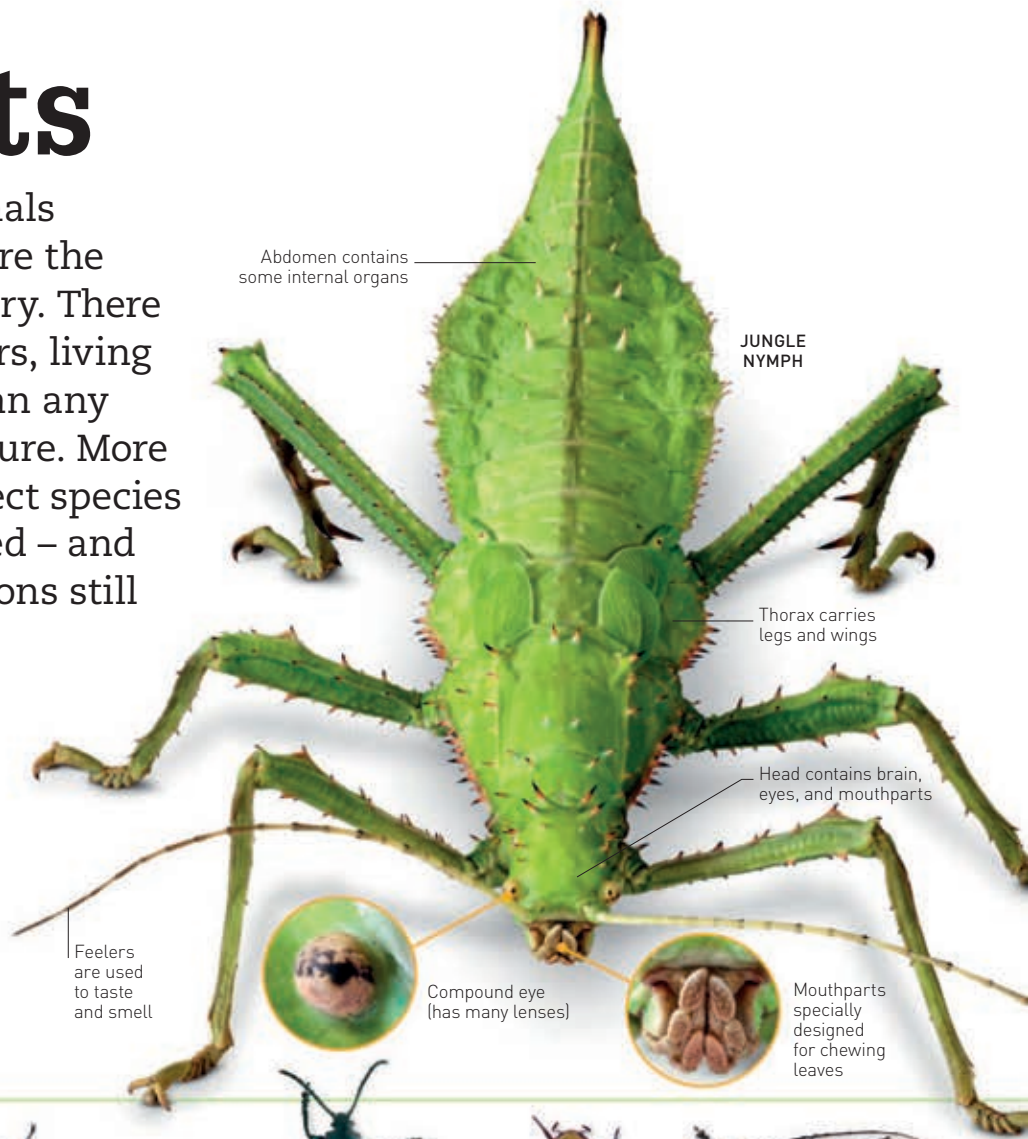
SIX JOINTED LEGS

# Insects

Out 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

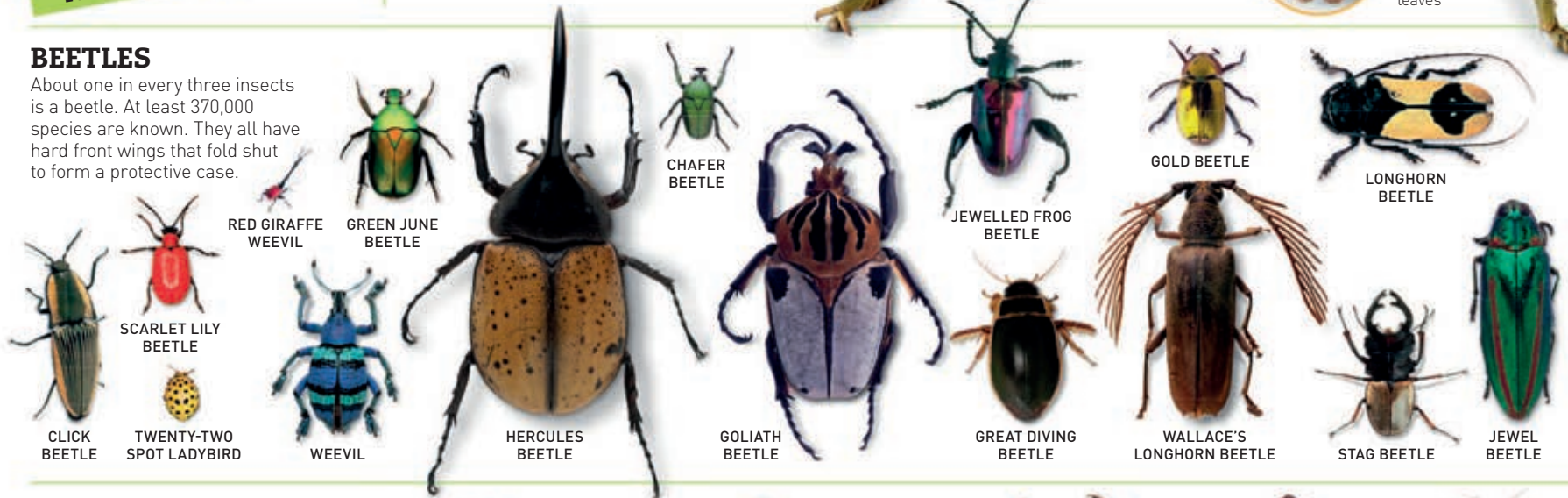
Insects have three main body segments: the head; the thorax, or midsection, to which the legs, and maybe wings, are attached; and the abdomen or belly. All these parts are protected by a hard outer skeleton.



**INSECTS WERE THE FIRST ANIMALS TO FLY, 400 MILLION YEARS AGO**

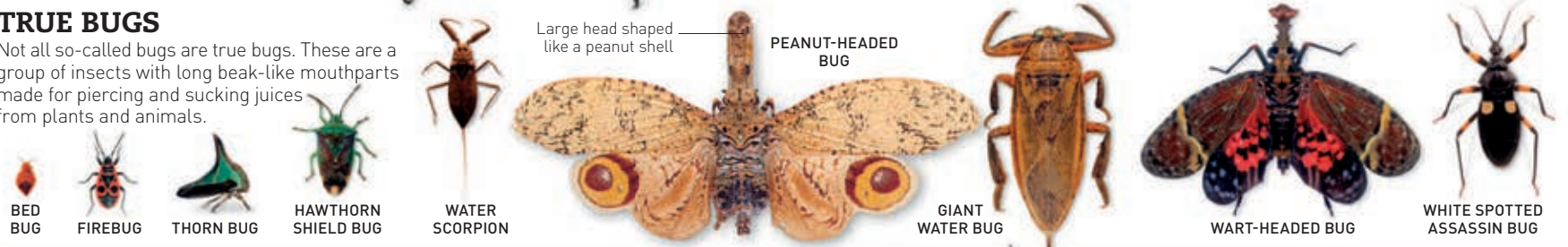
## BEETLES

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 beak-like mouthparts made 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

## FLIES

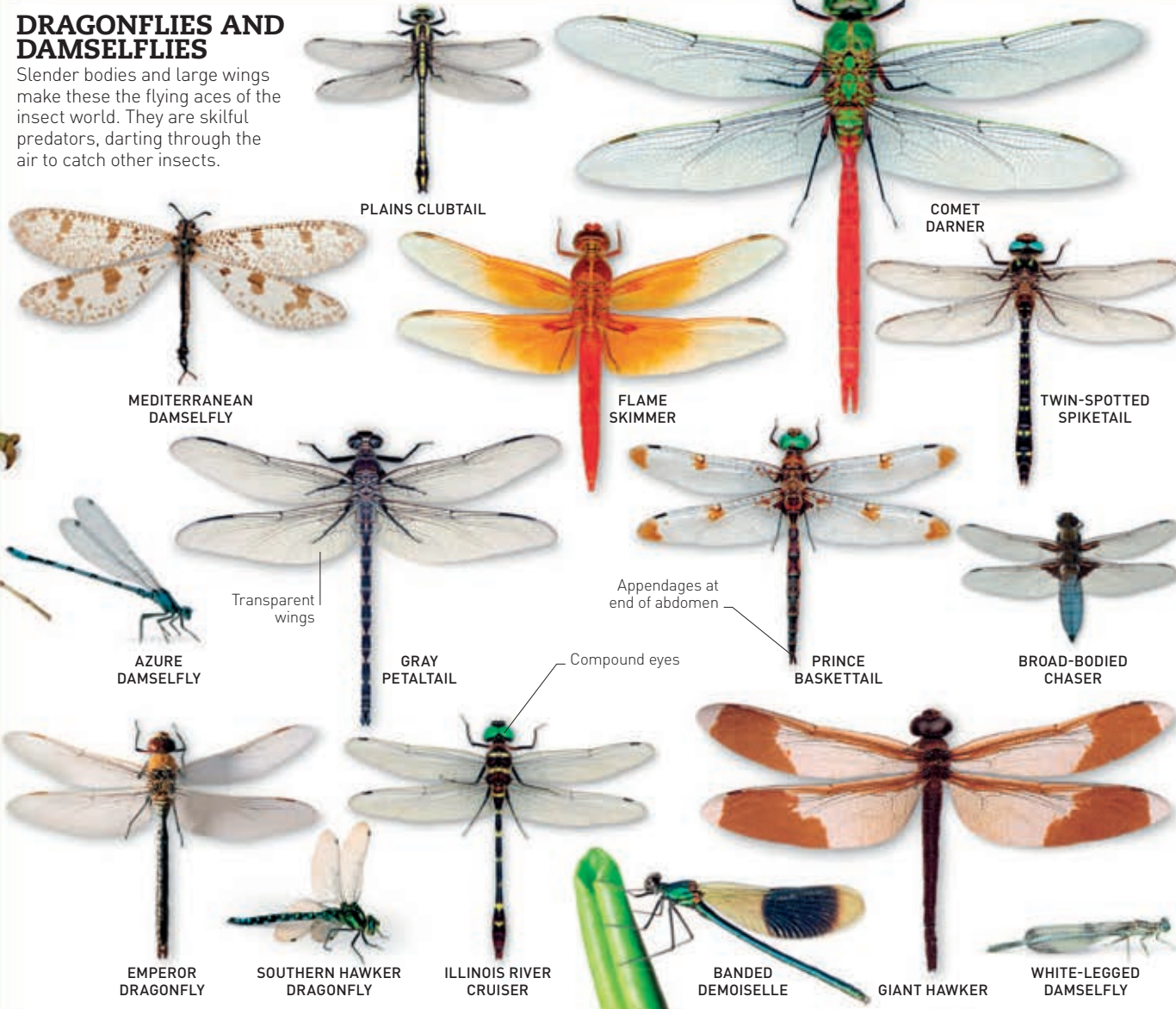
There are thousands of species of flies around the world. Although some types are disease-carrying pests, many are useful as pollinators of plants.



BLUEBOTTLE    TIMBER FLY    HOUSE FLY    GIANT BLUE ROBBER FLY

## DRAGONFLIES AND DAMSELFLIES

Slender bodies and large wings make these the flying aces of the insect world. They are skilful predators, darting through the air to catch other insects.

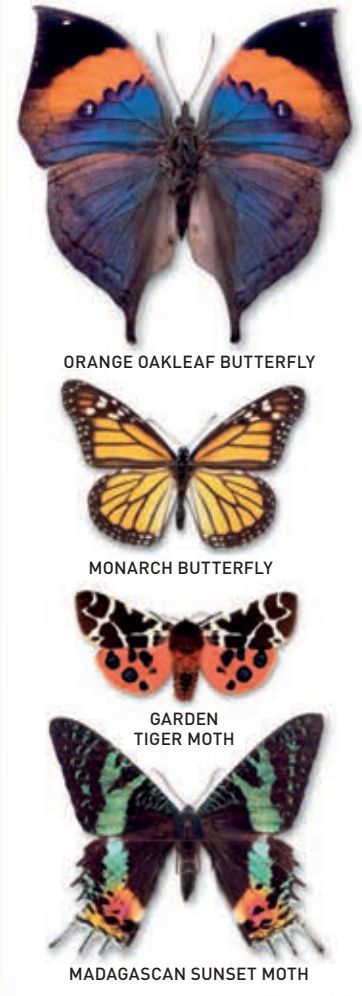


PLAINS CLUBTAIL    COMET DARTER    FLAME SKIMMER    TWIN-SPOTTED SPIKETAIL  
 MEDITERRANEAN DAMSELFLY    PRINCE BASKETTAIL    BROAD-BODIED CHASER  
 AZURE DAMSELFLY    GRAY PETALTAIL    EMPEROR DRAGONFLY    SOUTHERN HAWKER DRAGONFLY    ILLINOIS RIVER CRUISER    BANDED DEMOISELLE    GIANT HAWKER    WHITE-LEGGED DAMSELFLY

Transparent wings    Appendages at end of abdomen    Compound eyes

## BUTTERFLIES AND MOTHS

Often colourful, butterflies are daytime flyers. Moths are usually duller and most fly at night. Both have tiny scales on their wings.



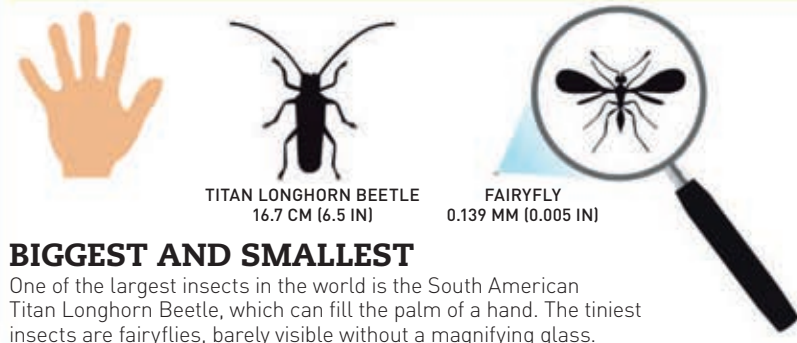
ORANGE OAKLEAF BUTTERFLY    MONARCH BUTTERFLY    GARDEN TIGER MOTH    MADAGASCAN SUNSET MOTH

## LIFECYCLE

All insects start life as an egg. Once they hatch out, 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 (non-feeding stage).  
**5 ADULT** Inside a tight wrapping, the pupa changes, and an adult ladybird emerges.



TITAN LONGHORN BEETLE 16.7 CM (6.5 IN)    FAIRYFLY 0.139 MM (0.005 IN)

## 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-ROUND 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.

HORSEFLY



Large compound eyes are very sensitive to movement

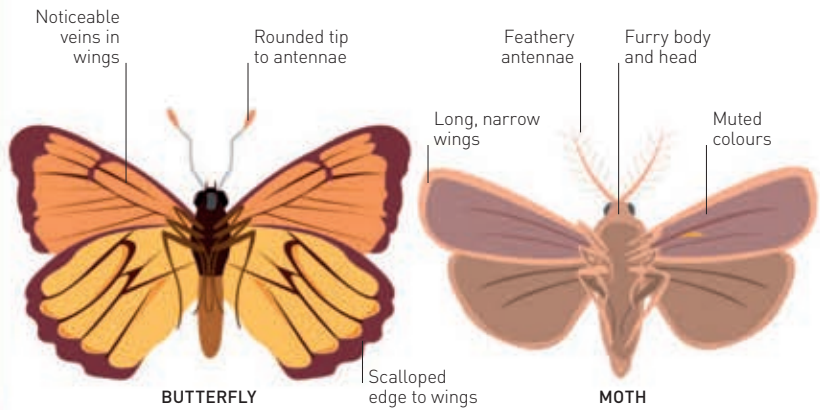


# Butterflies and moths

With their delicate shape and often stunning colours, butterflies and moths are beautiful insects. All 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?

Most butterflies fly by day and are brightly coloured. At rest, they usually fold their wings upright. Moths fly largely at night and most have duller colouring. They have furry bodies and 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 colours 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



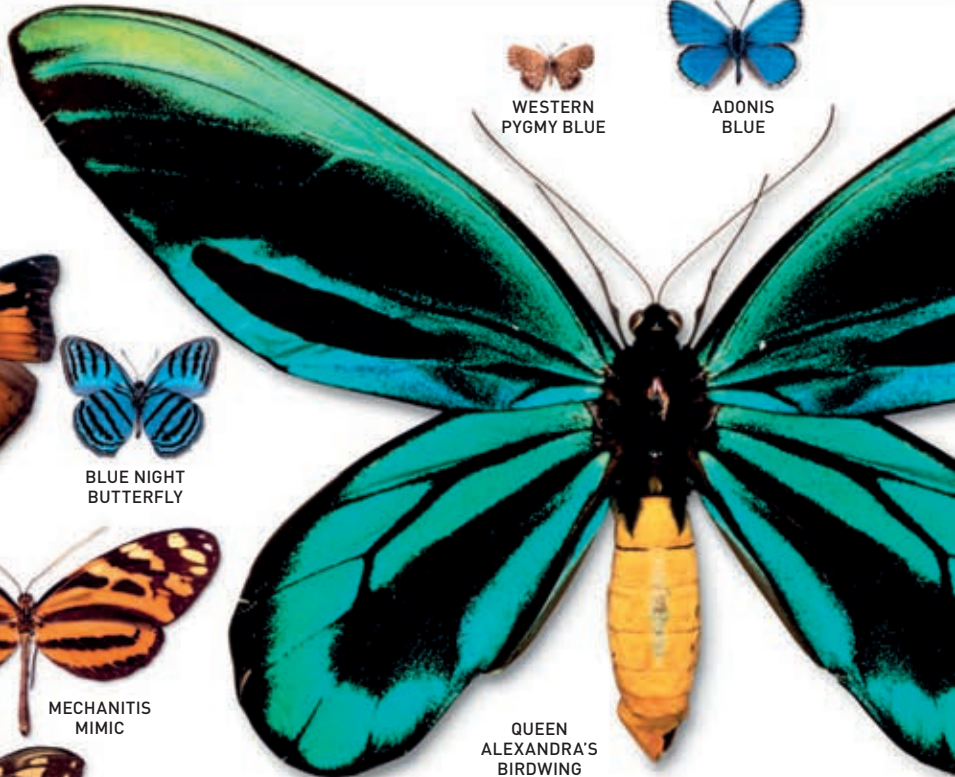
REGENT SKIPPER



MOORLAND CLOUDED YELLOW



MECHANITIS MIMIC



QUEEN ALEXANDRA'S BIRDWING



WESTERN PYGMY BLUE



ADONIS BLUE



BRAZILIAN DYNASTOR



TIGER SWALLOWTAIL



BLUE TRIANGLE



PEACOCK BUTTERFLY



APOLLO

## MOTHS

There are many more moths than butterflies. Most are less eye-catching, but spectacular species do occur. The gigantic moon moths can have wingspans of up to 30 cm (12 in).



PROVENCE BURNET



MADAGASCAN SUNSET MOTH



INFANT MOTH



GOLDEN EMPEROR



ORNATE MOTH



SMOOTH EMERALD



ORIZABA SILKMOTH



## LIFECYCLE OF A BUTTERFLY

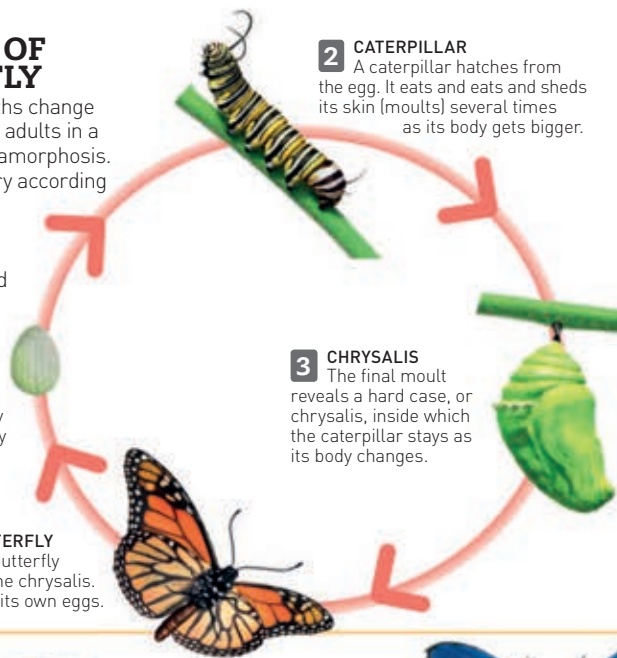
Butterflies and moths change from caterpillars to adults in a process called metamorphosis. Their life stages vary according to species. Some caterpillars change inside a silk cocoon rather than the hard case shown here.

**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 ADULT BUTTERFLY**  
A colourful butterfly emerges out of 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 (moult) several times as its body gets bigger.

**3 CHRYSALIS**  
The final moult reveals a hard case, or chrysalis, inside which the caterpillar stays as its body changes.



## LARGEST AND SMALLEST

The female Queen Alexandra's Birdwing is the world's biggest butterfly with a wingspan of up to 28 cm (11 in). The Western Pygmy Blue has a wingspan of less than 2 cm (0.5 in), making it one of the world's smallest.



WESTERN PYGMY BLUE

QUEEN ALEXANDRA'S BIRDWING

## CATERPILLAR MOVEMENT

Caterpillars have three pairs of legs at the front and between two and five pairs of false legs, which provide grip, at the hind end. They move with a wave-like motion.



**1 FRONT MOVES**  
The caterpillar moves its front part forwards, leaving the rear anchored.



**2 REAR CATCHES UP**  
It draws its hind end forwards while holding on with the front legs.

Two pairs of false legs  
Three pairs of walking 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



CHINESE OAK SILK MOTH



COMMON CLUBTAIL



HEWITSON'S BLUE HAIRSTREAK



LARGE BLUE



PURPLE HAIRSTREAK



GUAVA SKIPPER



BHUTAN GLORY



MARBLED WHITE



PIRATE BUTTERFLY



PAINTED LADY



GRIZZLED SKIPPER



JULIA



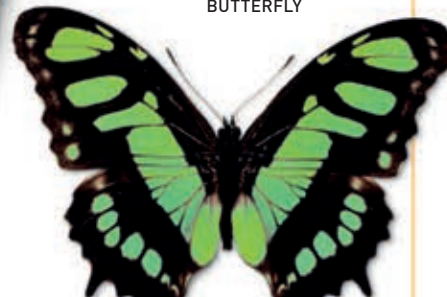
EUROPEAN MAP BUTTERFLY



EIGHTY-EIGHT BUTTERFLY



CATTLE HEART SWALLOWTAIL



MALACHITE



MONARCH



AFRICAN MOON MOTH



COMMON EPICOMA MOTH



LIME HAWK-MOTH



ELEPHANT HAWK-MOTH



HARTIG'S BRAHMAEA



GREEN SILVER-LINES MOTH



GIANT LEOPARD MOTH



LARGE MAPLE SPANWORM MOTH



BASKER



## 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.



KERRY SPOTTED SLUG

COMMON GARDEN SLUG

BLACK SLUG

## SEA SLUGS

As wobbly as jelly and often as brightly coloured, sea slugs creep over seabeds and corals. Some can swim in a clumsy fashion. They carry gills, or breathing organs, such as feathers or spikes on their backs.



VARICOSE SEA SLUG

SPANISH DANCER

ANNA'S SEA SLUG

HEADSHIELD SLUG

OPALESCENT SEA SLUG

ELEGANT SEA SLUG

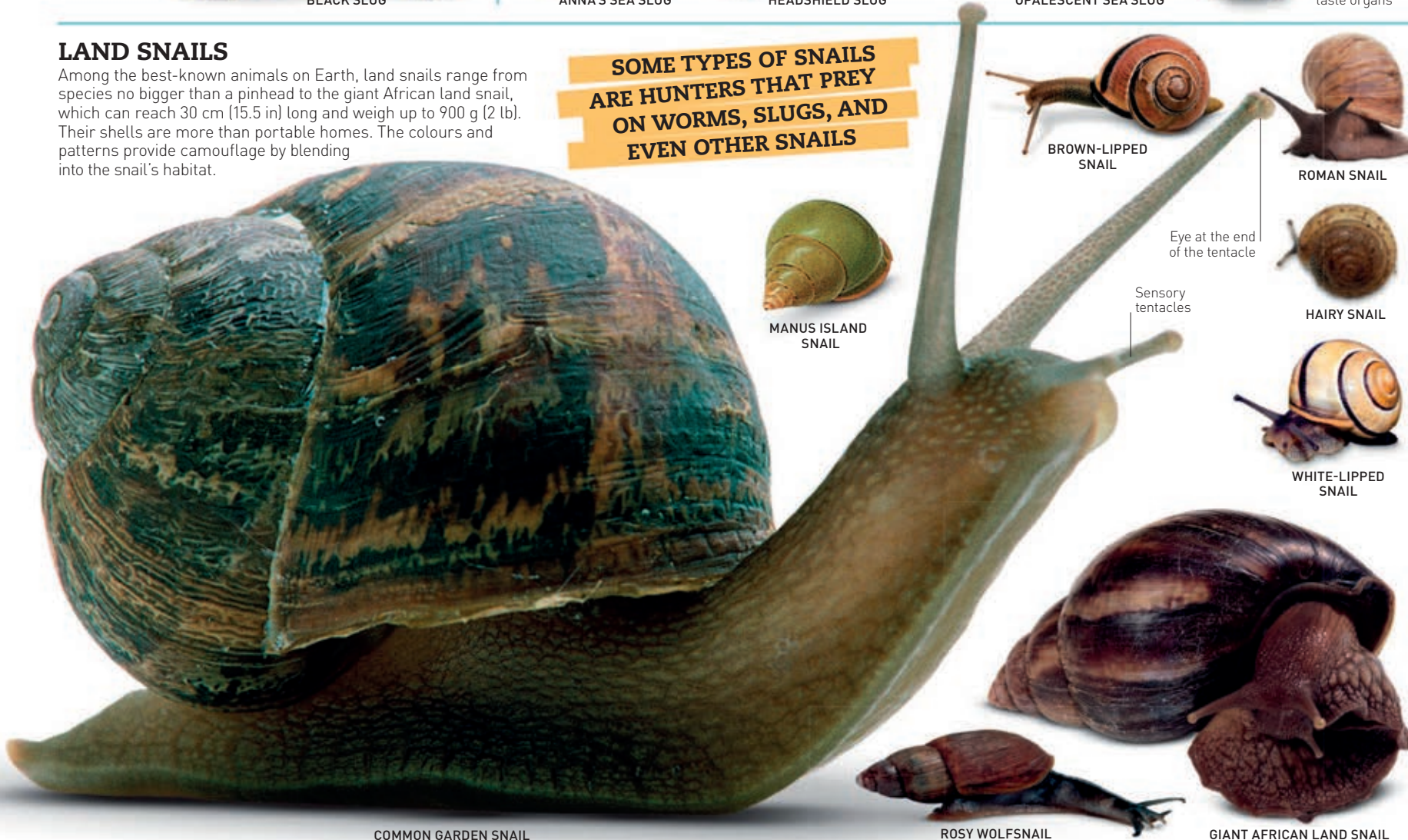
Gills

Smell or taste organs

## 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 30 cm (15.5 in) long and weigh up to 900 g (2 lb). Their shells are more than portable homes. The colours and patterns provide camouflage by blending into the snail's habitat.

**SOME TYPES OF SNAILS ARE HUNTERS THAT PREY ON WORMS, SLUGS, AND EVEN OTHER SNAILS**



COMMON GARDEN SNAIL

BROWN-LIPPED SNAIL

ROMAN SNAIL

Eye at the end of the tentacle

HAIRY SNAIL

Sensory tentacles

WHITE-LIPPED SNAIL

ROSY WOLFSNAIL

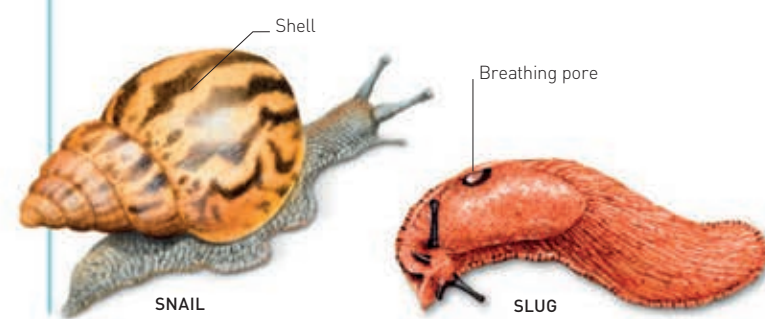
GIANT AFRICAN LAND SNAIL

# 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 coloured or have fantastically shaped shells.

## WHAT'S THE DIFFERENCE?

The bodies of slugs and snails look very alike, but a telltale feature lies beneath a snail's shell. This is a small hump containing most of the snail's internal organs. Some slugs have a tiny internal shell that serves as a calcium store.



SNAIL

SLUG





LETTUCE SEA SLUG

BLACK-MARGINED SEA SLUG



SPOTTED SEA HARE



VARIABLE NEON SEA SLUG

## AQUATIC SNAILS

Some of these snails live in the sea, others in fresh water. Sea snails are often highly colourful. Many have spectacular spiralling shells, like the huge Triton's trumpet snail, a predator that injects poison into its prey.



DOG WHELK



APPLE SNAIL



GREAT POND SNAIL

Shell up to 50 cm (20 in) long



RAMSHORN SNAIL



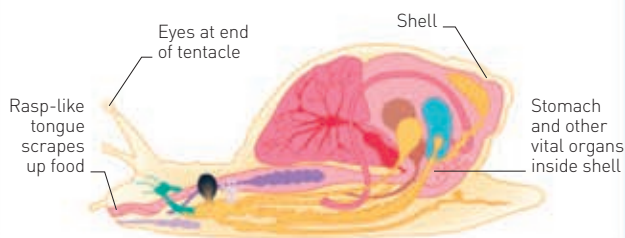
TRITON'S TRUMPET



COMMON WHELK

## 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

PEAR SHAPE

CAP 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.

## SURPRISING RELATIVES

The octopus seems an unlikely relative of slugs and snails, but it is in the same major scientific group – the molluscs. Many other animals, perhaps just as unexpected, also belong to this group. Some of them are shown here.



SMALL GIANT CLAM



AUSTRALIAN GIANT CUTTLEFISH



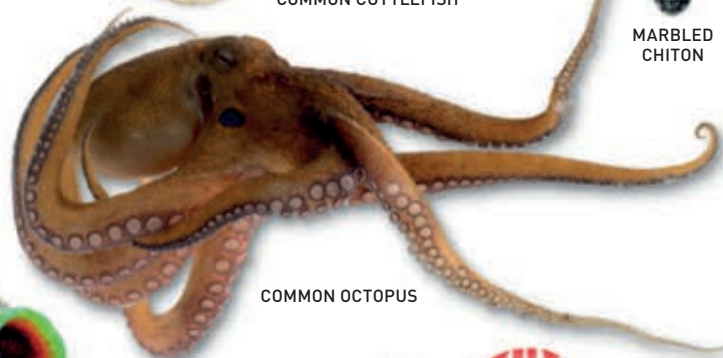
GEODUCK CLAM



COMMON CUTTLEFISH



PACIFIC THORNY OYSTER



COMMON OCTOPUS



MARBLED CHITON



BIGFIN REEF SQUID

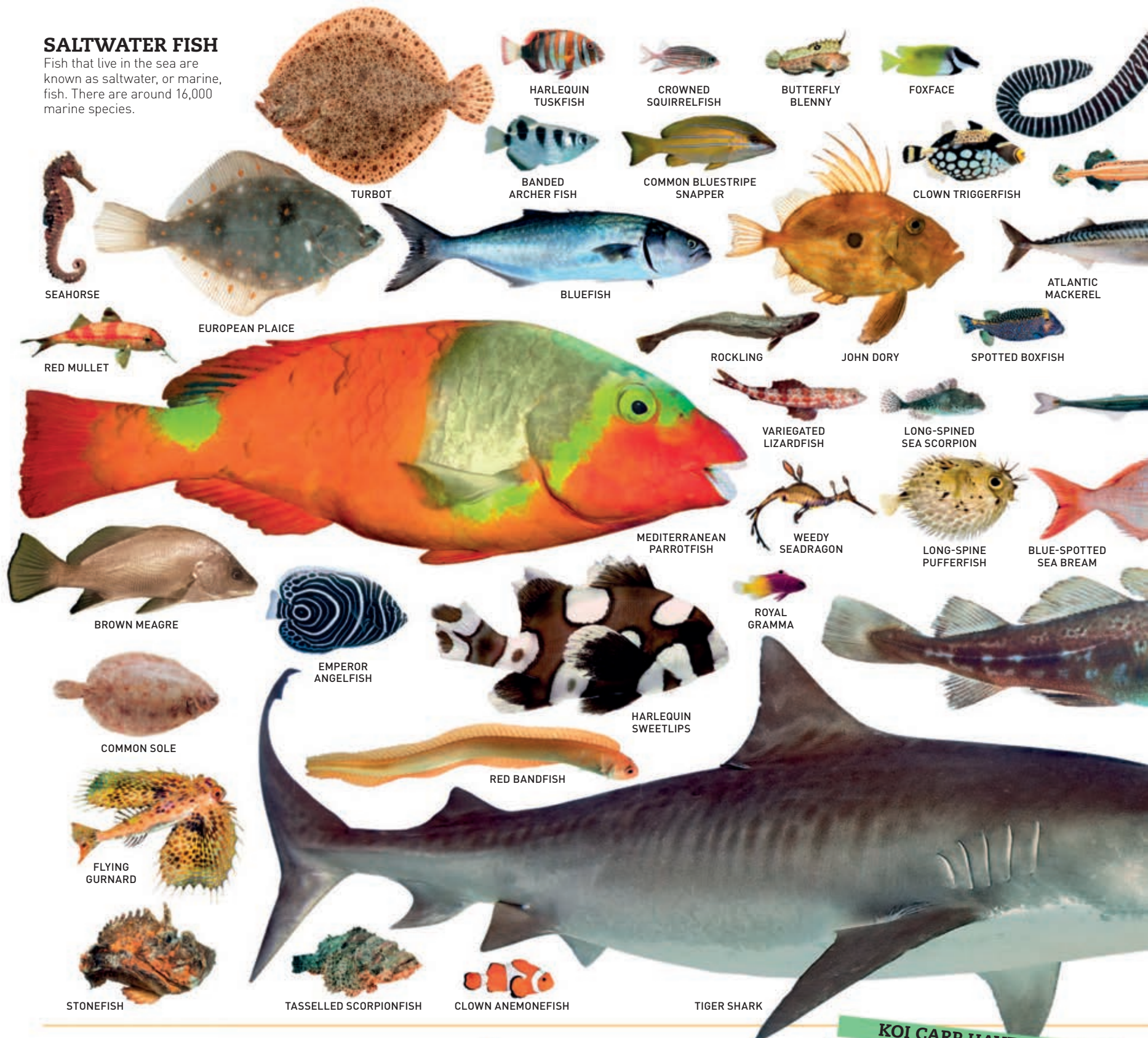


NAUTILUS



## SALTWATER FISH

Fish that live in the sea are known as saltwater, or marine, fish. There are around 16,000 marine species.

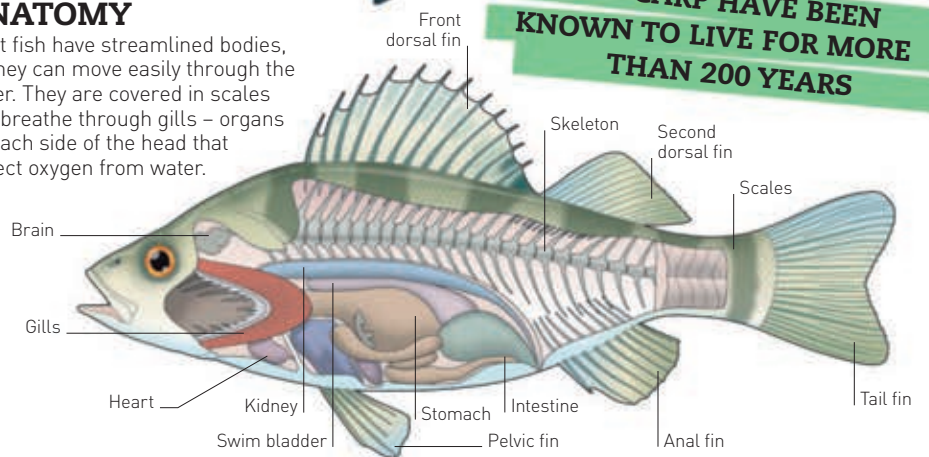


# Fish

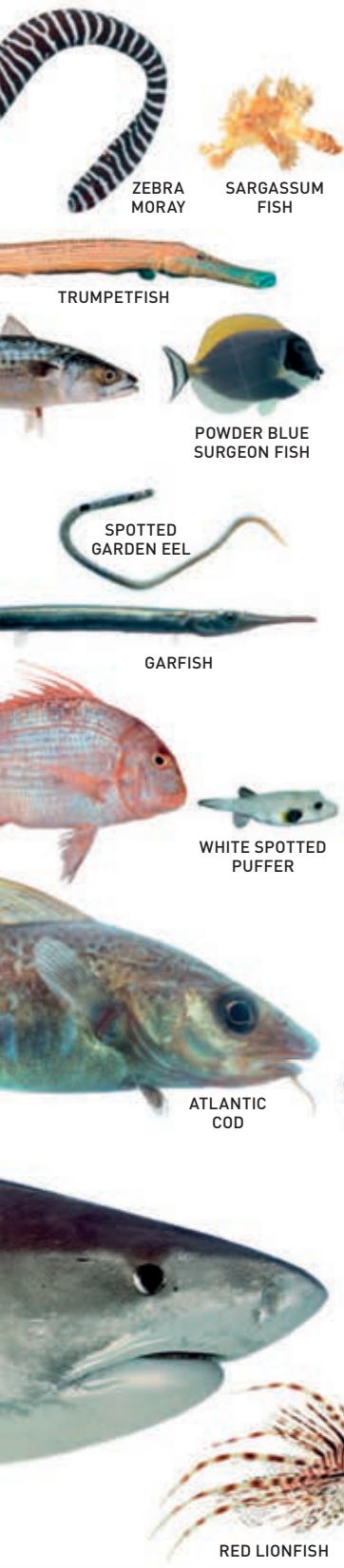
Fish can be found in nearly every type of watery environment, from mountain streams to the deepest oceans. They range from 12 mm (0.5 in) to 16 m (53 ft) in length, and there are more than 30,000 species.

## 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.

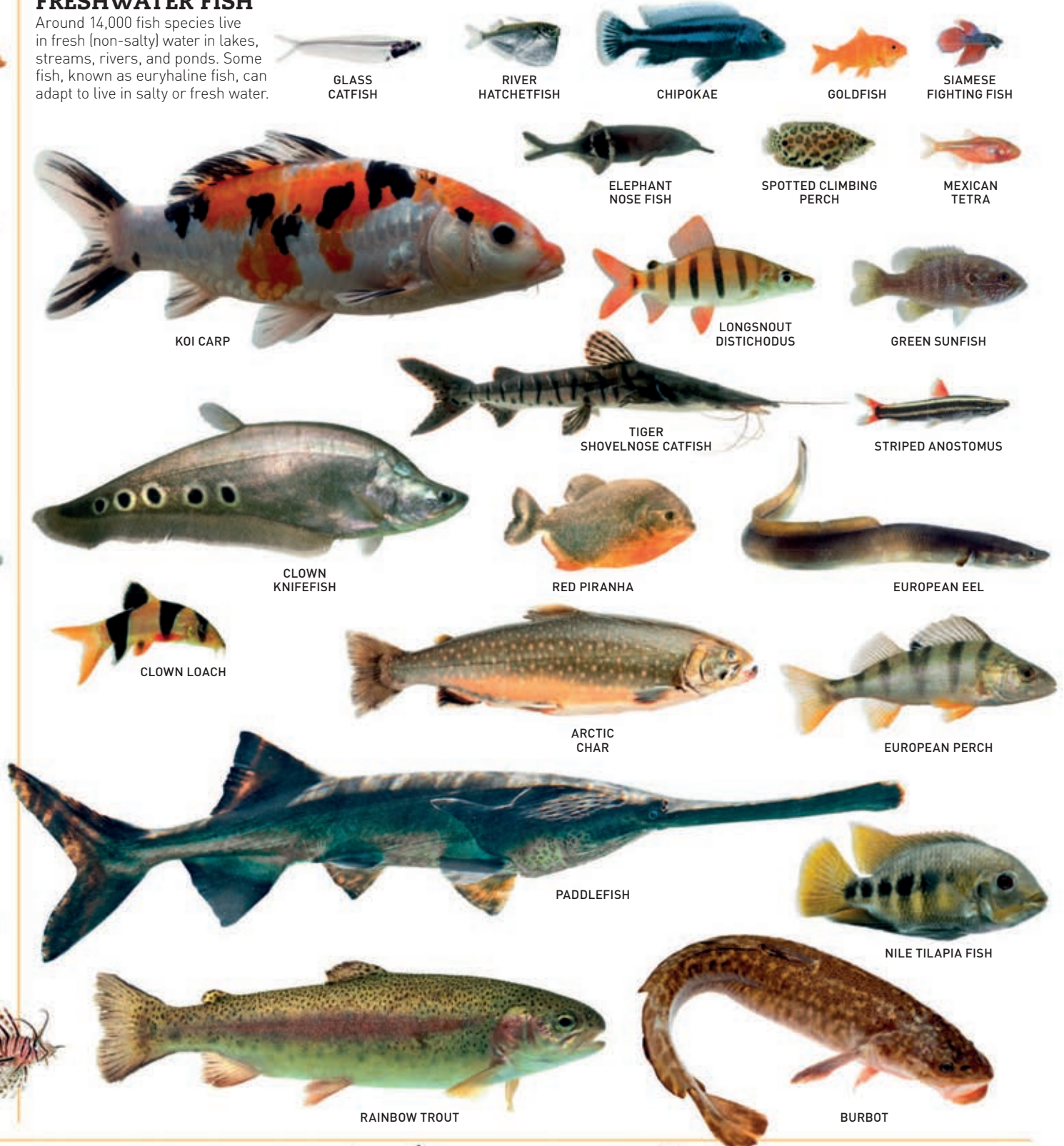






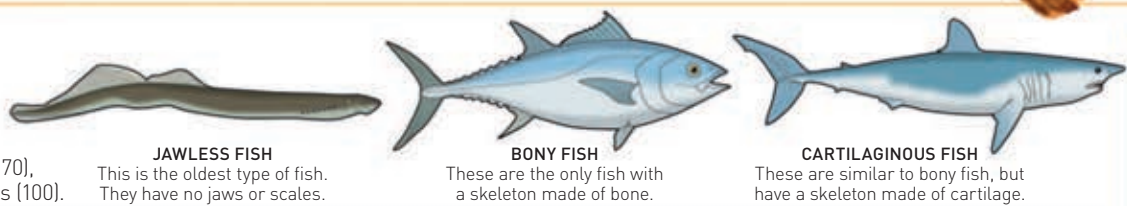
## FRESHWATER FISH

Around 14,000 fish species live in fresh (non-salty) 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.

## DEFENCE

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 to a predator like one big fish.



**BURIED IN SAND**  
Flat fish can alter the colour 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 porcupinefish 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 in a pouch until they hatch.



Eggs kept safely in pouch

**MALE SEAHORSE**

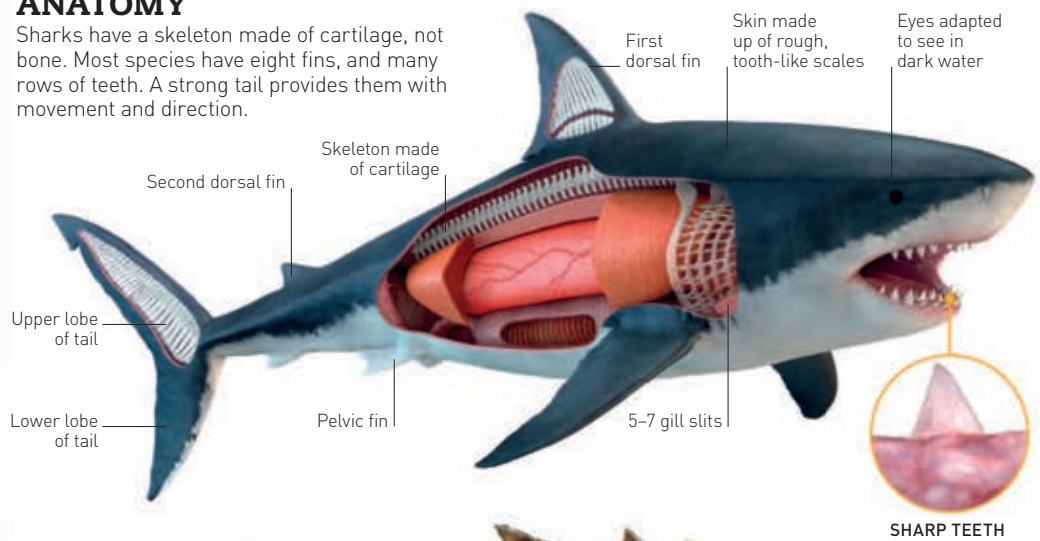


# Sharks

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, perhaps because they are so perfectly suited to their environment. There are around 500 different species of sharks.

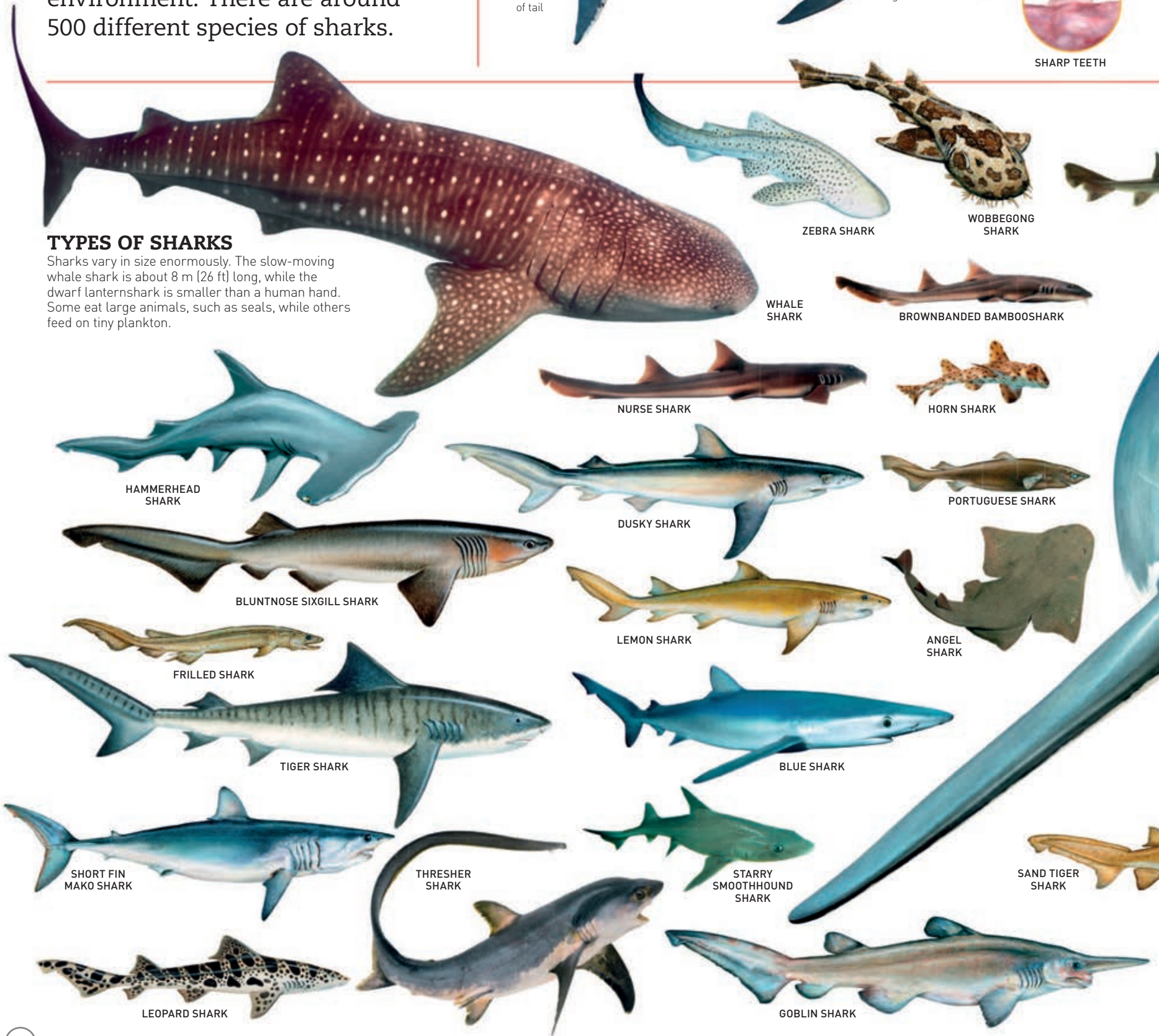
## ANATOMY

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 SHARKS

Sharks vary in size enormously. The slow-moving whale shark is about 8 m (26 ft) long, while the dwarf lanternshark is smaller than a human hand. Some eat large animals, such as seals, while others feed on tiny plankton.



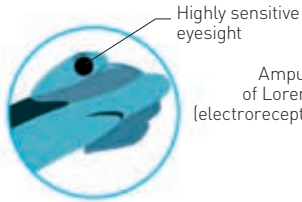


## SENSES

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.



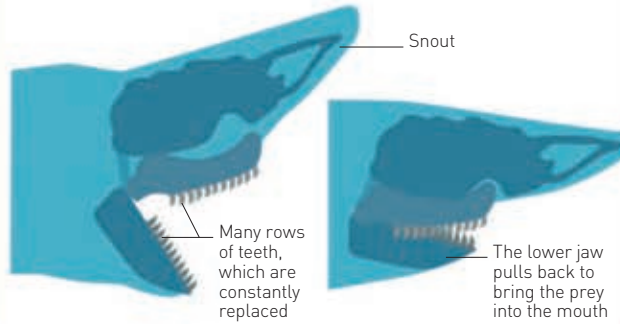
**EYES**  
A shark's eyes are about ten times more sensitive to light than human eyes.



**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.

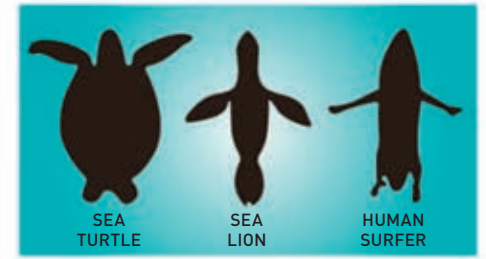


Many rows of teeth, which are constantly replaced

The lower jaw pulls back to bring the prey into the mouth

## MISTAKEN IDENTITY

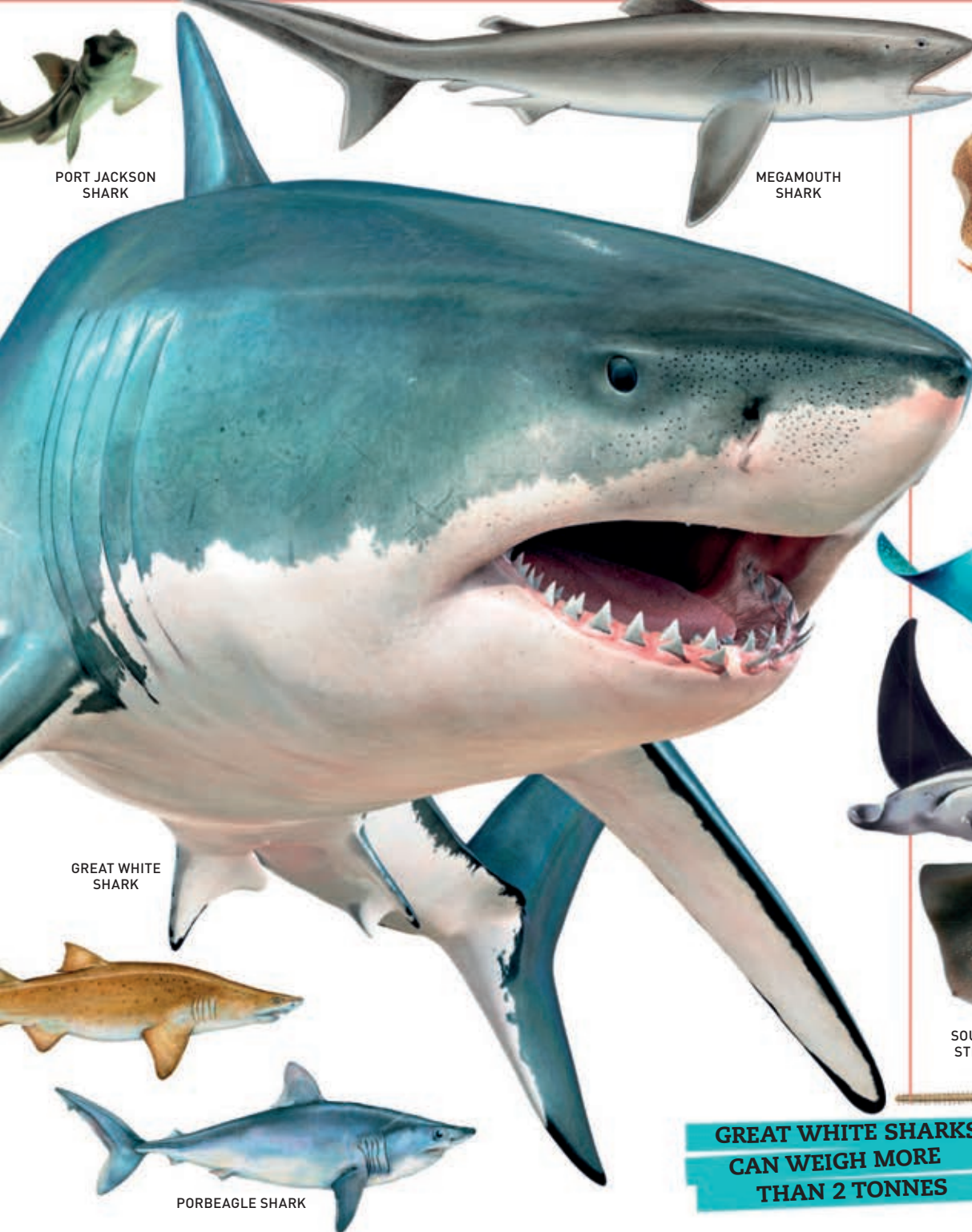
Although there are around 500 shark species, only 25 have been known to attack humans. This may be because they mistake people for fish, seals, sea lions, or turtles.



**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



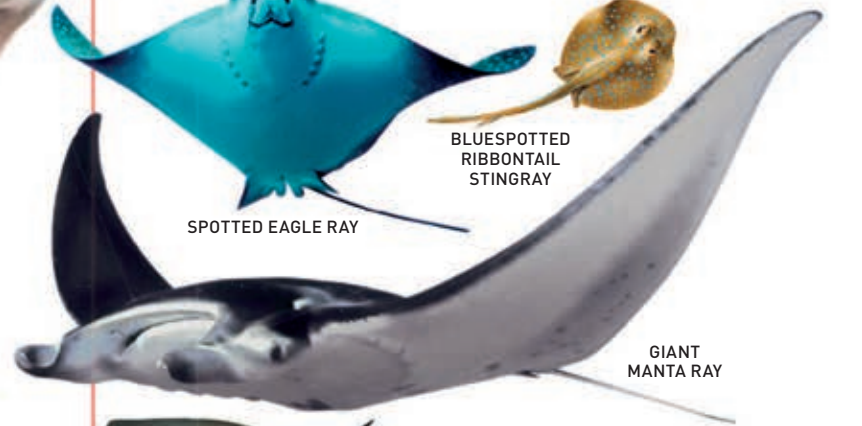
THORNBACK RAY

BARNDOOR SKATE



SPOTTED EAGLE RAY

BLUESPOTTED RIBBONTAIL STINGRAY



GIANT MANTA RAY



SOUTHERN STINGRAY

COMMON STINGRAY



SMALLTOOTH SAWFISH



SPOTTED RATFISH

**GREAT WHITE SHARKS CAN WEIGH MORE THAN 2 TONNES**



# Seashells

The shells that wash up on beaches are the empty homes of soft-bodied sea animals called molluscs. Shells come in amazing shapes and colours. Some have two joined halves, 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?

Molluscs 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.

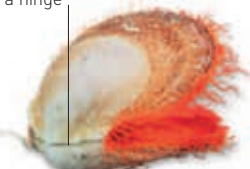
**THERE ARE MORE THAN 50,000 KNOWN SPECIES OF MOLLUSCS**



**LIMPET**

Tucked beneath its shell, a limpet clinging tightly to a rock is very difficult to dislodge.

Two parts open on a hinge



**FLAME SCALLOP**

It is hard for a predator to open a scallop shell once the hinged halves are firmly shut.

Snail's large foot emerges



**COMMON WHELK**

Like its land-based cousins, this sea snail pulls itself into its shell to escape danger.



**HERMIT CRAB**

This soft-bellied crab makes its home in discarded sea snail shells.

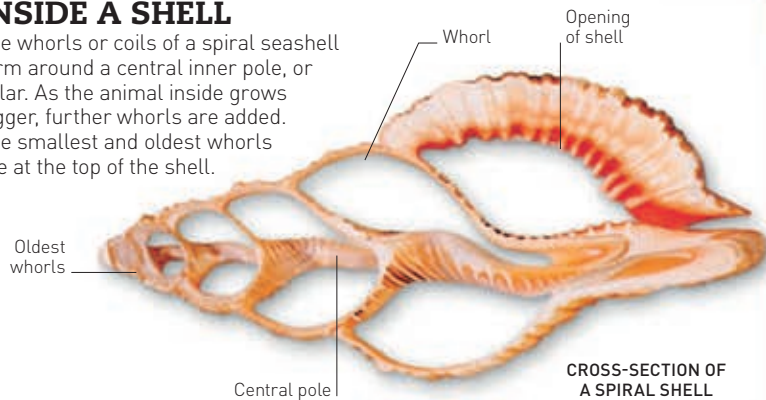


**SHORE CRAB**

Crabs regularly shed their own shells. Until a new one hardens, a "borrowed" scallop shell can provide protection.

## 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 molluscs on Earth are the giant clams, which can weigh as much as 227 kg (500 lb). The smallest shells belong to some minute sea snails, several of which would fit on a thumbnail.



**LARGEST SHELL: GIANT CLAM**  
1.2 m (4 ft)



**SMALLEST SHELL: SEA SNAIL**  
1 mm (0.04 in)



## HINGED SHELLS

Many sea animals – 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 about on a large fleshy foot.



**COMMON EGG COWRIE**



**HUMPBACK COWRIE**



**EYED COWRIE**



**HONEY COWRIE**



**TROSCHEL'S MUREX**



**SCARLET CONE**



**TEXTILE CONE**



**TRITON'S TRUMPET**



**SPOTTED TUN**

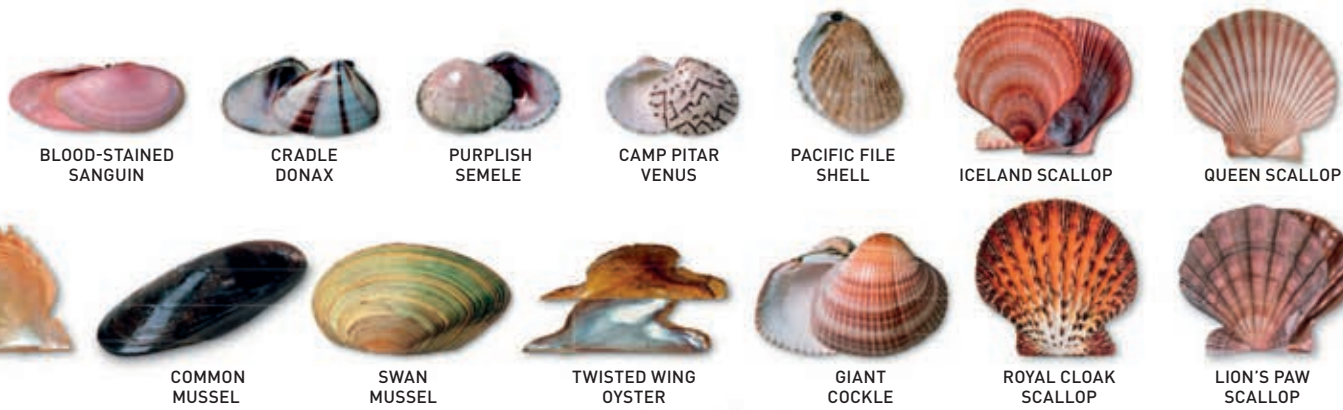


**MAPLE LEAF TRITON**



**ROBIN REDBREAST TRITON**





BLOOD-STAINED SANGUIN

CRADLE DONAX

PURPLISH SEMELE

CAMP PITAR VENUS

PACIFIC FILE SHELL

ICELAND SCALLOP

QUEEN SCALLOP



COMMON MUSSEL

SWAN MUSSEL

TWISTED WING OYSTER

GIANT COCKLE

ROYAL CLOAK SCALLOP

LION'S PAW SCALLOP

## 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

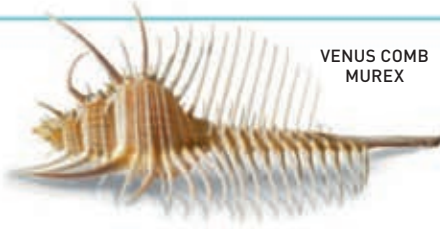


EUROPEAN CHINA LIMPET

LISTER'S KEYHOLE LIMPET

CINNABAR LIMPET

PACIFIC SUGAR LIMPET



VENUS COMB MUREX



COMMON PURPLE SEA SNAIL

PRECIOUS WENTLETRAP



EPISCOPAL MITRE

BLOODSUCKER MITRE

SUPERIOR MITRE

DENNISON'S MITRE

LITTLE FOX MITRE

BUTTERFLY MITRE

PUNCTURED MITRE



CLEAR SUNDIAL

STARRY MOON



LIGHTNING WHELK

## 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 squid-like 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.



MATCHLESS CONE

RAPA SNAIL

HOOPED WHELK

NORTH'S LONG WHELK

CLATHRATE DOG WHELK

GLANS DOG WHELK

PIMPLED DOG 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



NAUTILUS



COMMON SPIRULA



PAPER-NAUTILUS



## FROGS AND TOADS

There are around 5,860 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 start life in the water, where they breathe using gills. As adults they develop lungs, which allow them to live on the land too. 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



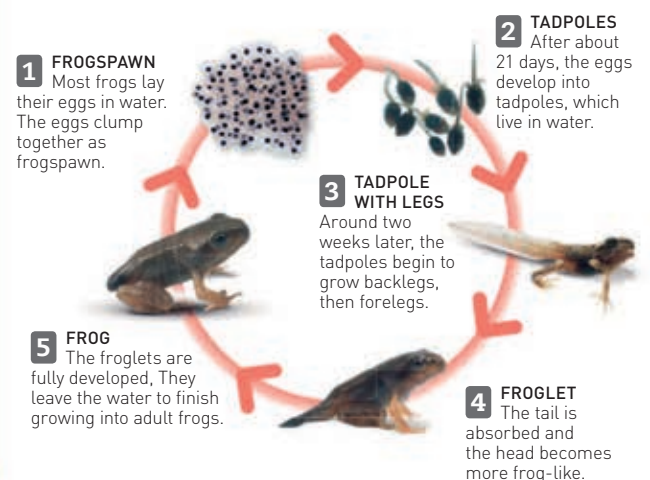
MANY HATCH AS TADPOLES



LAY EGGS TO REPRODUCE

## LIFECYCLE OF A FROG

Frogs lay hundreds of eggs because many of them get eaten by predators. Those that survive undertake remarkable changes, becoming tadpoles then frogs in a cycle that lasts 11 weeks.







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



PICKEREEL FROG



CANE TOAD



CROCODILE NEWT



SMOOTH NEWT



MARBLE NEWT

### CAECILIANS

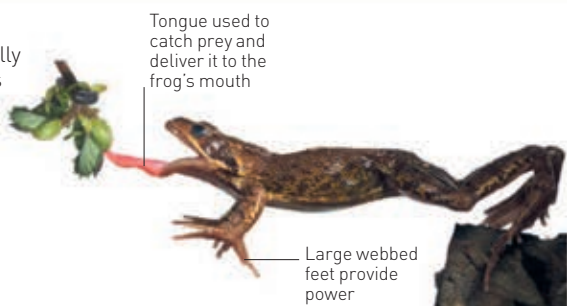
These limbless, worm-like amphibians are rarely seen. They live in soil, burrows, or underwater and use their sharp, curved teeth to catch worms.



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.

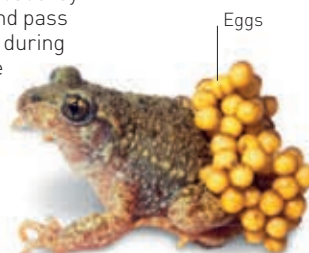


Tongue used to catch prey and deliver it to the frog's mouth

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. The smaller forelimbs help it to change direction.



**1 PULL**  
The frog pulls its back legs towards its body by contracting its thigh muscles.



**2 KICK**  
It pushes its forelimbs down to its sides as it begins to kick backwards.



**3 STEER**  
As the legs finish the kick, the forelimbs reach forwards 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.

#### 1 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.

#### 2 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.

#### 3 PHANTASMAL POISON FROG

This bright red and white frog lives in Ecuador. It is tiny – only 1–4 cm (0.4–1.6 in) – 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 sea, 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.



## 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.

**GALAPAGOS TORTOISES, THE LARGEST IN THE WORLD, CAN GROW UP TO 1.2 M (4 FT) LONG AND WEIGH UP TO 270 KG (595 LB)**



# 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



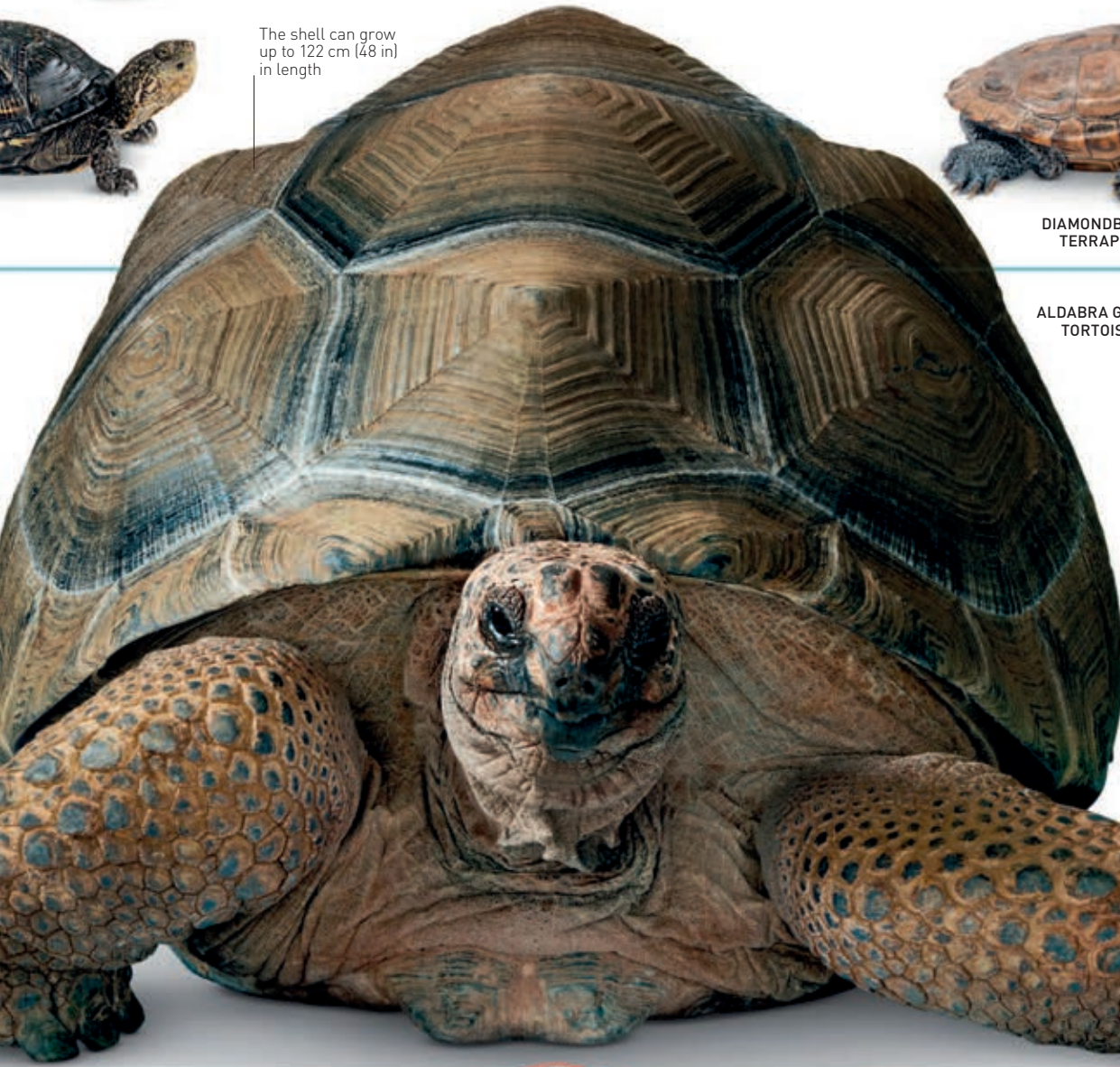
LITTLE PAINTED TURTLE



WOOD TURTLE



The shell can grow up to 122 cm (48 in) 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.

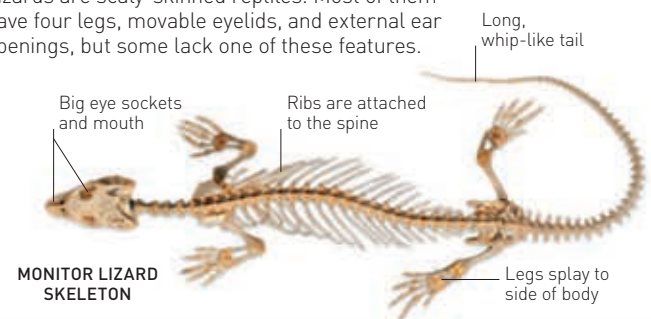


# Lizards

With more than 5,500 species, lizards are the largest group of reptiles on Earth. They are cold-blooded animals that live in every continent except Antarctica. Lizards are useful predators of insect pests.

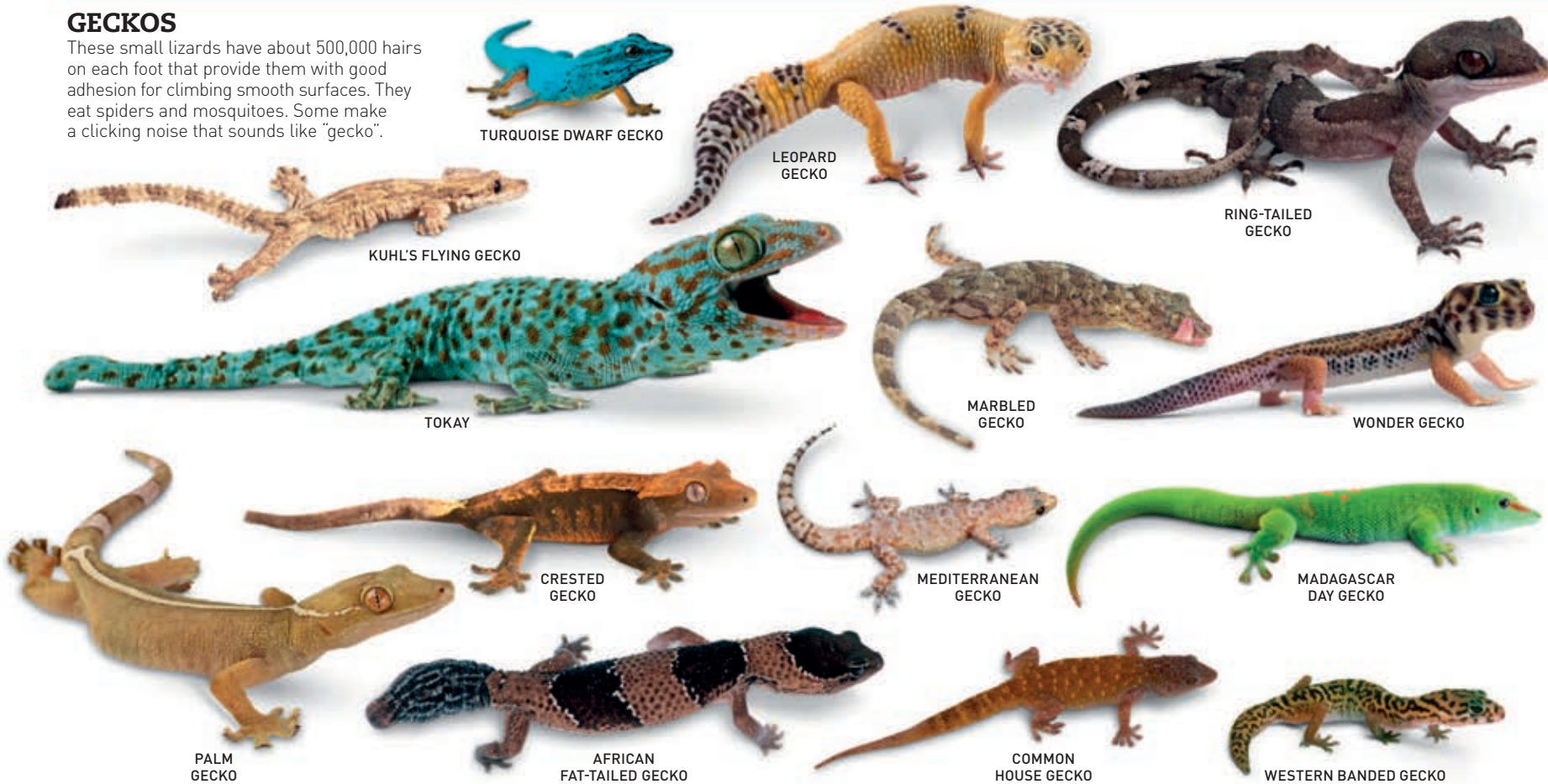
## ANATOMY

Lizards are scaly-skinned reptiles. Most of them have four legs, movable eyelids, and external ear openings, but some lack one of these features.



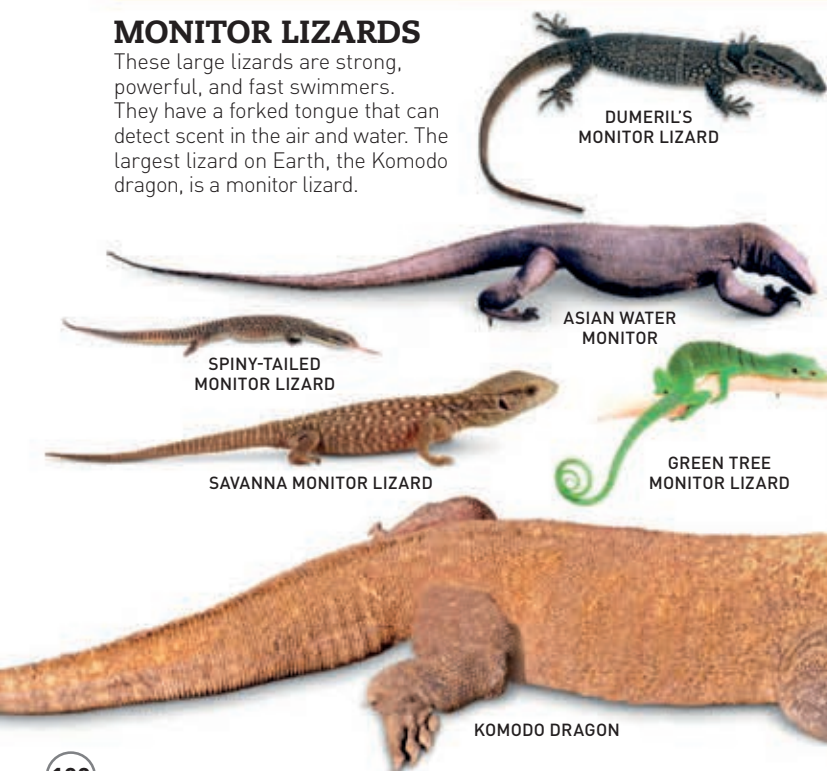
## GECKOS

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".



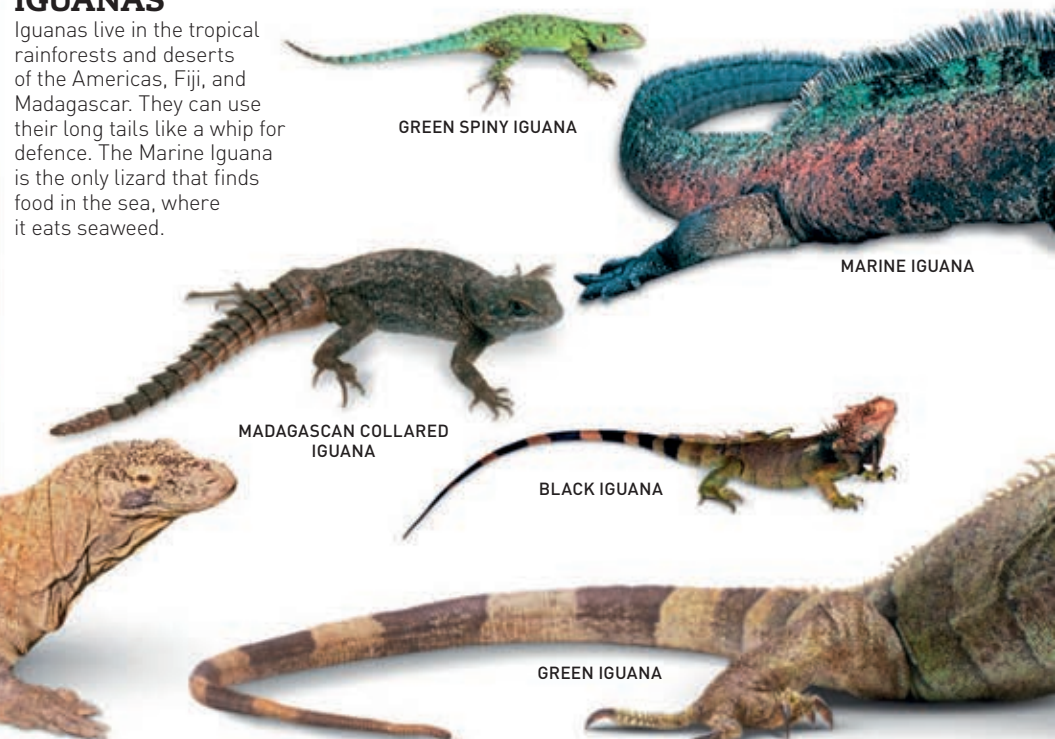
## MONITOR LIZARDS

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.



## 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 defence. The Marine Iguana is the only lizard that finds food in the sea, where it eats seaweed.





## 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 ten 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 70 kg (154 lb) and can hunt down large animals.



**BRITISH VIRGIN ISLAND DWARF GECKO**  
18 mm (0.75 in) long

**KOMODO DRAGON**  
3.1 m (10 ft) 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

### COLOUR CHANGE

Chameleons have special skin cells containing tiny sacs of different coloured pigments. The lizard's moods – such as anger and fear – cause changes in its body that trigger the release of colour from the sacs.



### PANTHER CHAMELEON

A calm chameleon is usually a pale green colour. When it wants to show off to a possible mate, the chameleon may display all sorts of colours 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 lizards. Some are small families, such as the seven tegu species, while others are large, such as the 391 species of anole lizards.



KNIGHT ANOLE

GREEN ANOLE

FRILLED LIZARD

RED TEGU

THAI WATER DRAGON



# Snakes

There are several thousand different types of snakes. Most of them are not venomous or dangerous to people, and many are beautiful, with bright colours 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

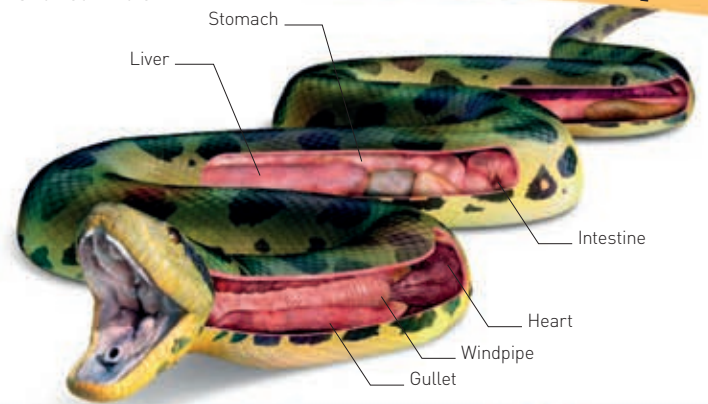


FORKED TONGUE

## INSIDE A SNAKE

A snake's inner organs are designed 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**



## COLUBRIDS

With their diverse colours 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

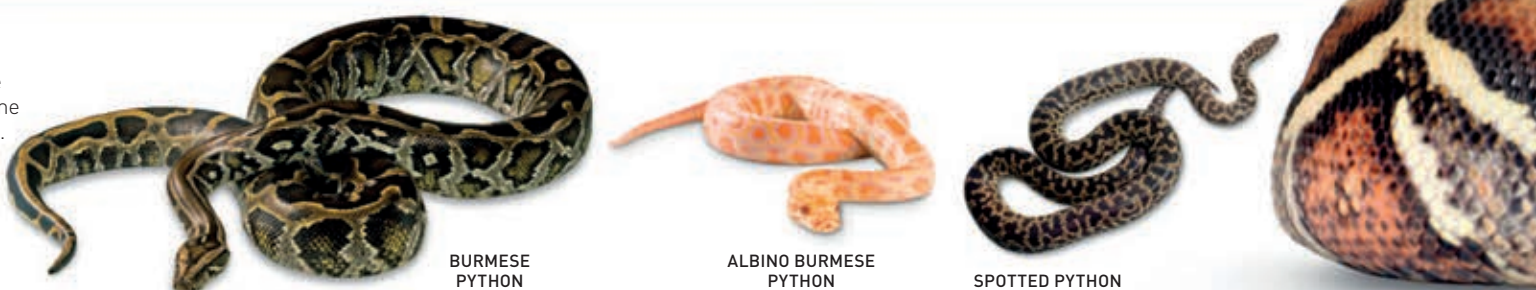
CENTRAL AMERICAN CORAL SNAKE

RED SPITTING COBRA

KING COBRA

## PYTHONS

These often very big constricting snakes come from Asia and Africa. Some types are popular as pets.



BURMESE PYTHON

ALBINO BURMESE PYTHON

SPOTTED PYTHON





## 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.



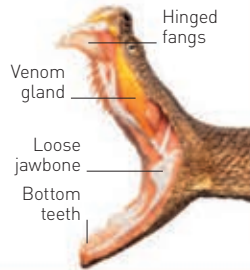
**2 HEAD FIRST**  
Its prey held head first, the snake is ready to eat.



**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. In some species, the fangs move forwards 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 15 m (50 ft) long and weighed 1,130 kg (2,500 lb).

Titanoboa:  
Length 15 m (50 ft)

Average human:  
Height 1.8 m (6 ft)



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

PARAGUAYAN  
ANACONDA

GREEN  
ANACONDA

COMMON BOA

DUMERIL'S  
BOA

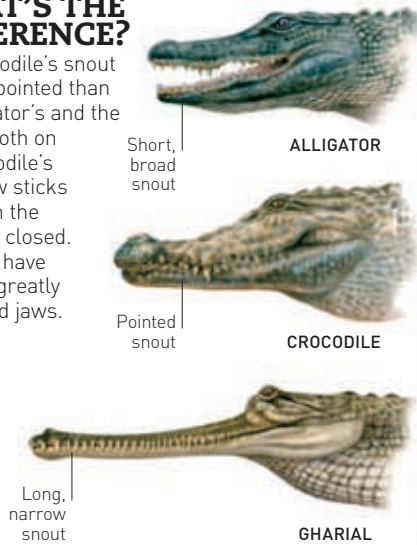
CALABAR GROUND BOA

**AFTER A LARGE MEAL A BOA  
MAY NOT EAT AGAIN FOR  
WEEKS OR EVEN MONTHS**



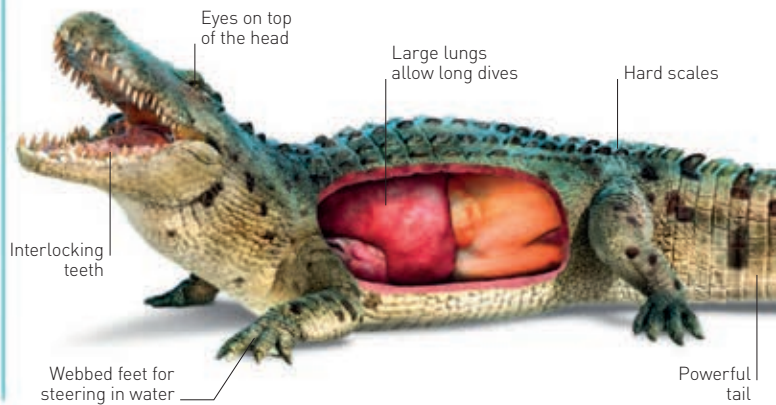
## WHAT'S THE DIFFERENCE?

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.



## ARMOURED 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 under water. 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.



**JUST HATCHED**  
The mother carries her newly hatched young in her mouth to take them to the water.

# 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 endangered gharial occurs only in the rivers of India. Its long jaws are ideal for catching fish. Unlike other crocodylians, 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 USA. 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-SNOUDED CAIMAN



SPECTACLED CAIMAN



CUBAN CROCODILE



DWARF CROCODILE

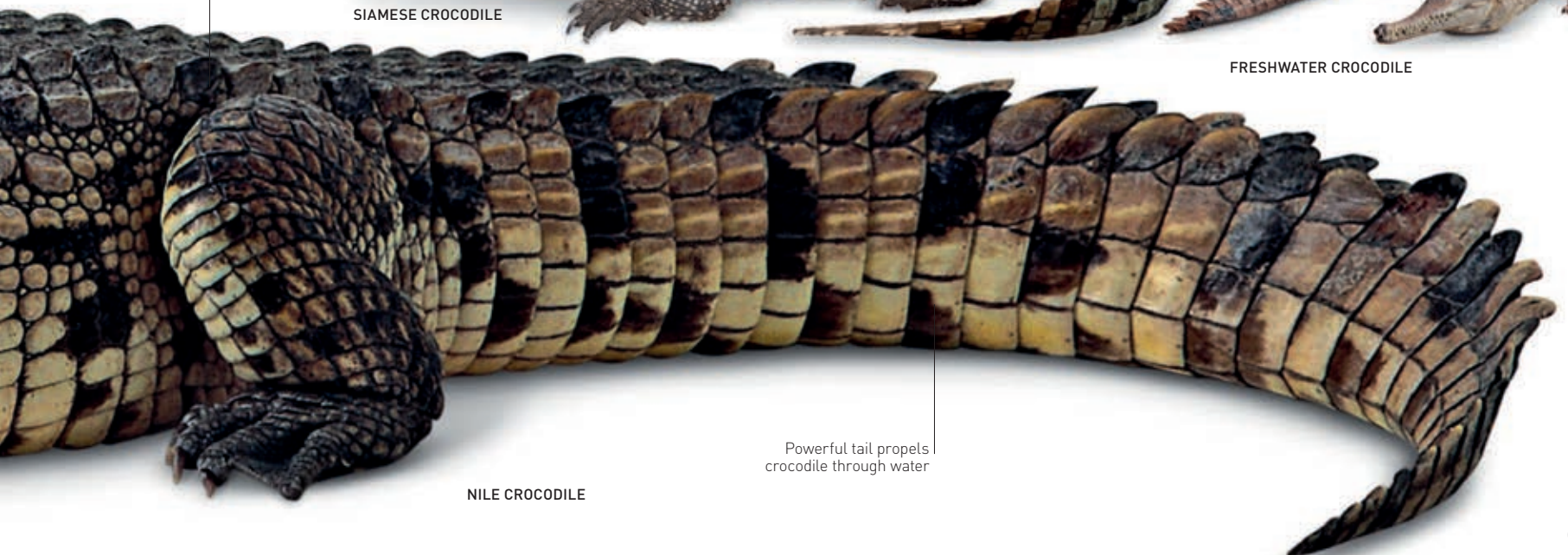


SIAMESE CROCODILE



FRESHWATER CROCODILE

Large scales armoured 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.



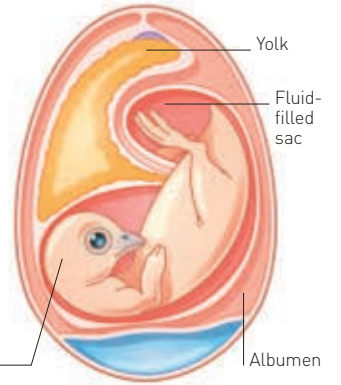
**SPHERICAL**  
Usually laid by birds that build deep nests.



**CONICAL**  
These eggs pack closely in the nest for equal warmth.

## INSIDE AN EGG

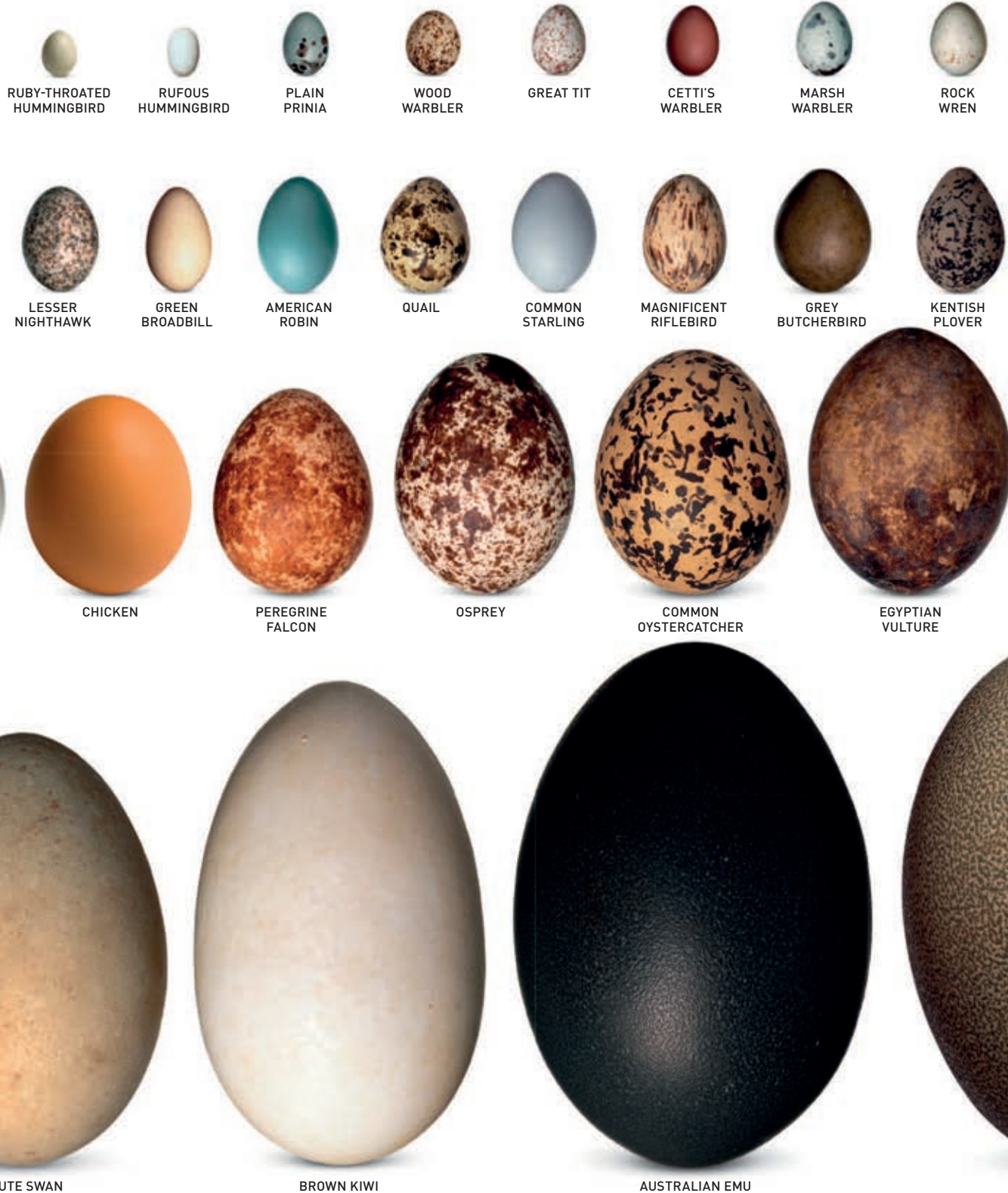
The developing bird, which is known as the "embryo", is cushioned inside a sac or bag full of fluid. The yellow yolk provides the embryo with most of its food, but the albumen, or "white", also gives it protein and water.



**CHICKEN EMBRYO INSIDE EGG**

## BIRD EGGS

Eggs come in lots of different colours and patterns, which may help to camouflage them from predators. The colours 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



GREY TINAMOU



OSTRICH



SOUTHERN CASSOWARY

## 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-THIGGED TORTOISE GALAPAGOS 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.

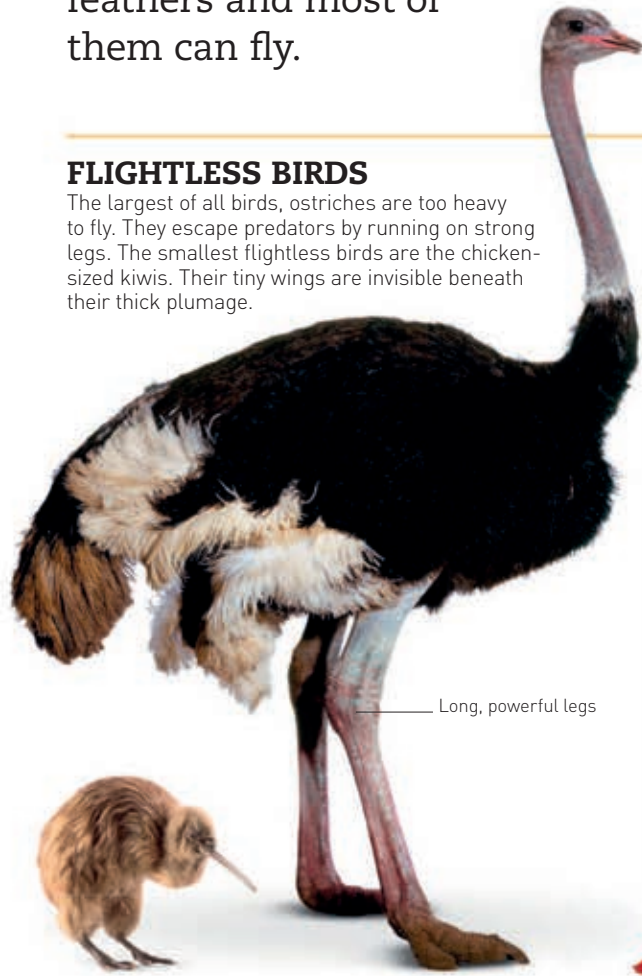


GOLDFISH  
RAINBOW TROUT CHINESE OAK SILK MOTH CATERPILLAR  
OWL BUTTERFLY CATERPILLAR SLUG  
LESSER SPOTTED DOGFISH



# 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.



Long, powerful legs

KIWI

OSTRICH

**OSTRICHES CAN SPRINT FASTER THAN MOST HORSES CAN GALLOP, REACHING SPEEDS OF UP TO 70 KM/H (43 MPH)**

## PENGUINS

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 further north.



EMPEROR PENGUIN  
AND CHICK

## 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.



GREEN HERON

SCARLET IBIS

GREY HERON

EUROPEAN WHITE STORK

## PELICANS

The long-beaked pelicans, and their relatives the gannets, are fisheaters. Pelicans scoop up their catch in a large throat pouch.



BROWN PELICAN

NORTHERN GANNET

## 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.



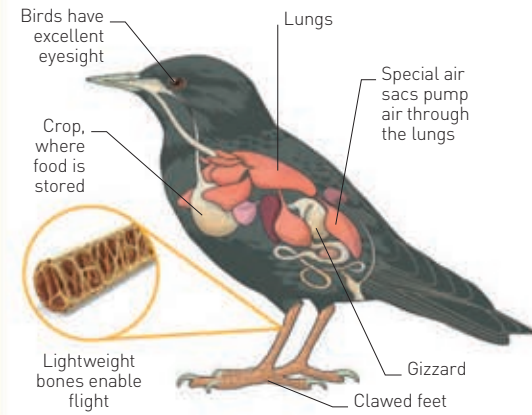
**TOOTHLESS BEAK**  
Having no teeth, birds grind their food in a "gizzard".



**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.



Birds have excellent eyesight

Lungs

Special air sacs pump air through the lungs

Crop, where food is stored



Lightweight bones enable flight

Gizzard  
Clawed feet

## FLIGHTLESS BIRDS

The largest of all birds, ostriches are too heavy to fly. They escape predators by running on strong legs. The smallest flightless birds are the chicken-sized kiwis. Their tiny wings are invisible beneath their thick plumage.

## GAME BIRDS

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.



GREY PARTRIDGE

COMMON PHEASANT

CALIFORNIAN QUAIL

INDIAN PEACOCK

SPRUCE GROUSE

TURKEY

## 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.



GREAT SPOTTED CUCKOO

GREATER ROADRUNNER

RED-CRESTED TURACO

## OWLS

These night hunters have forward-facing eyes and see well in poor light. Fringed feathers allow owls to fly without making a sound.

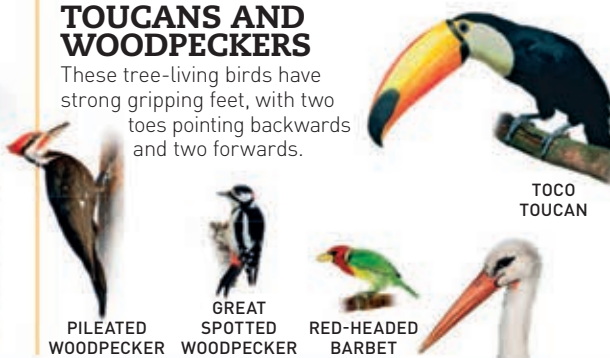


EURASIAN EAGLE OWL

LITTLE OWL

## TOUCANS AND WOODPECKERS

These tree-living birds have strong gripping feet, with two toes pointing backwards and two forwards.



PILEATED WOODPECKER

GREAT SPOTTED WOODPECKER

RED-HEADED BARBET

TOCO TOUCAN

## 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.



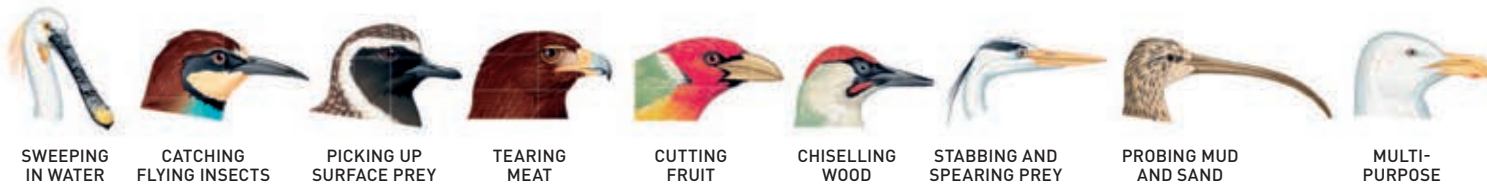
RED KITE

BALD EAGLE



## 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 chiselling off tree bark to reach insects.



SWEEEPING IN WATER

CATCHING FLYING INSECTS

PICKING UP SURFACE PREY

TEARING MEAT

CUTTING FRUIT

CHISELLING WOOD

STABBING AND SPEARING PREY

PROBING MUD AND SAND

MULTI-PURPOSE

## BABY BIRDS

Family life is usually a brief but very busy period. Most birds lay their eggs in a nest. Hatchlings need constant feeding and 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 hatchlings rely on their parents for care and food.

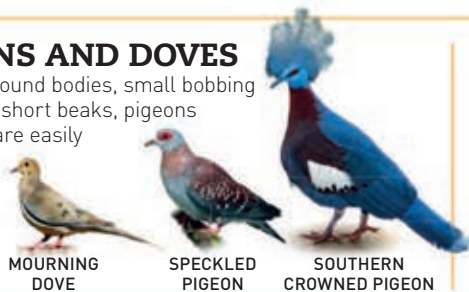
**3 FIVE-DAY-OLD CHICKS**  
Now called "nestlings", the chicks' eyes open and small "pin" feathers develop.

**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 coloured 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.



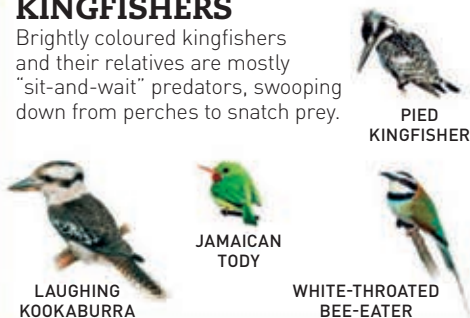
BRAZILIAN RUBY

LUCIFER HUMMINGBIRD

WHITE-THROATED SWIFT

## KINGFISHERS

Brightly coloured kingfishers and their relatives are mostly "sit-and-wait" predators, swooping down from perches to snatch prey.



LAUGHING KOOKABURRA

JAMAICAN TODDY

WHITE-THROATED BEE-EATER

PIED KINGFISHER

## 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

LONG-TAILED DUCK

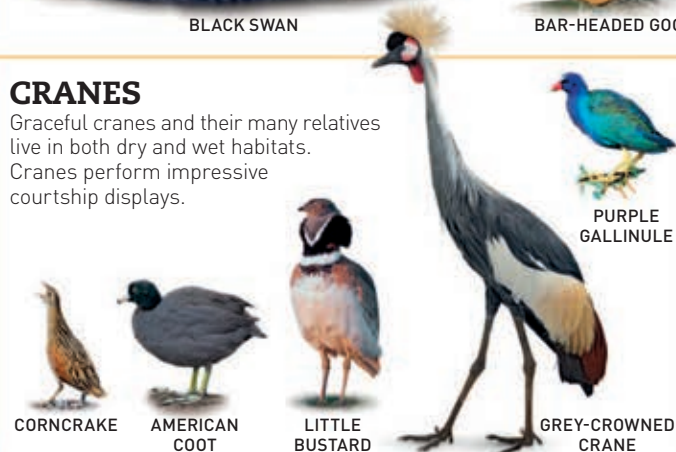
PLUMED WHISTLING DUCK

BAIKAL TEAL

KING EIDER 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

GREY-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.



HEERMAN'S GULL

EURASIAN OYSTERCATCHER

PIED AVOCET

ATLANTIC PUFFIN

COMMON REDSHANK

## PERCHING BIRDS

Most birds are perching birds - their unique feet can grip even very slender branches. Many species are songbirds.



BARN SWALLOW

EASTERN YELLOW ROBIN

LESSER BIRD OF PARADISE

EURASIAN SKYLARK

YELLOW WARBLER

DUNNOCK

WREN TIT

**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.

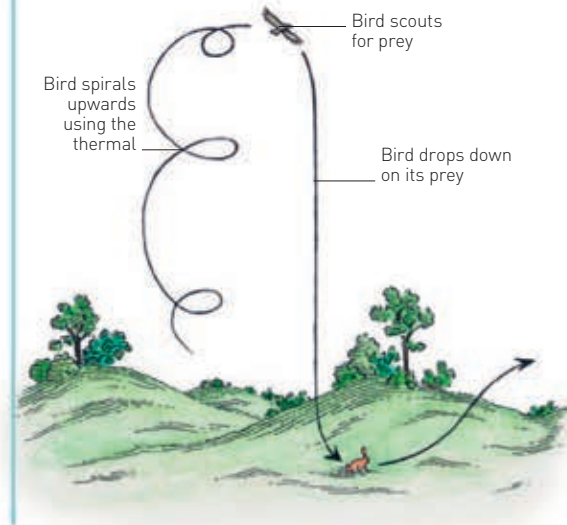


**KILLING FEET**  
Long, curved talons are designed to grasp prey such as rabbits.

**AN EAGLE'S VISION IS AT LEAST FOUR TIMES MORE POWERFUL THAN THAT OF A HUMAN**

## SOARING HIGH

The large wings of some hawks and eagles allow them to soar high in the sky by riding 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 like hawks, eagles, and falcons, this group also includes the largely ground-dwelling secretary birds. Vultures, such as the Andean Condor, rarely kill prey and instead feed on dead animals.

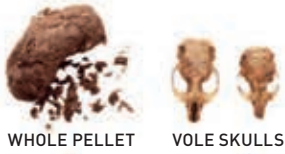




## OWL PELLETS

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



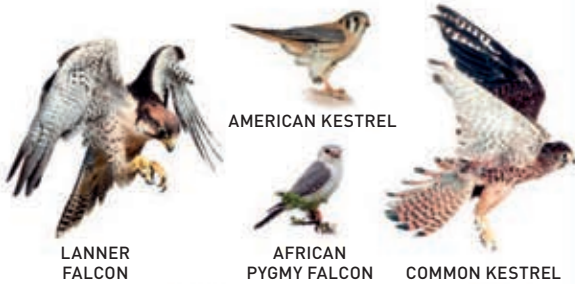
LEG BONES



HIP BONES FRONT-LIMB BONES SHOULDER BLADES



SNAIL KITE MISSISSIPPI KITE WHITE-TAILED KITE



AMERICAN KESTREL

LANNER FALCON AFRICAN PYGMY FALCON COMMON KESTREL



CRESTED CARACARA STRIATED CARACARA



Diet includes snakes

Powerful legs are used to stamp on prey

SECRETARY BIRD

## 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 GREY 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



BOOBOOK 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 to 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 moults 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 colours can help attract a mate.



**CAMOUFLAGE**  
Patterns help bird blend into background.

## TYPES OF FEATHERS

Birds have two main types of feathers: 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.

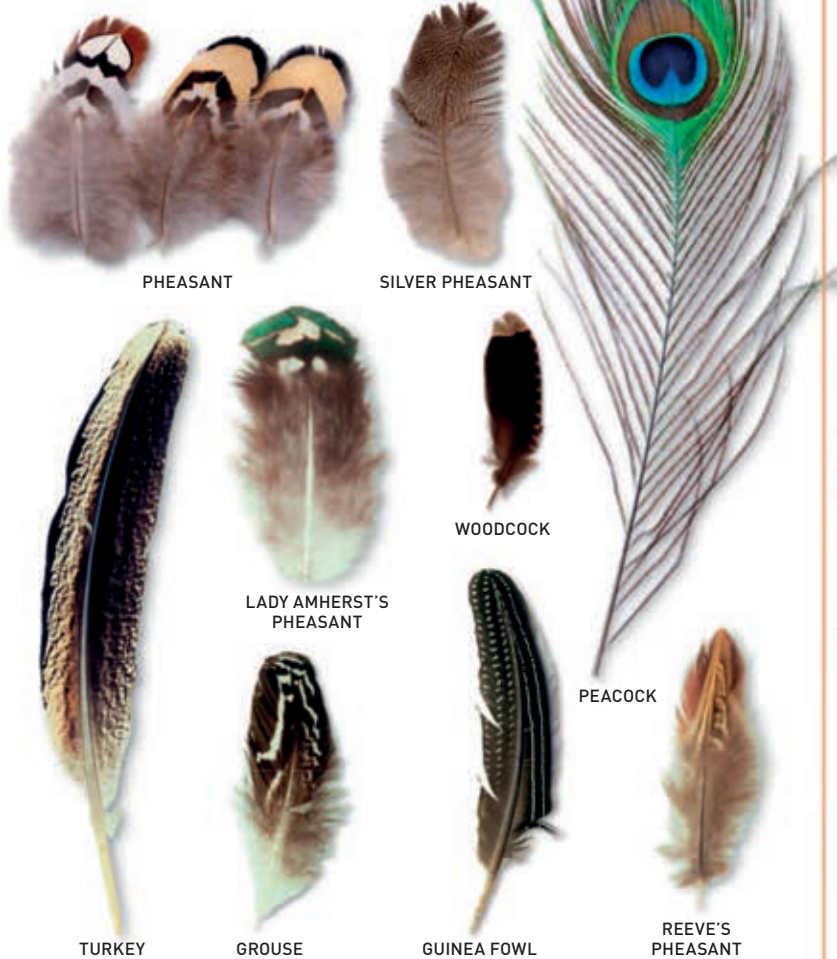
**PRIMARIES**  
These are flight feathers, attached to the front section of the wing.

**TAIL FEATHERS**  
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.



PHEASANT

SILVER PHEASANT

WOODCOCK

LADY AMHERST'S PHEASANT

PEACOCK

TURKEY

GROUSE

GUINEA FOWL

REEVE'S PHEASANT

## PARROTS AND COCKATOOS

Parrots use their brightly coloured feathers to attract the opposite sex. The vivid colours may also help disguise these birds against the vibrant green of the forests where they live.



REGENT PARROT

COCKATIEL

AFRICAN GREY PARROT

BUDGERIGAR

MACAW

## TOUCANS AND WOODPECKERS

Woodpeckers and toucans do not have any soft down feathers, even when they are chicks.



GREEN WOODPECKER

ARACARI

## BIRDS OF PREY

There are two families of birds of prey: falcon-like birds that are awake in the daytime, and owls that are awake at night. Some can soar for hours to look for food, others achieve great speed when they dive down to catch their prey.



BARN OWL

MERLIN

KESTREL

BUZZARD

HAWK

EAGLE OWL

GOLDEN EAGLE

## COLOURFUL DISPLAY

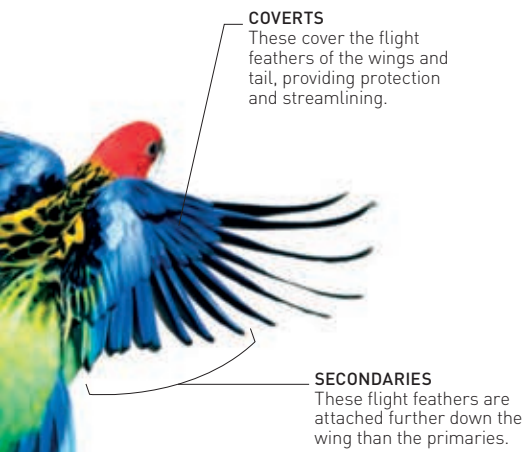
Male peacocks have amazingly colourful tail feathers that spread up and around into a fan shape behind them when they want to attract a mate. The females choose a mate depending on how many eye spots are on his tail – the more the better.



TAIL FEATHERS DOWN

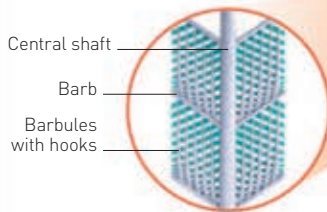
TAIL FEATHERS ON DISPLAY





## FEATHER STRUCTURE

Contour feathers have stiff shafts in the centre, 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.

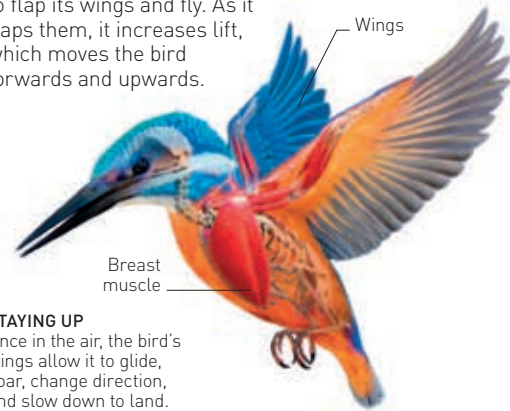


**CLOSE-UP**  
This complex but strong structure holds the feather together.



## 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 forwards and upwards.



**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.



**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.



## PERCHING BIRDS

The stiff tail feathers of many of these birds help them to balance while perching on small branches and garden fences.



**AFTERFEATHER**  
The fluffy part of the bottom of the feather is called the afterfeather. It gives birds an added layer of warmth.

## 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 don't have any contour feathers, only soft down feathers.





# Animal journeys

Every year, some animals move 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.

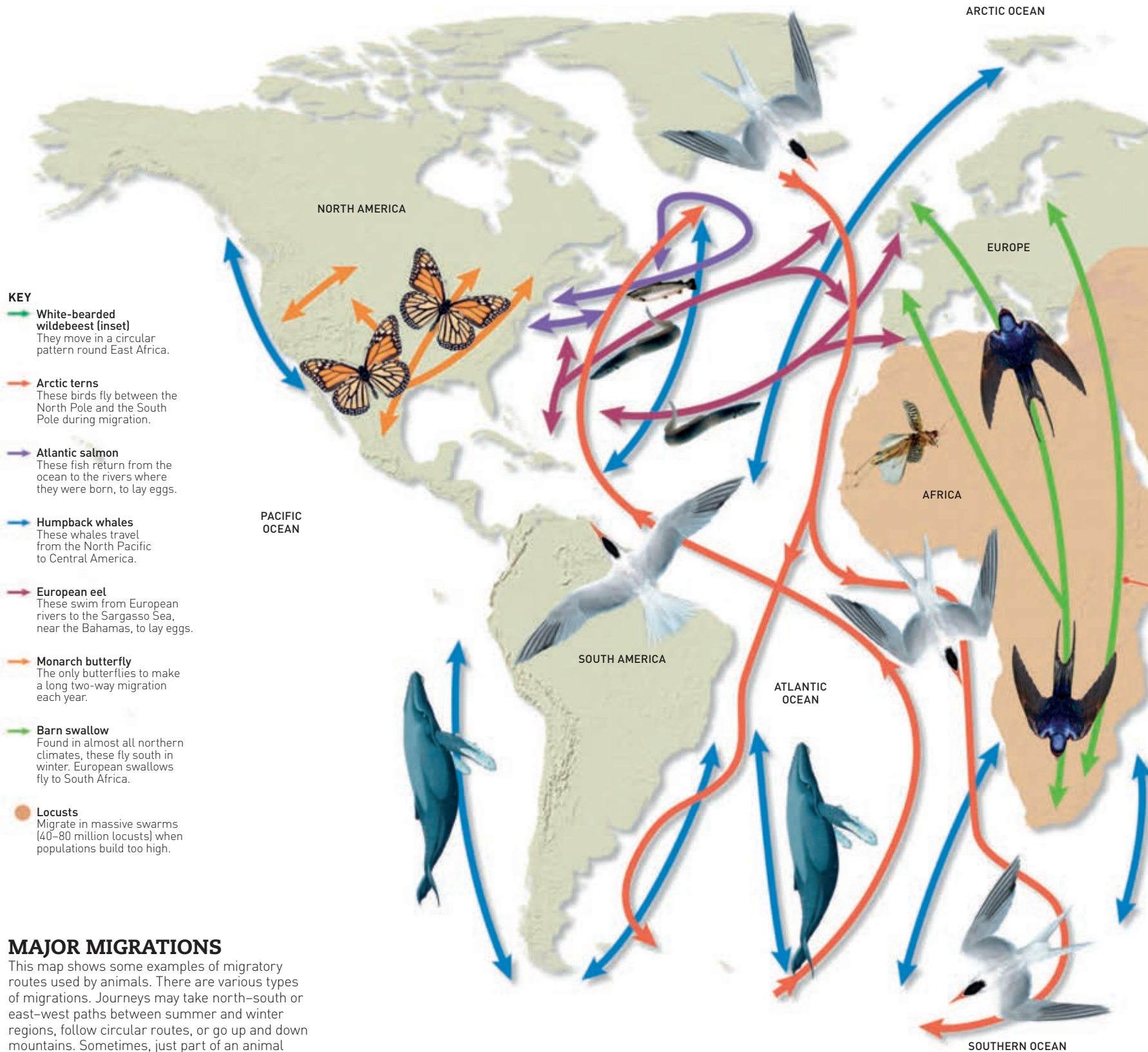
## WHY ANIMALS MIGRATE

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.



**FOR FOOD**  
Many animals migrate from one place to another during the year in search of food, as supplies in one place run out.

**WALRUSES ALWAYS MIGRATE IN SEPARATE MALE AND FEMALE GROUPS**



### KEY

- **White-bearded wildebeest (inset)**  
They move in a circular pattern round East Africa.
- **Arctic terns**  
These birds fly between the North Pole and the South Pole during migration.
- **Atlantic salmon**  
These fish return from the ocean to the rivers where they were born, to lay eggs.
- **Humpback whales**  
These whales travel from the North Pacific to Central America.
- **European eel**  
These swim from European rivers to the Sargasso Sea, near the Bahamas, to lay eggs.
- **Monarch butterfly**  
The only butterflies to make a long two-way migration each year.
- **Barn swallow**  
Found in almost all northern climates, these fly south in winter. European swallows fly to South Africa.
- **Locusts**  
Migrate in massive swarms (40–80 million locusts) when populations build too high.

## MAJOR MIGRATIONS

This map shows some examples of migratory routes used by animals. There are various types of migrations. Journeys may take north–south or east–west paths between summer and winter regions, follow circular routes, or go up and down mountains. Sometimes, just part of an animal population moves, leaving the rest behind.





### 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 autumn. 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.



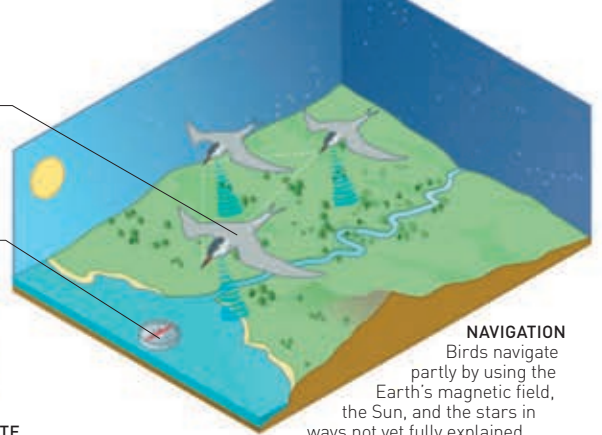
NORMAL BODY FAT



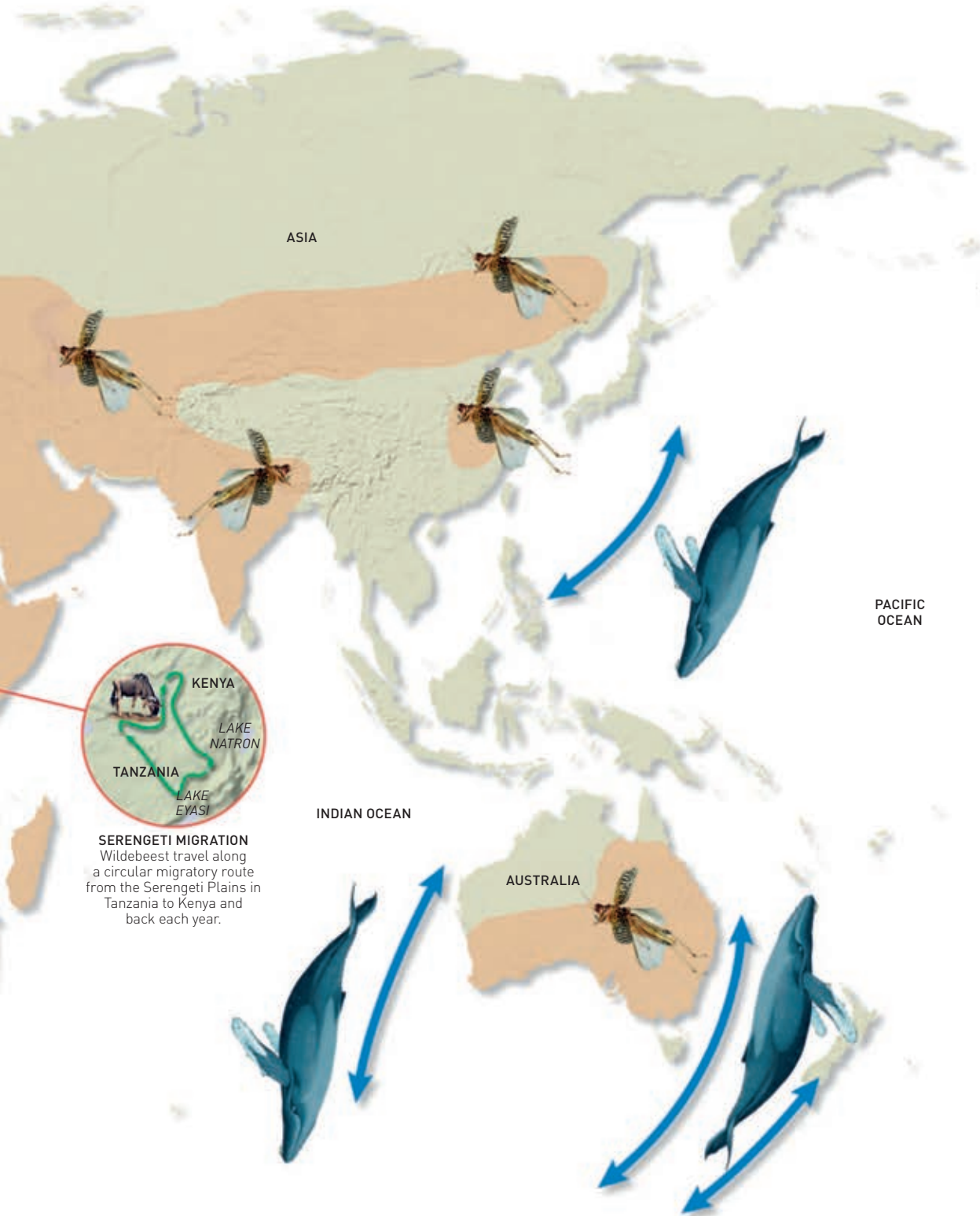
READY TO MIGRATE

Height depends on wind patterns and landforms

The Sun and stars help to set the course



**NAVIGATION**  
Birds navigate partly by using the 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 up 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: 71,000 km (44,000 miles)

This tiny bird migrates further than any other animal in the world, zigzagging between Greenland and Antarctica.



### BAR-TAILED GODWIT

Longest nonstop flight: 11,500 km (7,145 miles)  
One of these shorebirds covered this distance in eight days without a break for food.

### LEATHERBACK TURTLE

Longest recorded aquatic journey: 20,558 km (12,774 miles)  
These travel across the Pacific Ocean to the beach where they were born.



### WHITE-BEARDED WILDBEEST

Largest land migration: 1.3 million wildebeest  
Vast herds can travel 1,610 km (1,000 miles) in a year.



### BAR-HEADED GOOSE

Highest journey: 7,290 m (23,9170 ft)  
Flying at extreme altitude, these birds fly with only ten per cent 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.



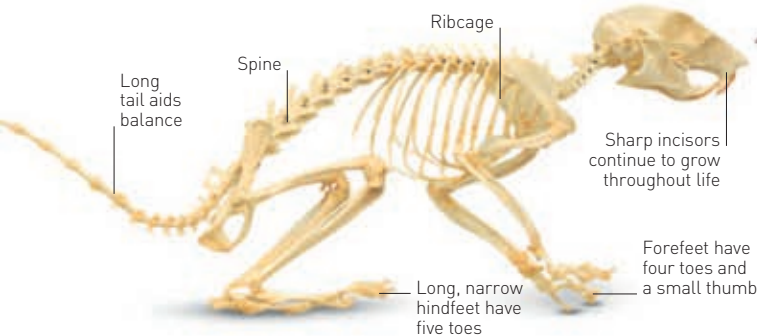


# Rodents

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 are gnawing animals that must constantly wear down their ever-growing front teeth.

## 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 tunnelling, and webbed toes for swimming.



### CLIMBERS

Swivelling 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.

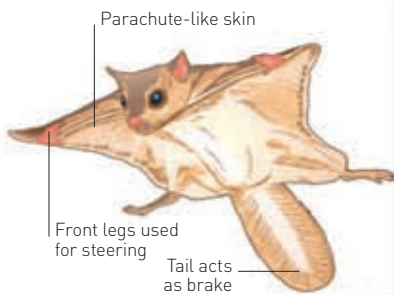


### SWIMMERS

Beavers have webbed feet and a flat tail that is used as a rudder. Thick underfur keeps them warm in water.

## HOW SQUIRRELS "FLY"

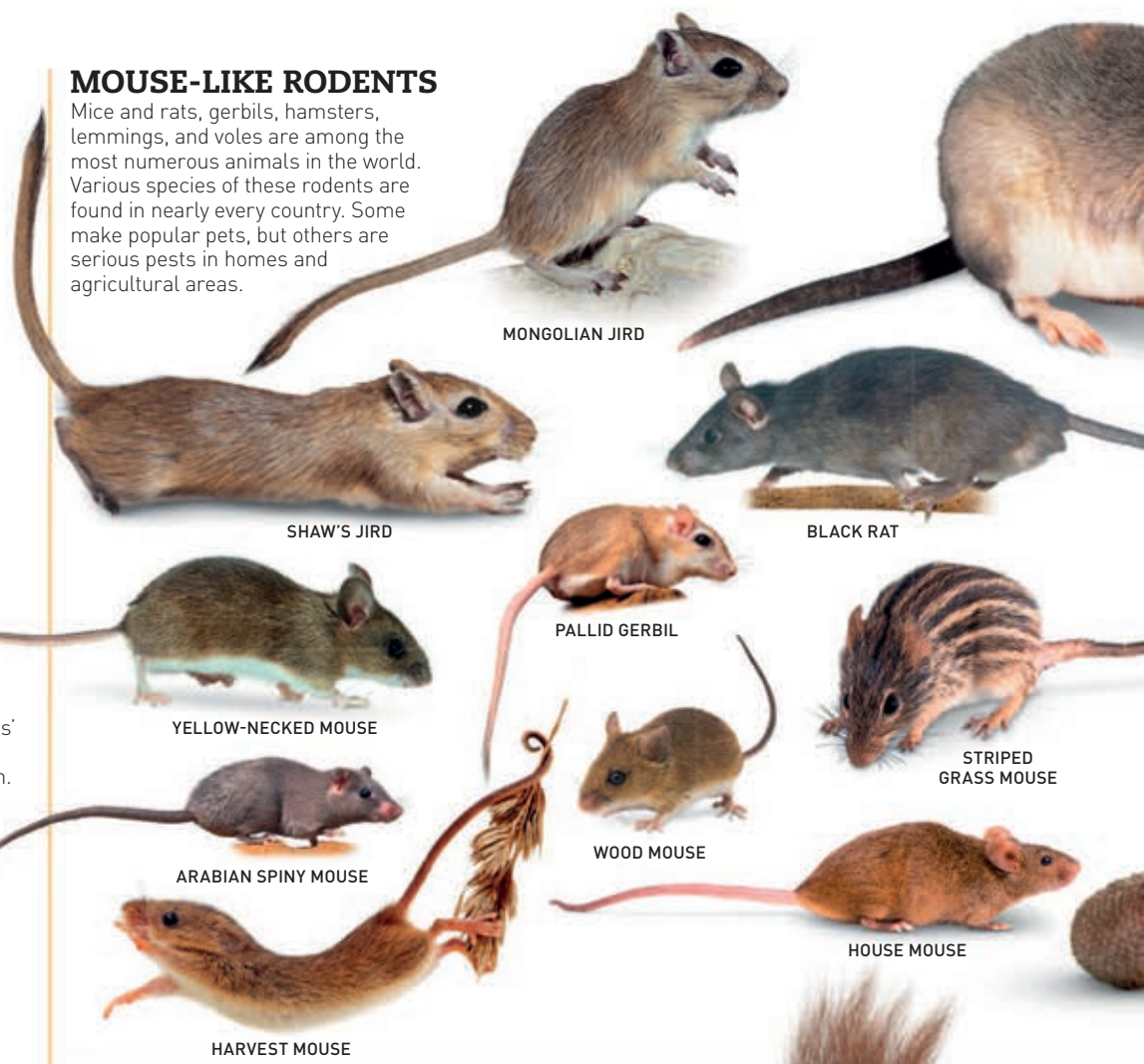
The rodent group includes the flying squirrels. As they move between trees, these animals travel through the air in what appears to be real flight. In fact, they are gliders. A flying squirrel has thin, loose skin between its legs that spreads out like a parachute to keep it aloft. To steer in midair, 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 50 M (165 FT)**

## MOUSE-LIKE 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, thick fur, and most have bushy tails and big eyes. They are found throughout the world in habitats from rainforest to semi-arid desert to big cities. Some live in trees, others on the ground.



## CAVY-LIKE 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 hairless, nearly blind mole-rat, which lives underground.







MALAGASY GIANT RAT

BROWN RAT



STRIPED DWARF HAMSTER



ROBOROVSKY'S DESERT HAMSTER



NORWEGIAN LEMMING



COMMON HAMSTERS



GOLDEN HAMSTER



SYRIAN HAMSTER



MUSKRAT



ORKNEY VOLE



AFRICAN DORMOUSE



HAZEL DORMOUSE



FOREST DORMOUSE



BANK VOLE



COMMON VOLE



SOUTH AFRICAN GROUND SQUIRREL



NORTHERN FLYING SQUIRREL



HARRIS'S ANTELOPE SQUIRREL



EASTERN CHIPMUNKS



HOPI CHIPMUNK



RED BUSH SQUIRREL



YELLOW-BELLIED MARMOT



BLACK-TAILED PRAIRIE DOG



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 to 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 BEHAVIOUR

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**



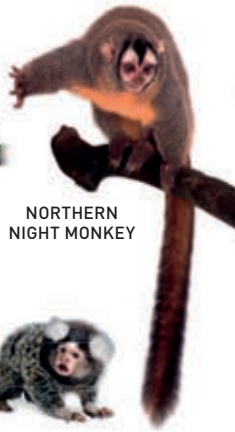
**GOLDEN LION TAMARIN**



**COTTON-TOP TAMARIN**



**WEEPER CAPUCHIN**



**NORTHERN NIGHT MONKEY**



**COMMON MARMOSET**



**PYGMY MARMOSET**



**RED HOWLER MONKEY**



**GREY WOOLLY MONKEY**



**PIG-TAILED MACAQUE**



**BARBARY MACAQUE**

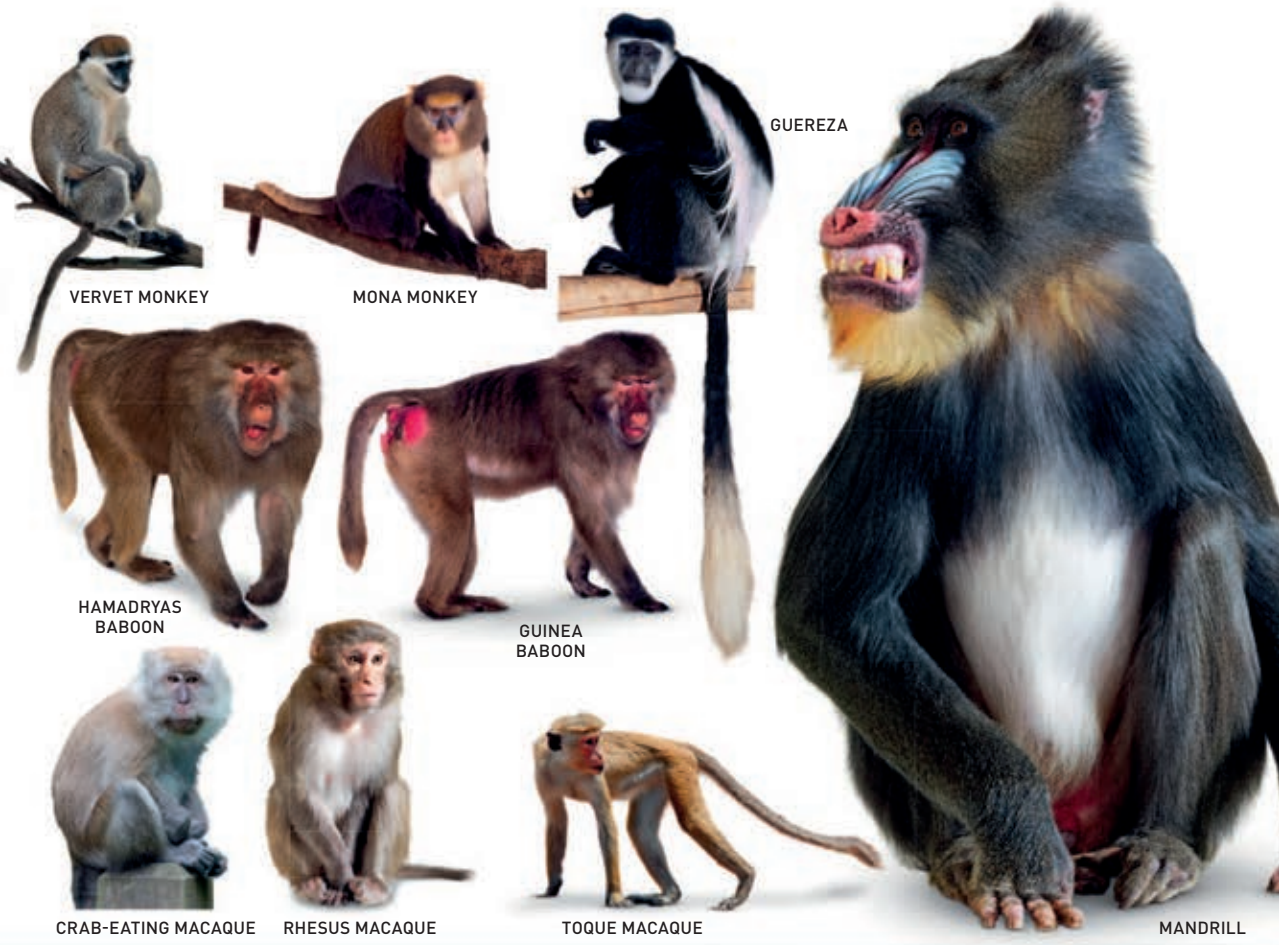
## APES

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**





VERVET MONKEY

MONA MONKEY

GUEREZA

HAMADRYAS BABOON

GUINEA BABOON

CRAB-EATING MACAQUE

RHESUS MACAQUE

TOQUE MACAQUE

MANDRILL



LAR GIBBON

PILEATED GIBBON

WHITE-CHEEKED CRESTED GIBBON

SIAMANG

BONOBO

COMMON CHIMPANZEE

WESTERN GORILLA

### OTHER PRIMATES

Many other species belong to the order of primates. Lemurs are found only on the island of Madagascar in Africa. Other relatives of apes and monkeys include galagos, bandros, and bushbabies, which are all nocturnal.



BROWN GREATER GALAGO

SENEGAL BUSHBABY

BANDRO

VERREAUX'S SIFAKA

BLACK LEMUR

GREATER BAMBOO LEMUR

RING-TAILED LEMUR

MONGOOSE LEMUR

RED-BELLIED LEMUR

RED-COLLARED LEMUR

BLACK AND WHITE RUFFED LEMUR



# 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

■ BENGAL TIGER

■ INDOCHINESE CLOUDED LEOPARD

■ SNOW LEOPARD

■ AMUR TIGER

■ DIARD'S CLOUDED LEOPARD

■ ASIATIC LION

■ 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 colours 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 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 113 km/h (70 mph). Strong muscles, large lungs, and a large heart mean it can take in lots of oxygen very fast and so accelerate very quickly. It has to rest after about 20–60 seconds.

**A CHEETAH CAN  
CLOSE IN ON ITS  
PREY IN JUST  
60 SECONDS**

Wind direction – the lionesses attack downwind so their prey cannot smell them

As the lionesses attack, the panicked prey run towards their predators

Grazing impala

Each lioness has a different role. These three will eventually kill the prey

The lionesses fan out to surround their prey

## 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.

### 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 7–8 m (23–26 ft) 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.



LEOPARD CAT



JUNGLE CAT



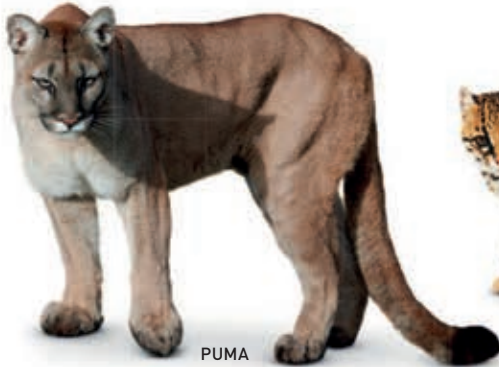
BOB CAT



SAND CAT



MARGAY



PUMA



OCELOT



CHEETAH



INDIAN DESERT CAT



CANADIAN LYNX

A tiger's stripes are unique – no two tigers will ever have the same pattern



BENGAL TIGER



AMUR TIGER



SNOW LEOPARD



AMUR LEOPARD



BLACK LEOPARD



JAGUAR

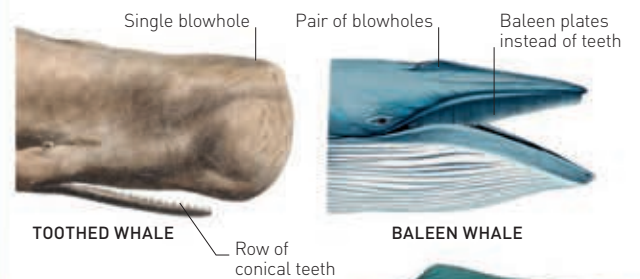


# Whales and dolphins

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.

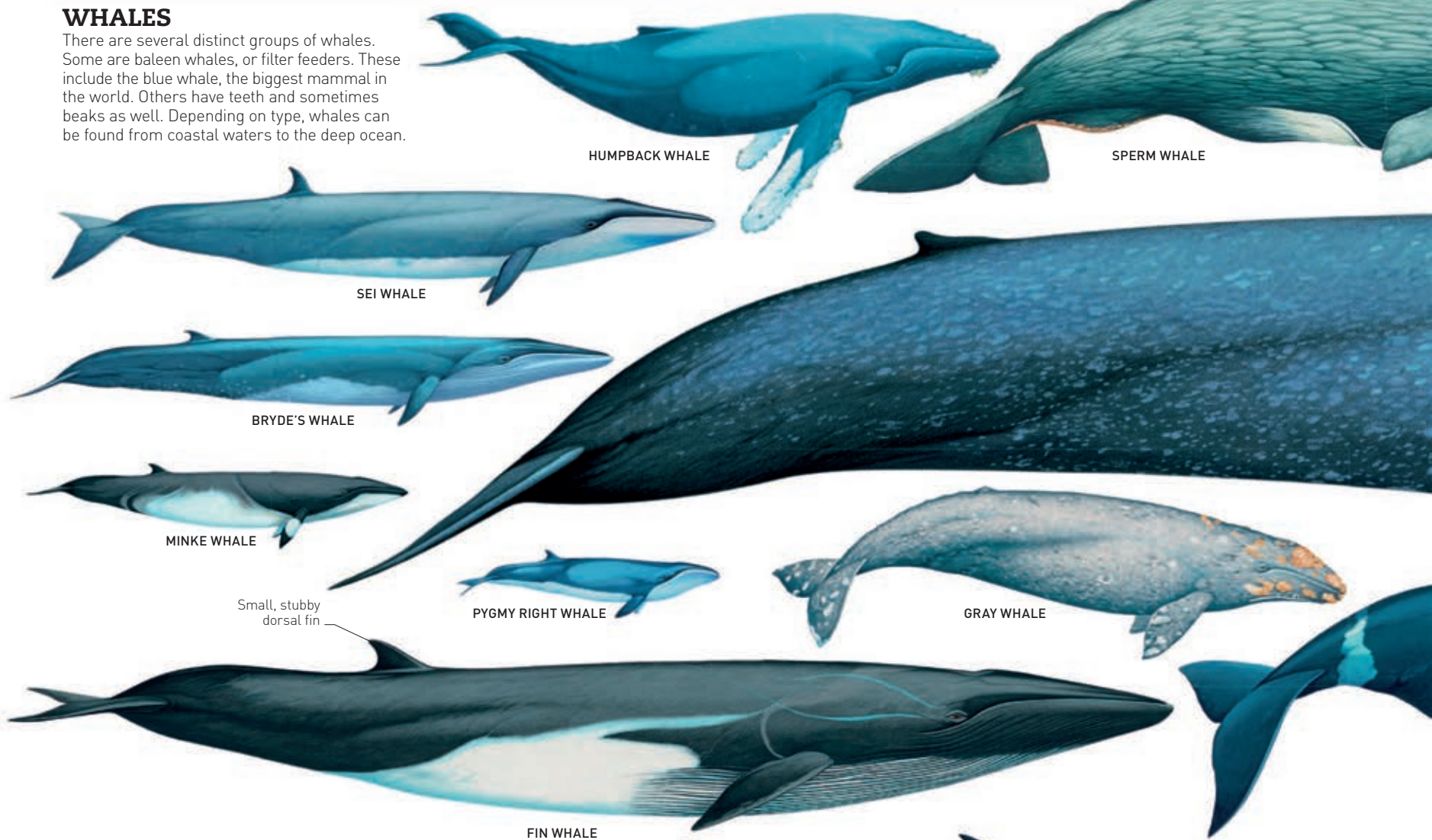
## TEETH AND FILTERS

Some whales have teeth for catching prey such as fish or squid. Filter-feeding whales have comb-like plates called baleen hanging from their upper jaw. As they swim, baleen whales gulp water and the plates trap tiny prey.



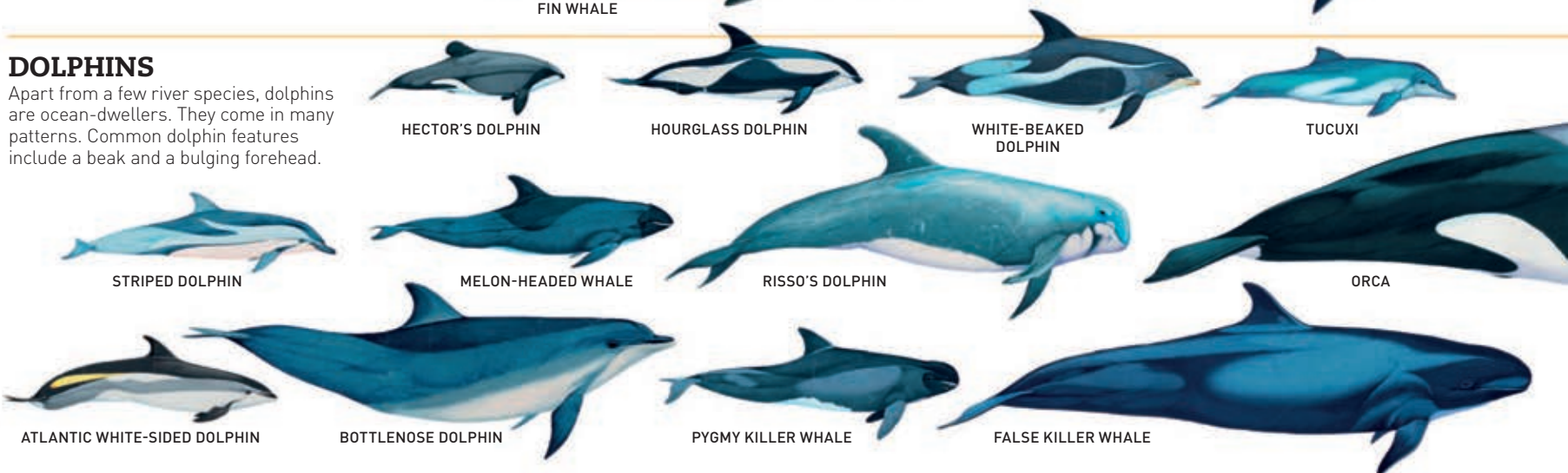
## WHALES

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

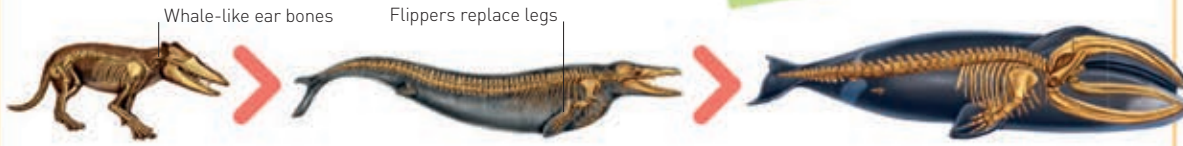
Apart from a few river species, dolphins are ocean-dwellers. They come in many patterns. Common dolphin features include a beak and a bulging forehead.





## 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.

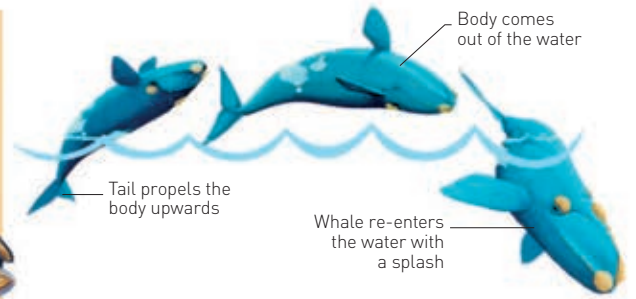


**1 PAKICETUS (50 MYA)**  
About the size of a large dog, this animal sometimes swam after fish. Its fossilized ear bones match those of modern whales.

**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.

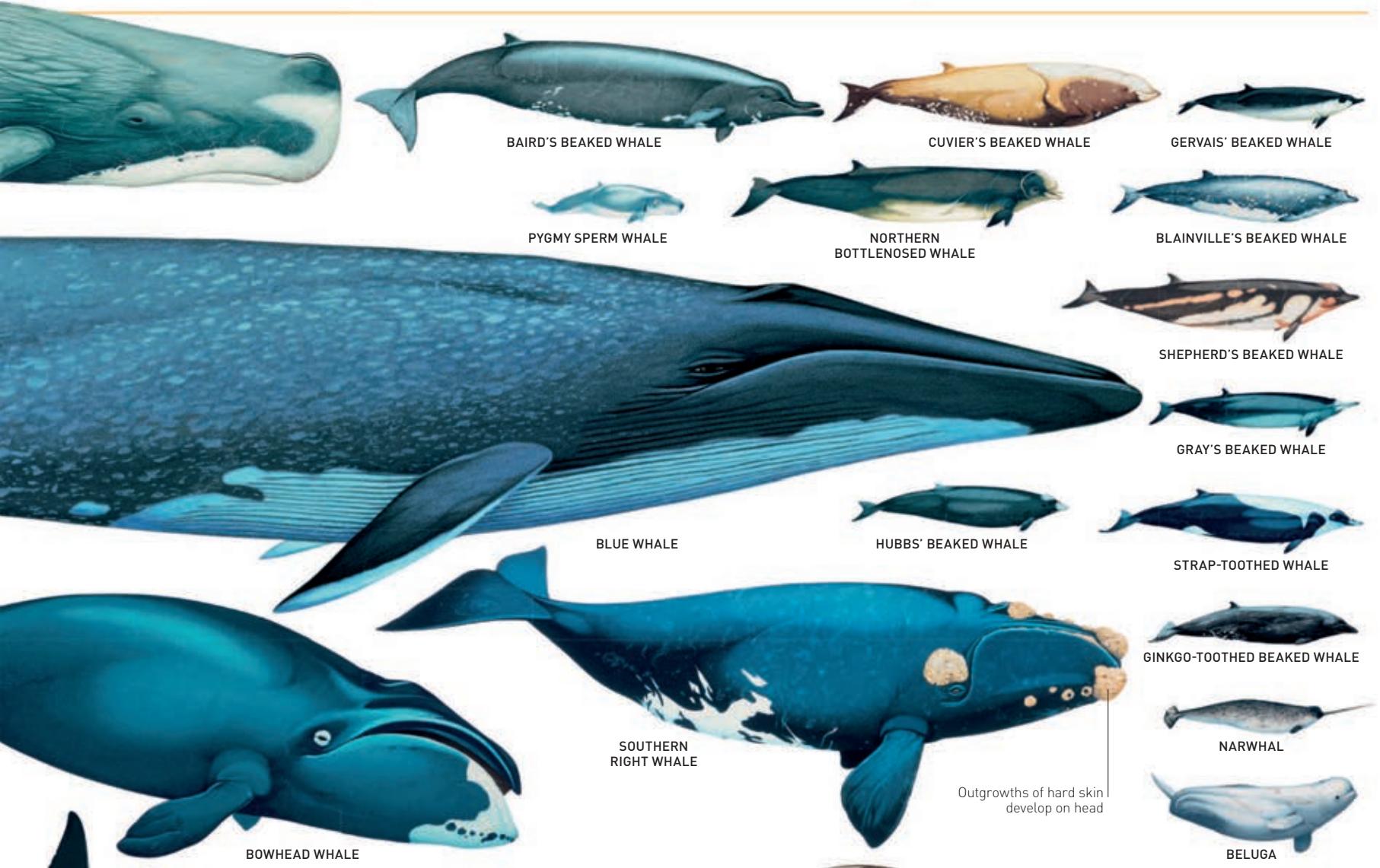
**3 MODERN WHALE**  
Perfectly adapted for ocean life, the whale has a streamlined body, powerful flippers, and a flat tail to aid propulsion. The hindlegs have vanished.

**THE BLUE WHALE CAN MEASURE UP TO 30.5 M (100 FT) LONG**



## 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 signalling or helps to 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

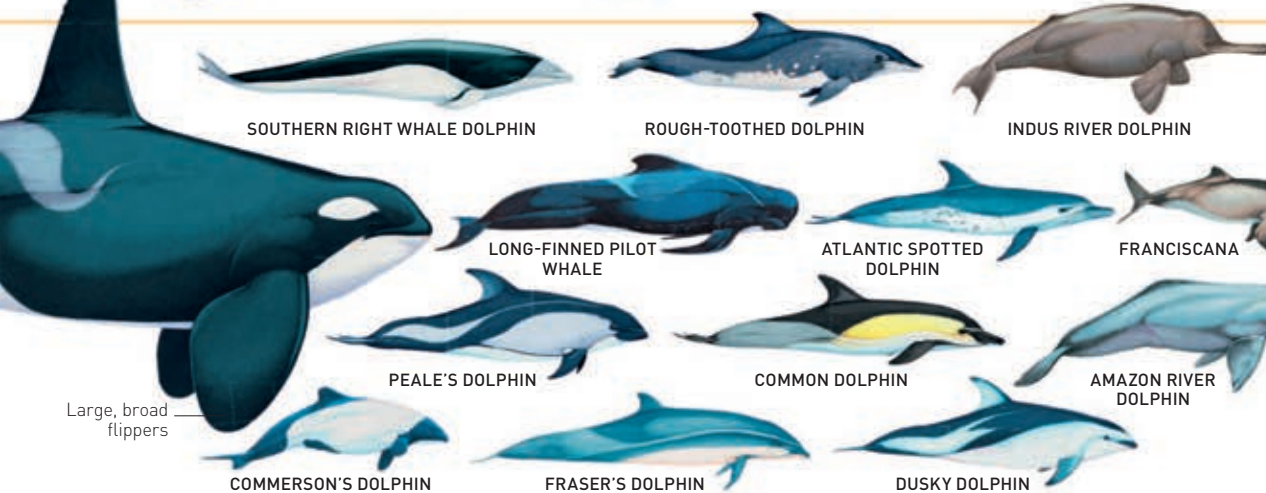
GINKGO-TOOTHED BEAKED WHALE

NARWHAL

Outgrowths of hard skin develop on head

BOWHEAD WHALE

BELUGA



SOUTHERN RIGHT WHALE DOLPHIN

ROUGH-TOOTHED DOLPHIN

INDUS RIVER DOLPHIN

LONG-FINNED PILOT WHALE

ATLANTIC SPOTTED DOLPHIN

FRANCISCANA

PEALE'S DOLPHIN

COMMON DOLPHIN

AMAZON RIVER DOLPHIN

COMMERSON'S DOLPHIN

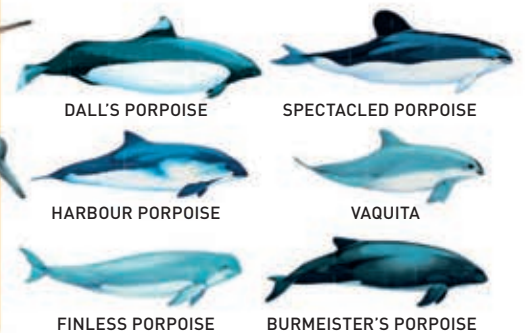
FRASER'S DOLPHIN

DUSKY DOLPHIN

Large, broad flippers

## PORPOISES

Most of this group are smaller and round-bodied than their relatives. Porpoises are usually found in shallow seas near the coast.



DALL'S PORPOISE

SPECTACLED PORPOISE

HARBOUR PORPOISE

VAQUITA

FINLESS PORPOISE

BURMEISTER'S PORPOISE



# 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

Long backbone has hundreds of curved ribs attached to it



FROG



TURTLE



TORTOISE



CHAMELEON



GECKO



LIZARD



CAIMAN

Flexible backbone extends into a long tail



PENGUIN



STARLING



CROW



DUCK



PIGEON



BUZZARD



KESTREL



OWL



EAGLE





## OUTER SKELETONS

Several groups of invertebrates have an armour-like external skeleton. The rigid casing protects inner organs from damage and possibly from predators. When insects or creatures such as crabs grow, they shed their exoskeleton and make a new one.



LOBSTER



RHINOCEROS BEETLE



DRAGONFLY



MILLIPEDE



TARANTULA



CRAB



MEALWORM LARVA

## ECHINODERM SKELETON

Echinoderms include marine invertebrates like sea urchins and starfish. 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

## 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

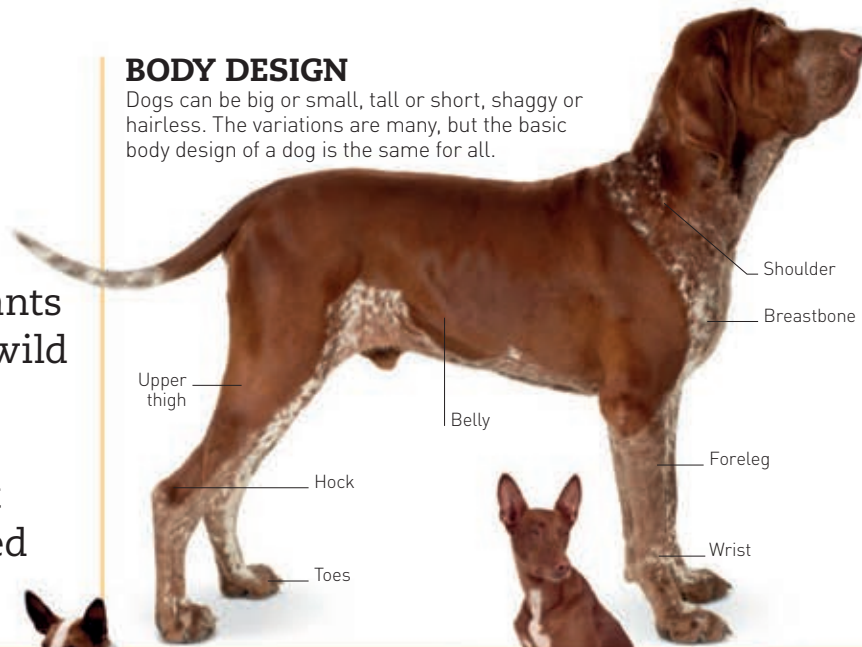


# Dogs

People and dogs have been together for at least 12,000 years. All dogs are descendants of grey 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 DESIGN

Dogs can be big or small, tall or short, shaggy or hairless. The variations are many, but the basic body design of a dog is the same for all.



## EVOLUTION

There are around 500 million dogs worldwide. All of them are related to each other through their ancestor, the grey 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 semi-wild.



## 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.



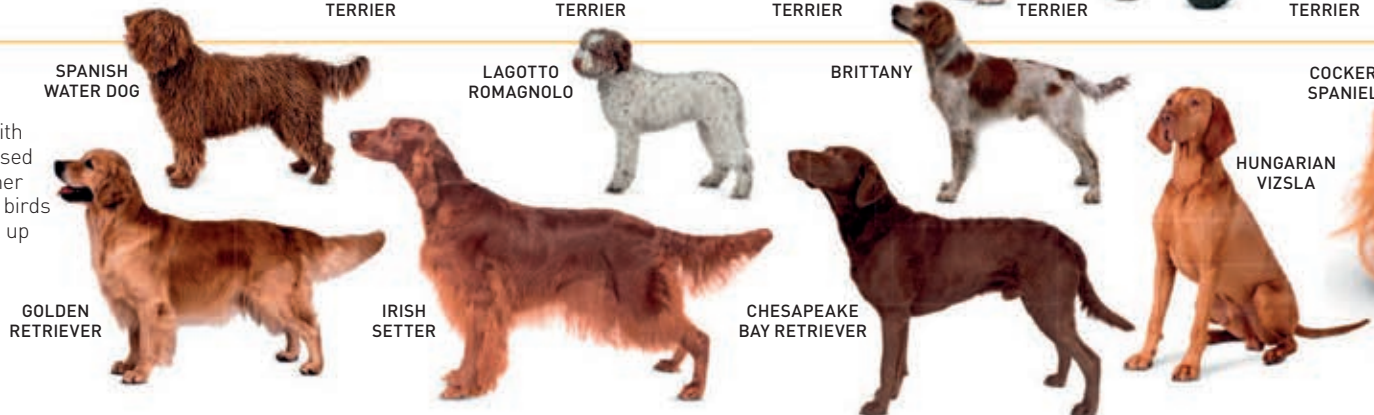
## TERRIERS

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 favourite game of many terriers is digging holes.



## GUNDOGS

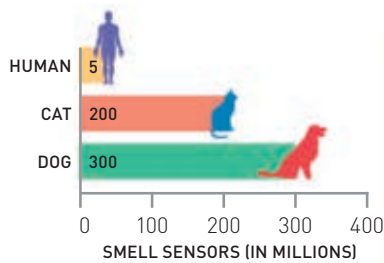
These dogs were developed to work with hunters. Some are used for locating prey. Other gundogs drive game birds out of cover and pick up those that are shot.





## 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.



ERECT

CANDLE FLAME

ROSE

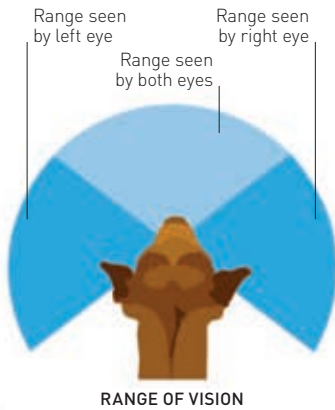
BUTTON

DROP

PENDANT

## A DOG'S-EYE VIEW

Dogs have a wider field of vision than humans, so can see more without moving their heads. They see detail clearly, have good 3-D vision, and can see movement at long range.



RANGE OF VISION

## BEHAVIOUR

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.

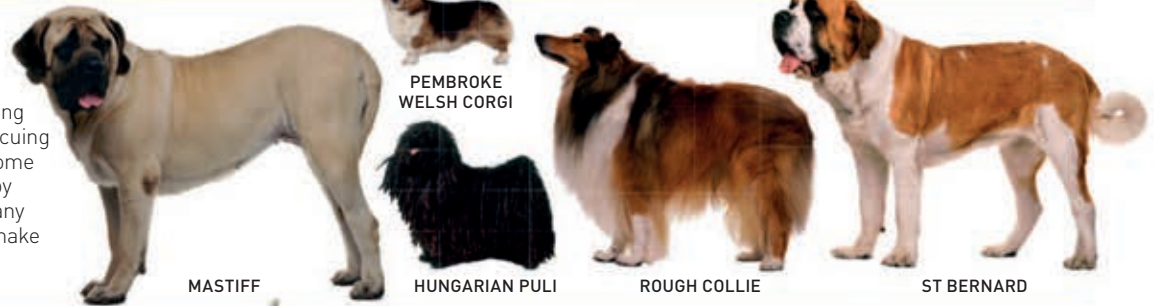


DIGGING

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.



MASTIFF

PEMBROKE  
WELSH CORGI

HUNGARIAN PULI

ROUGH COLLIE

ST BERNARD

## 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.



BASSET HOUND

DACHSHUND

BEAGLE

RHODESIAN  
RIDGEBACK

BILLY

DOBERMANN

## 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.



IRISH  
WOLFHOUND

SALUKI

GREYHOUND

AFGHAN HOUND

## 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.



RUSSIAN  
TOY

CHIHUAHUA

FRENCH  
BULLDOG

DALMATIAN

BICHON  
FRISE

LHASA APSO

THAI  
RIDGEBACK

KING CHARLES SPANIEL

PUG

POODLE

HIMALAYAN  
SHEEPDOG

## CROSSBREDS

Some dogs are the result of a planned cross between two recognized breeds. Dogs with unknown parentage are called mixed breeds.



GOLDDOODLE

LABRADOODLE

BULL  
BOXER

COCKERPOO

LURCHER

LUCAS  
TERRIER

BICHON  
YORKIE



# 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.



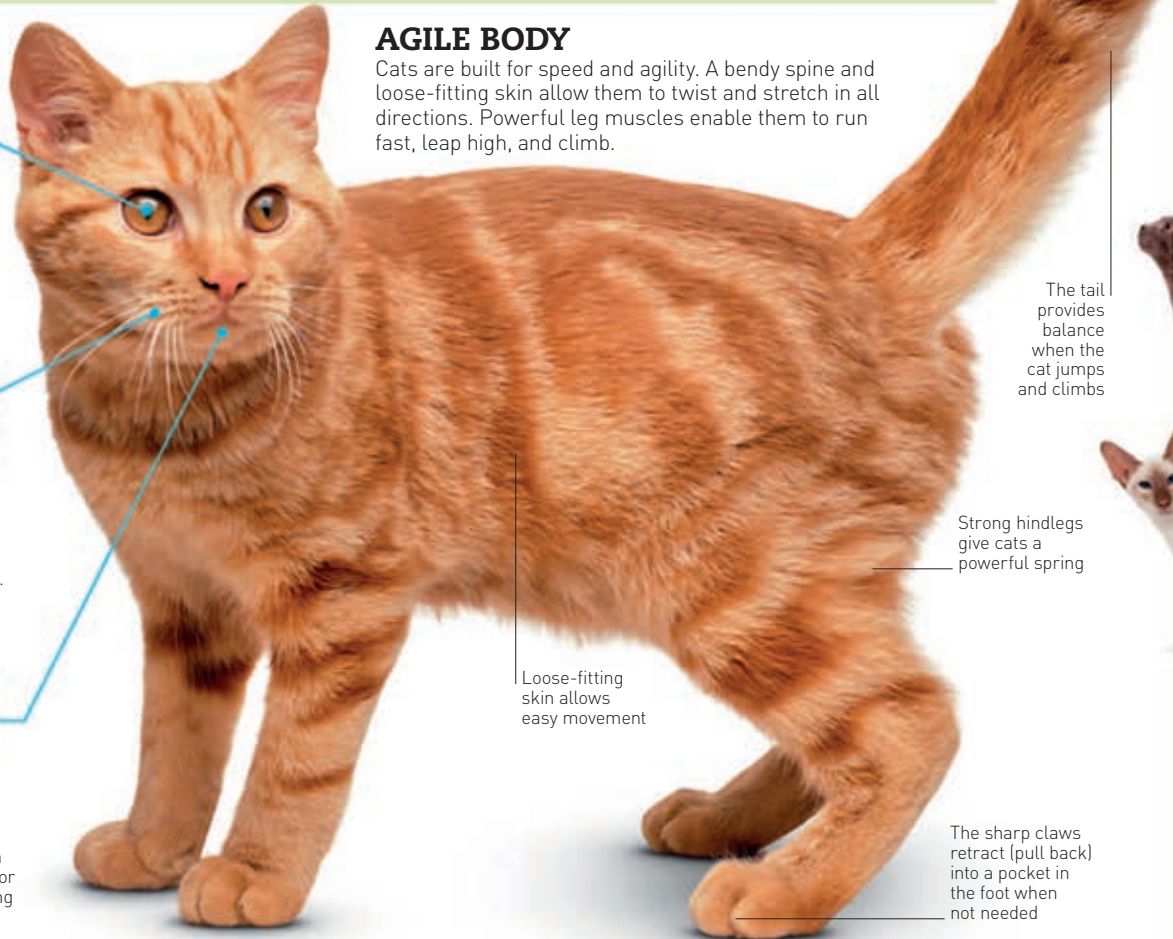
## WHISKERS

The touch-sensitive whiskers help a cat to 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.

Loose-fitting skin allows easy movement

The tail provides balance when the cat jumps and climbs

Strong hindlegs give cats a powerful spring

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 favourite with cat owners today. Colours and markings show up clearly on short hair and the coat is easy to groom.



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 to 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 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 glued 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 about, 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



BURMESE



OICAT



SAVANNAH



DEVON REX



SNOWSHOE



BRITISH SHORTHAIR



MANX



RUSSIAN BLUE



SCOTTISH FOLD



AUSTRALIAN MIST



ORIENTAL



JAPANESE BOBTAIL



BENGAL



KORAT



ASIAN



SINGAPURA



SELKIRK REX

**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.



SPHYNX



KINKALOW



AMERICAN CURL



KURILIAN BOBTAIL



PERSIAN



MAINE COON



PIXIEBOB LONGHAIR



BIRMAN



SOMALI



TURKISH ANGORA



LAPERM LONGHAIR



RAGDOLL



SCOTTISH FOLD LONGHAIR



CYMRIC



MUNCHKIN LONGHAIR



CHANTILLY TIFFANY



TIFFANIE



BALINESE-JAVANESE



# 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 transport 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.

## 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.

## 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.

### MODERN HORSES EVOLVED DURING THE LAST ICE AGE



**1 HYRACOTHERIUM (55-45 MYA)**  
This little forest-dwelling animal had padded toes instead of hoofs.

**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 draught 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 draught 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

Forelock

Crest (topline of neck)

Withers (highest point of shoulders)

Flank

Hock (joint similar to human ankle)

Fetlock joint

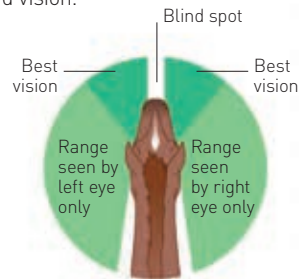
Hoof





## HOW HORSES SEE

As prey animals, horses need to spot danger. Eyes on the sides of their heads give them almost all-round vision.



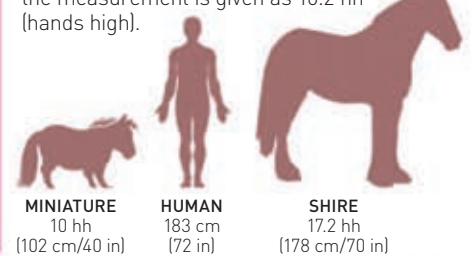
## LEG MARKINGS

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 10.2 cm (4 in) – 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 colours. They are named according to their pattern.



## COAT COLOURS

Horses have many coat colours and patterns. Manes and tails are often a different colour from the body.



## PONIES

A pony is a small horse standing no taller than 147 cm (58 in) – 14.2 hh – at the highest part of its back. There are many breeds native to different countries and regions.



## 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 about 50 billion 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, 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

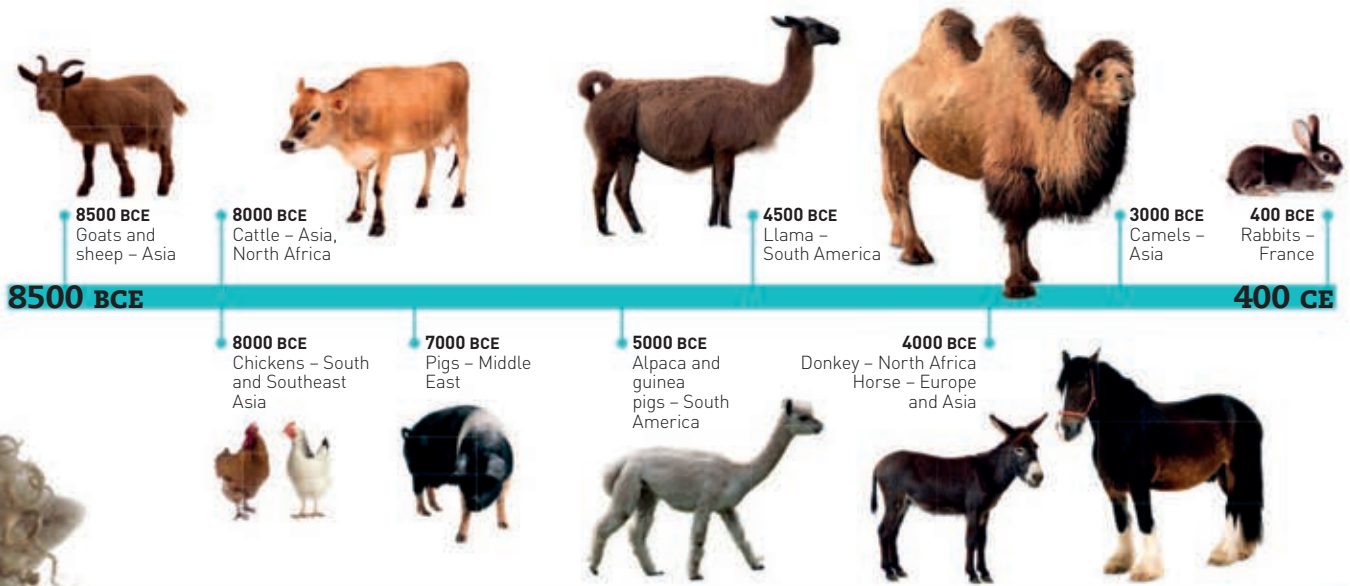


JACOB



## 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.



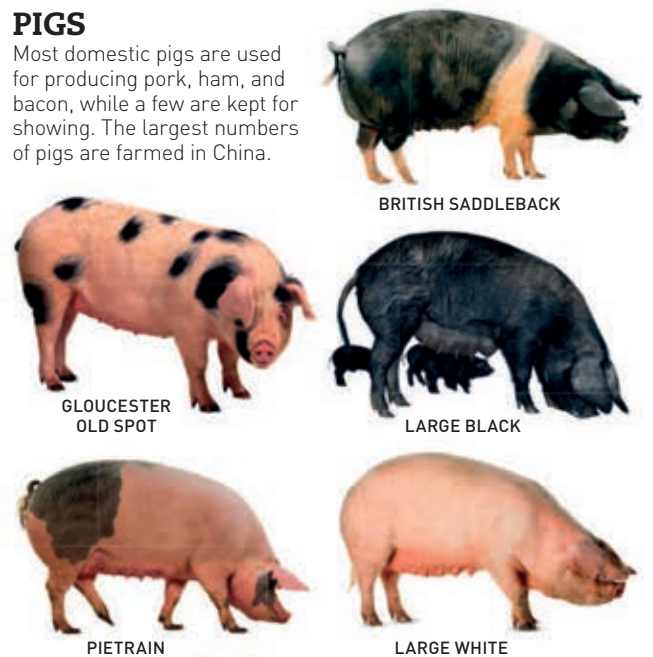
### GOATS

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.



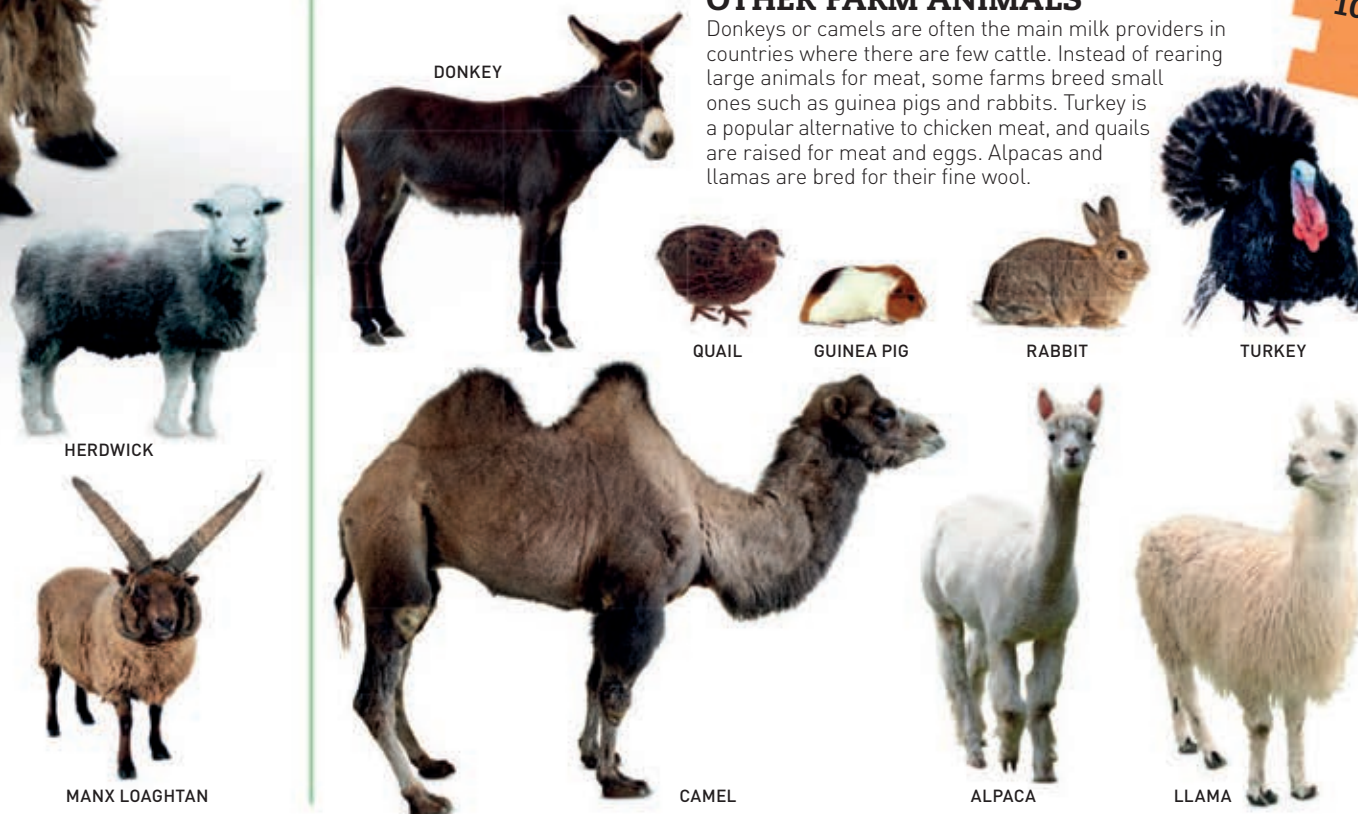
### PIGS

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 per cent 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.

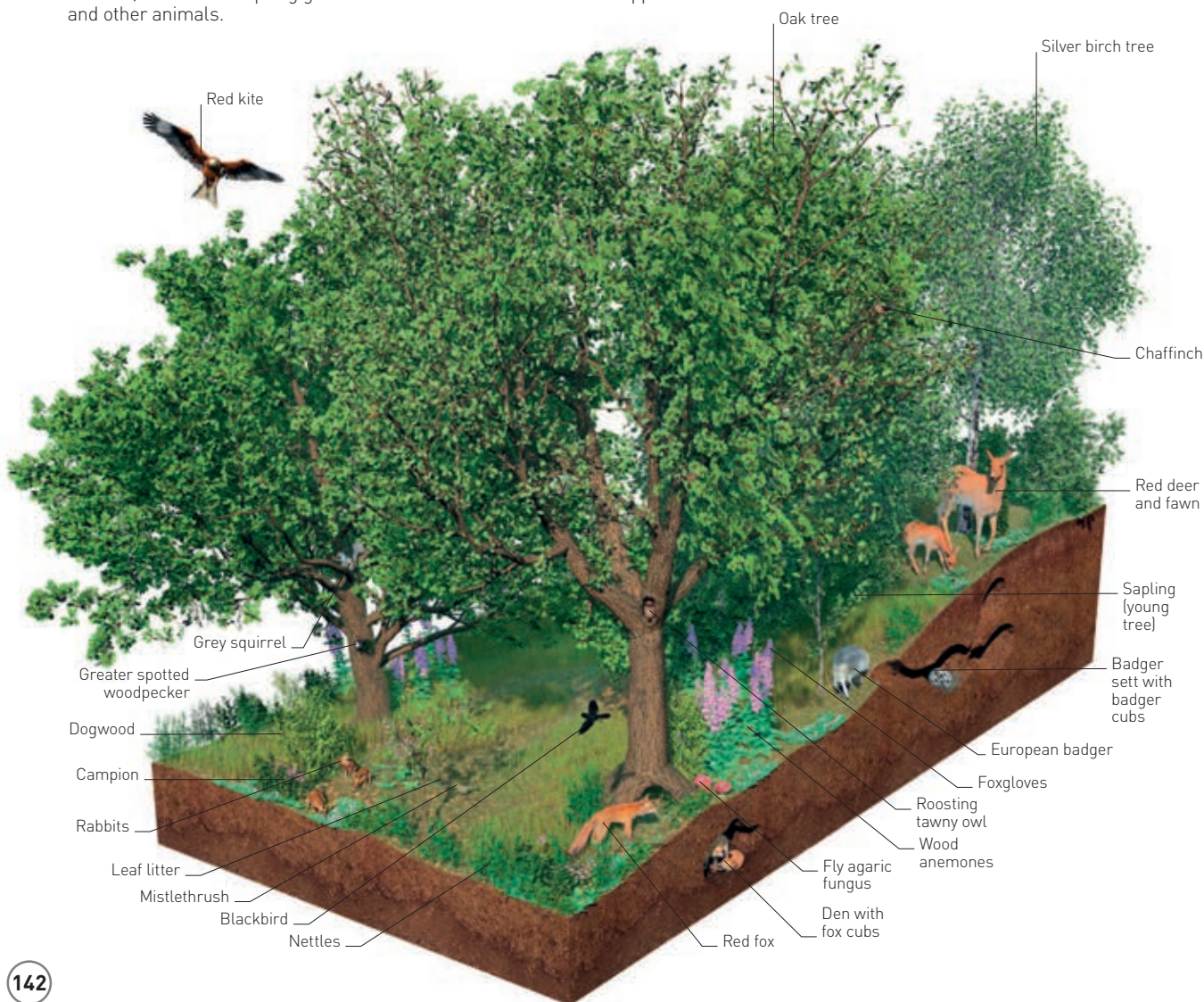
## WHERE ON EARTH?

Forests grow wherever the climate is warm and rainy enough to support large numbers of trees. This allows forest of different types to grow on every continent, except Antarctica – from the hot, tropical rainforests near the equator to the cooler, snowy forests in the Arctic region.



## 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



AMERICAN MINK



OTTER



EURASIAN BADGER



BEECH MARTEN



HEDGEHOG



RACCOON



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.



BARN 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



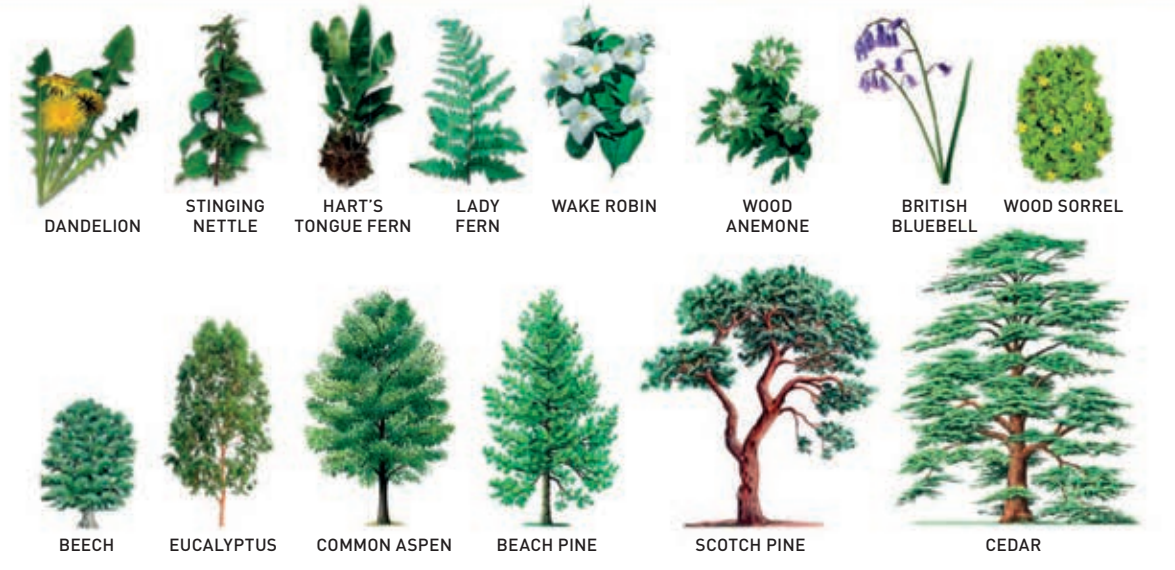
MONTPELLIER MAPLE





**INVERTEBRATES**

Most forest animals are insects, spiders, snails, worms, and other invertebrates. They flourish in summer, but most of them hide away or die in winter.



**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.







## EMERGENT LAYER

The forest 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.



**HARPY EAGLE**  
Mexico to South America



**BLUE MORPHO BUTTERFLY**  
Central and South America



**SCARLET MACAW**  
Mexico to South America

**DENDROBIUM ORCHID**  
Southeast Asia



**HANGING PARROT**  
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.



**BLUE POISON-DART FROG**  
South America



**SHINING-GREEN HUMMINGBIRD**  
South America



**RED-EYED TREE FROG**  
Central America



**WHITE-THROATED TOUCAN**  
South America



**GREEN TREE PYTHON**  
New Guinea; Australia



**AFRICAN GREY PARROT**  
West and Central Africa



**MISTLETOE CACTUS**  
Central America

## UNDERSTOREY

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.



**MAGNIFICENT BIRD OF PARADISE**  
Papua New Guinea



**EMERALD TREE BOA**  
South America



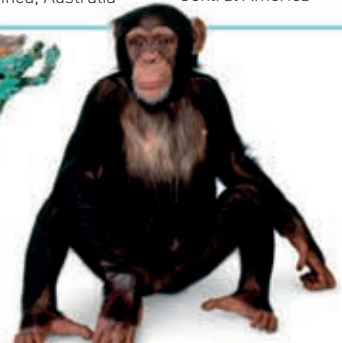
**FRANQUET'S FRUIT BAT**  
West and Central Africa



**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.



**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.



**MADAGASCAN TOMATO FROGS**  
Madagascar



**MATAMATA TURTLE**  
South America



**PIRANHA**  
South America



**CAPYBARA**  
South America



**NILE CROCODILE**  
Africa



# 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.



**VAMPIRE BAT**  
Mexico to South America

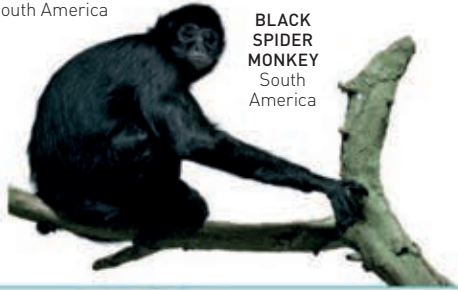


**KAPOK TREE**  
Mexico; Central and South America; West Africa



**MALAYAN FLYING FOX**  
Southeast Asia

**BRAZIL NUT TREE**  
South America



**BLACK SPIDER MONKEY**  
South America



**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

**PITCHER PLANT**  
Southeast Asia; Australia



**BROMELIAD PLANT**  
Mexico to South America



**COCOA TREE**  
Central and South America



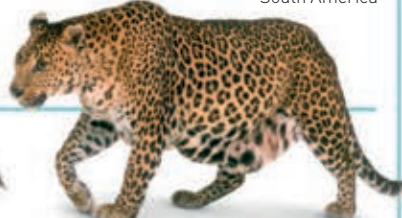
**JUNGLE NYMPH**  
Southeast Asia



**SOUTH AMERICAN COATI**  
South America



**GIANT ANTEATER**  
Central and South America



**JAGUAR**  
Central and South America



**ANACONDA**  
South America and Trinidad



**SCARLET IBIS**  
South America; Caribbean



## 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 forests provide homes for many dangerous animals and plants. This list includes some of the most deadly.

### POISON-DART FROG

These tiny, but vividly coloured 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**

### CURARE

Extracted from various South American plants, curare was used to poison the tips of blow darts for hunting.

### BRAZILIAN WANDERING SPIDER

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 football pitch 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 our 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 are 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.

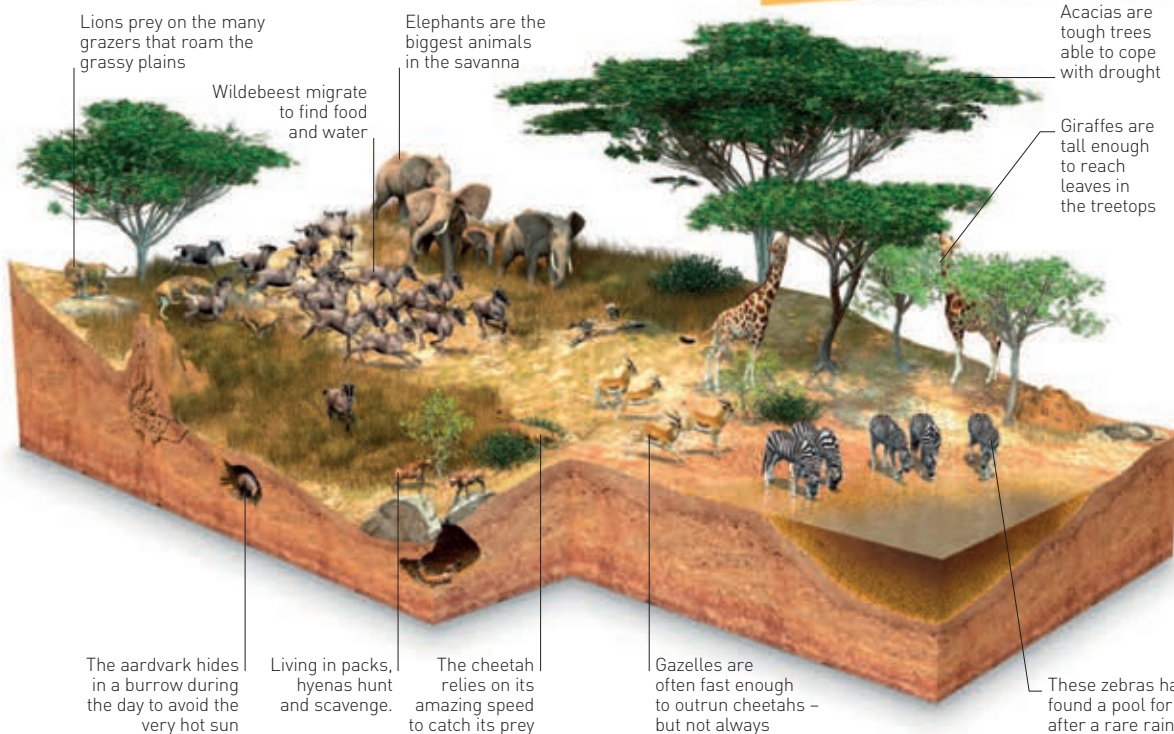


**MONTANE SAVANNA**

Above the tree line it is cooler than in shortgrass savanna.

## LIFE IN THE 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 10 CM (4 IN) OF RAIN**

## UNDER THREAT

The wild animals and plants of the savanna are threatened by poaching, habitat loss and fragmentation, farming, and climate change.

### HUNTING

Illegal hunting of savanna animals such as elephants, rhinos, and gazelles is endangering some species. These animals will become extinct if it continues.

### OVERGRAZING

Many farmers keep goats and cattle on the savanna. If there are too many animals, they eat all the wild plants, and the grassland will turn into a barren desert.

### FARMING

More of the savanna is being turned into farmland. Almost half of the wild tropical grassland in South America is now planted with crops such as maize.

### WATER LOSS

Farm crops need regular watering to survive the tropical dry season. The water is taken from natural sources, so there is not enough left for wild animals and plants.

### CLIMATE CHANGE

Global climate change may result in more grasslands turning to desert. But it may also cause some rainforest regions to dry out and become savanna grasslands.

## 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.



GRANT'S GAZELLE

IMPALA

EMU

HIPPOTAMUS

## 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.



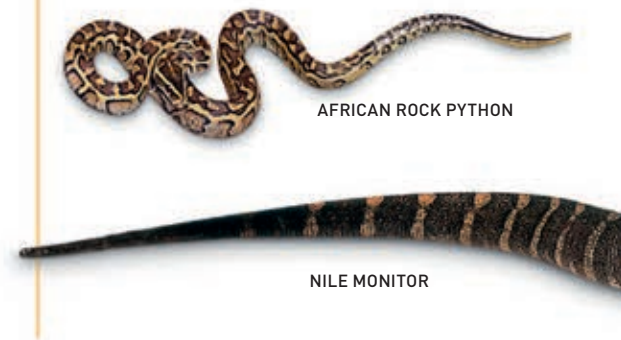
BLACK VULTURE

SERVAL

LION

## REPTILES, AMPHIBIANS, AND INSECTS

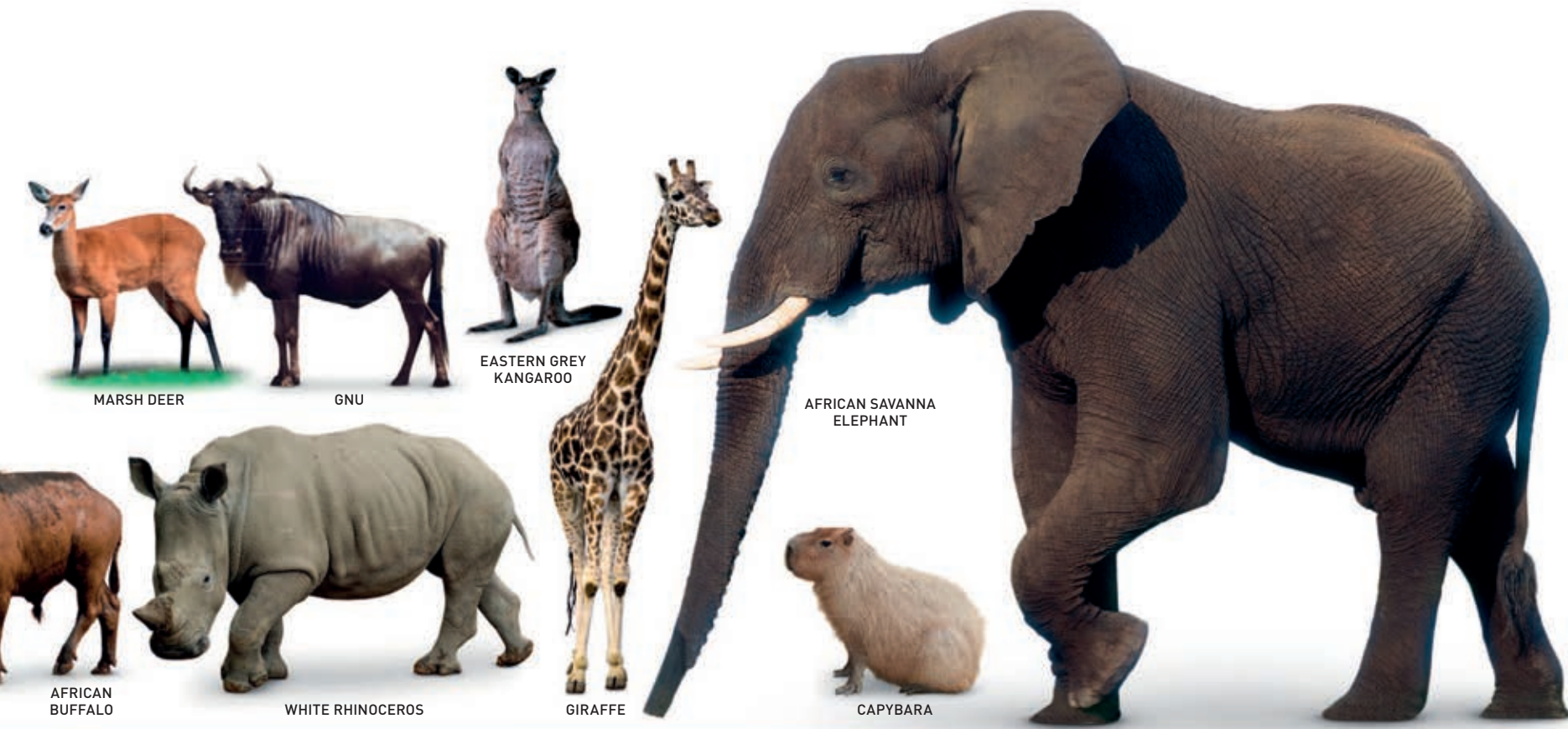
The savanna grasslands swarm with insects such as flies, beetles, and termites. There are also many species of frogs, lizards, and snakes.



AFRICAN ROCK PYTHON

NILE MONITOR





MARSH DEER

GNU

EASTERN GREY KANGAROO

AFRICAN SAVANNA ELEPHANT

AFRICAN BUFFALO

WHITE RHINOCEROS

GIRAFFE

CAPYBARA



AFRICAN WHITE-BACKED VULTURE

GIANT ANTEATER

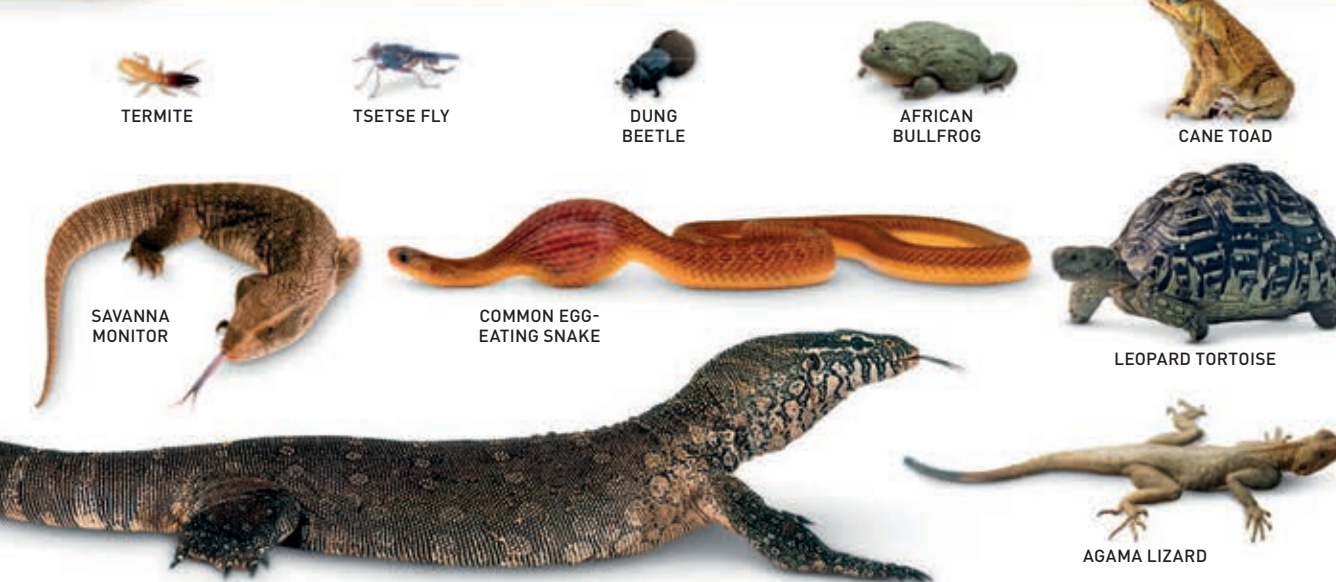
MANED WOLF

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 25 cm (10 in) 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**

Cold deserts are far from oceans. They are much cooler than hot deserts, with short summers and heavy snowfall in the winter.



**COASTAL DESERT**

Where deserts occur by the sea they may be covered in fog but still go for years without rainfall, remaining very dry.

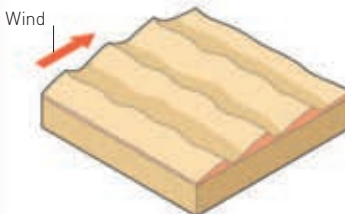
## SAND DUNES

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 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

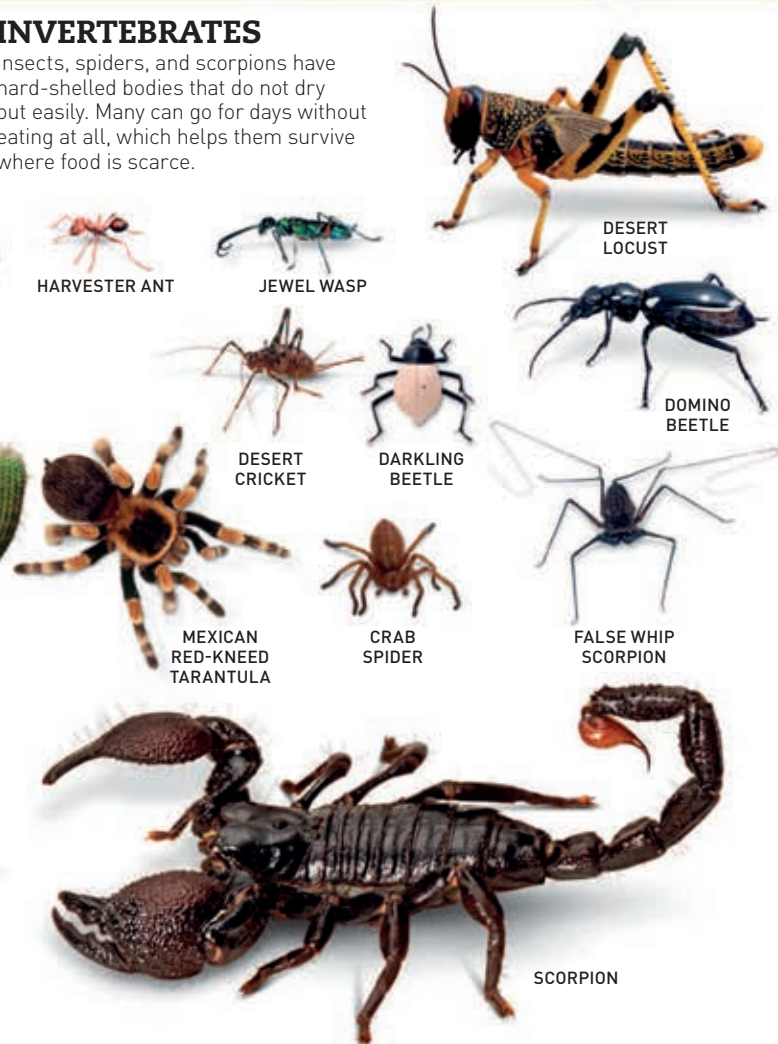
LANNER FALCON

BURROWING OWL

TURKEY VULTURE

## 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

DOMINO BEETLE

DESERT CRICKET

DARKLING BEETLE

MEXICAN RED-KNEED TARANTULA

CRAB SPIDER

FALSE WHIP SCORPION

SCORPION

## LIFE IN THE DESERT

Only a few types of plants and animals can survive in deserts with extremely dry climates. In some deserts 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 rain has never been recorded.

**AFTER IT RAINS, THE DESERT SPRINGS TO LIFE, WITH MANY PLANTS FLOWERING AT ONCE**



The fierce 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 only a few tiny invertebrates live in Antarctica.

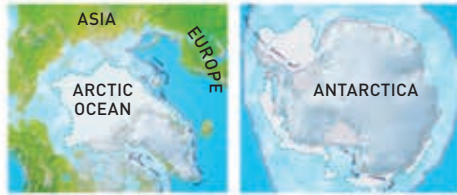
## WHERE ON EARTH?

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.

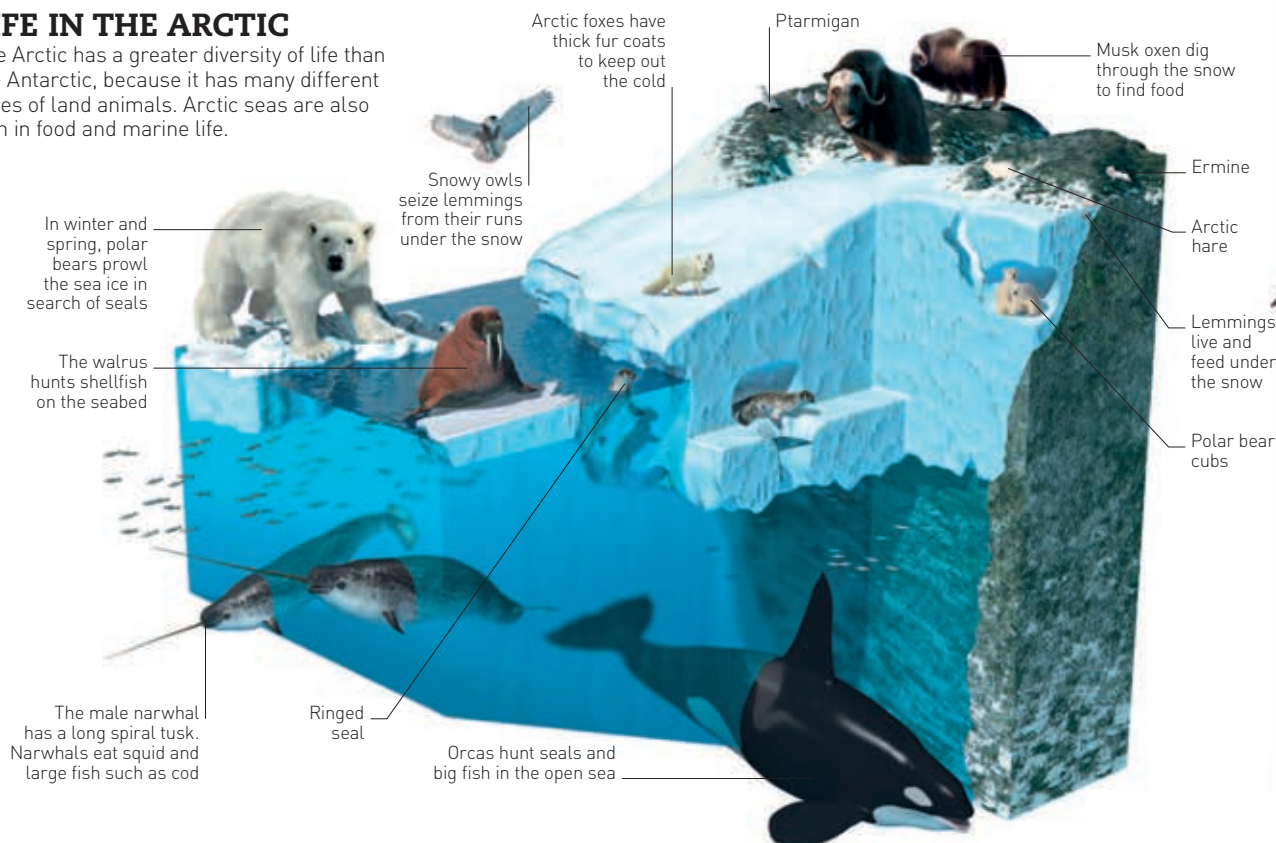


**THE ARCTIC**  
The Arctic is an icy ocean with land all around it, where animals can live.

**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

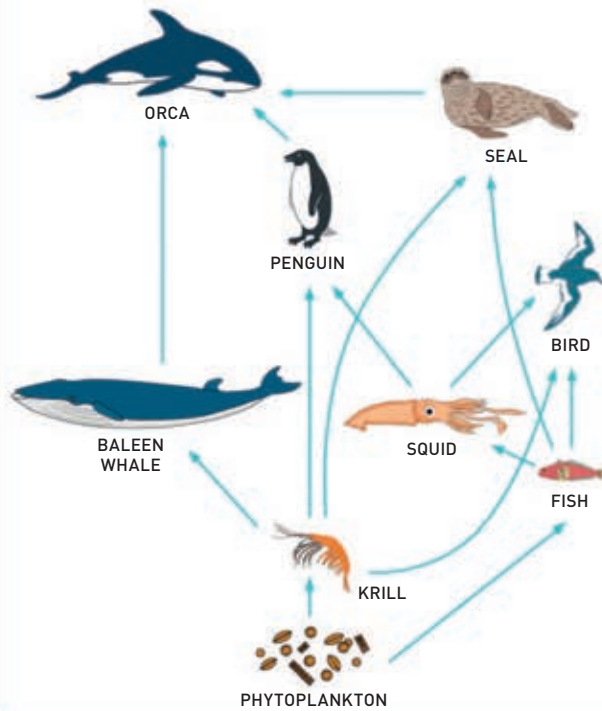
As Earth spins, most places experience day and night. But because of the tilt of Earth's axis, the polar regions are always dark in midwinter, and stay light in midsummer. This is one reason why polar winters are so bitterly cold.



**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.



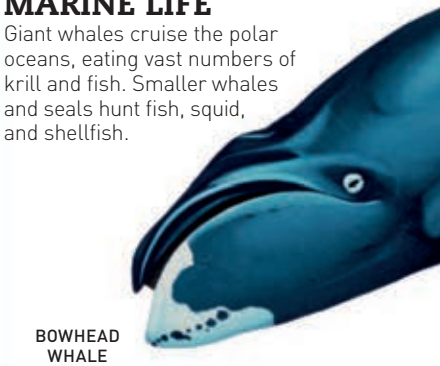
## LAND MAMMALS

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.



## MARINE LIFE

Giant whales cruise the polar oceans, eating vast numbers of krill and fish. Smaller whales and seals hunt fish, squid, and shellfish.



## BIRDS

Many land birds range over the Arctic, but all Antarctic birds, such as penguins, find their food in the ocean.







ARCTIC FOX

WOLVERINE

ARCTIC WOLF

POLAR BEAR

REINDEER

MUSK OX



BELUGA

ORCA

NARWHAL

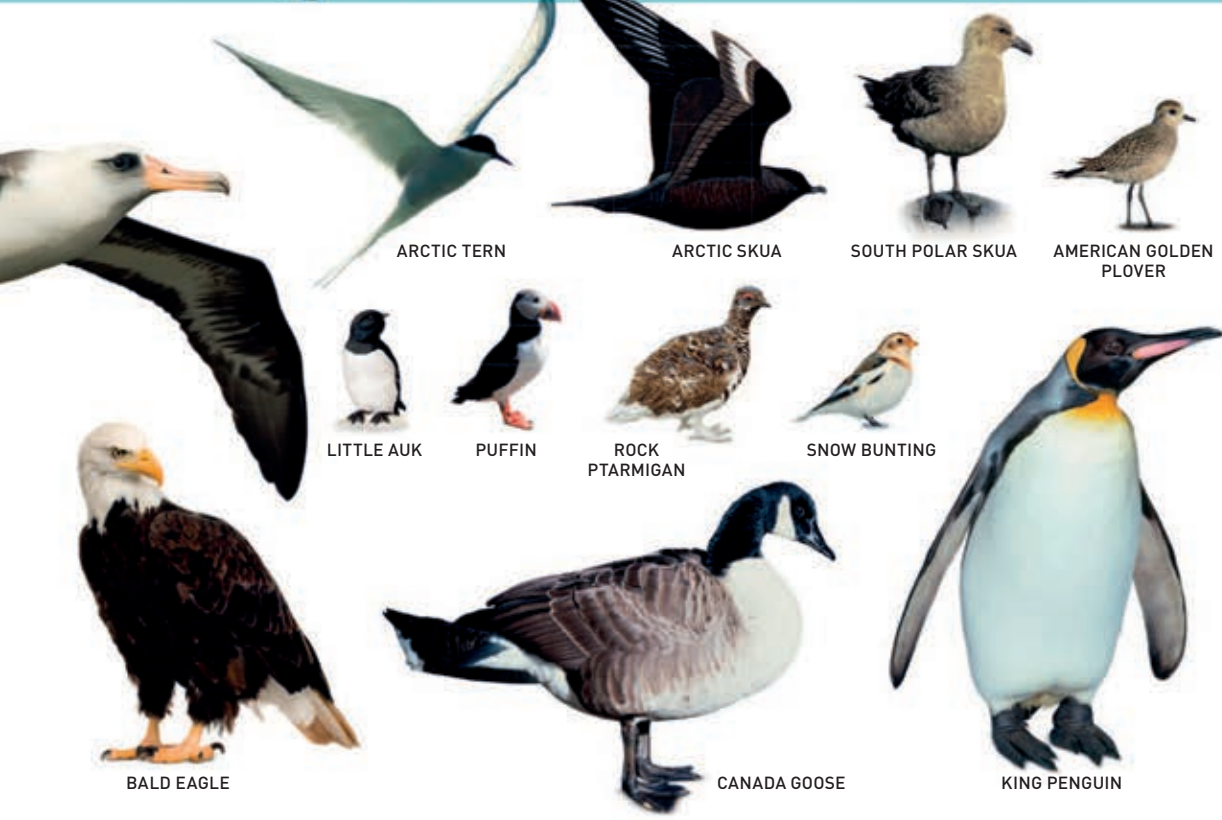
BEARDED SEAL

WALRUS

LEOPARD SEAL

HARP SEAL

GREENLAND SHARK



ARCTIC TERN

ARCTIC SKUA

SOUTH POLAR SKUA

AMERICAN GOLDEN PLOVER

LITTLE AUK

PUFFIN

ROCK PTARMIGAN

SNOW BUNTING

BALD EAGLE

CANADA GOOSE

KING PENGUIN

**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

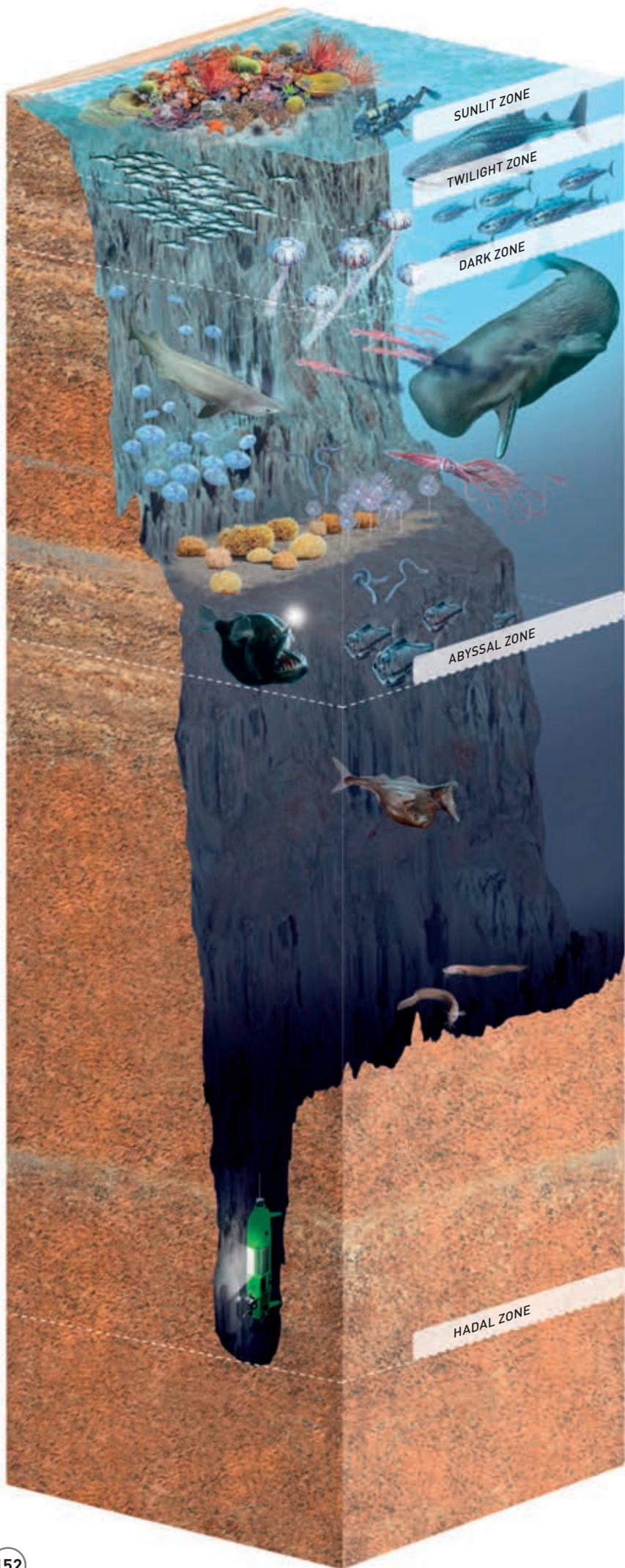


ARCTIC POPPY



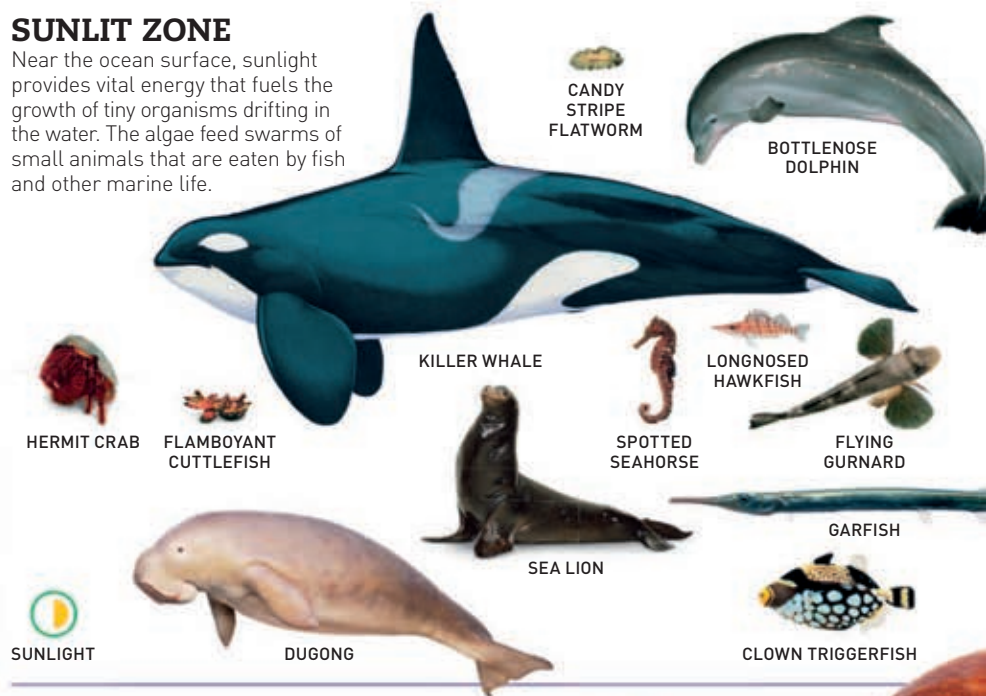
PASQUE FLOWER





## 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.



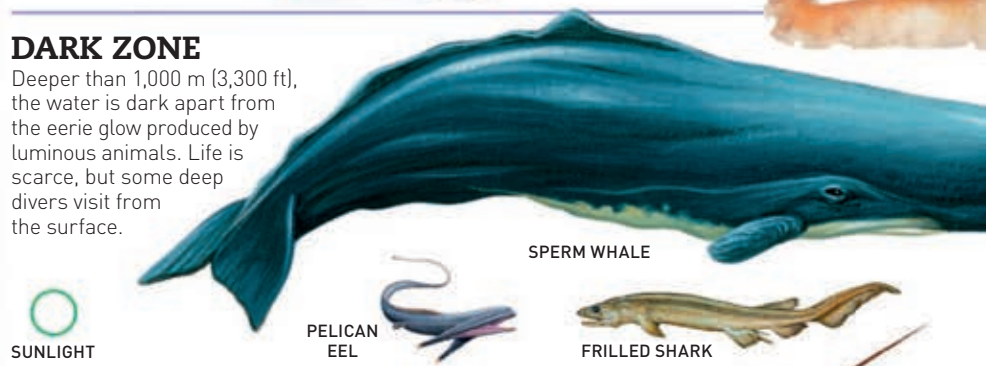
## TWILIGHT ZONE

Below 200 m (660 ft) 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

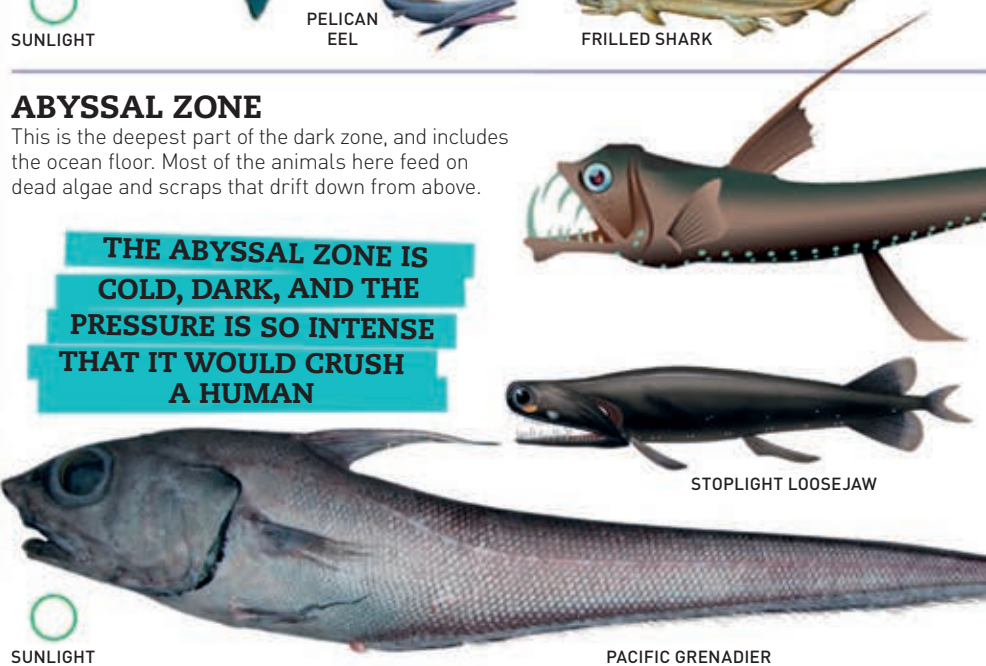
Deeper than 1,000 m (3,300 ft), the water is dark apart from the eerie glow produced by luminous animals. Life is scarce, but some deep divers visit from the surface.



## ABYSSAL ZONE

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.

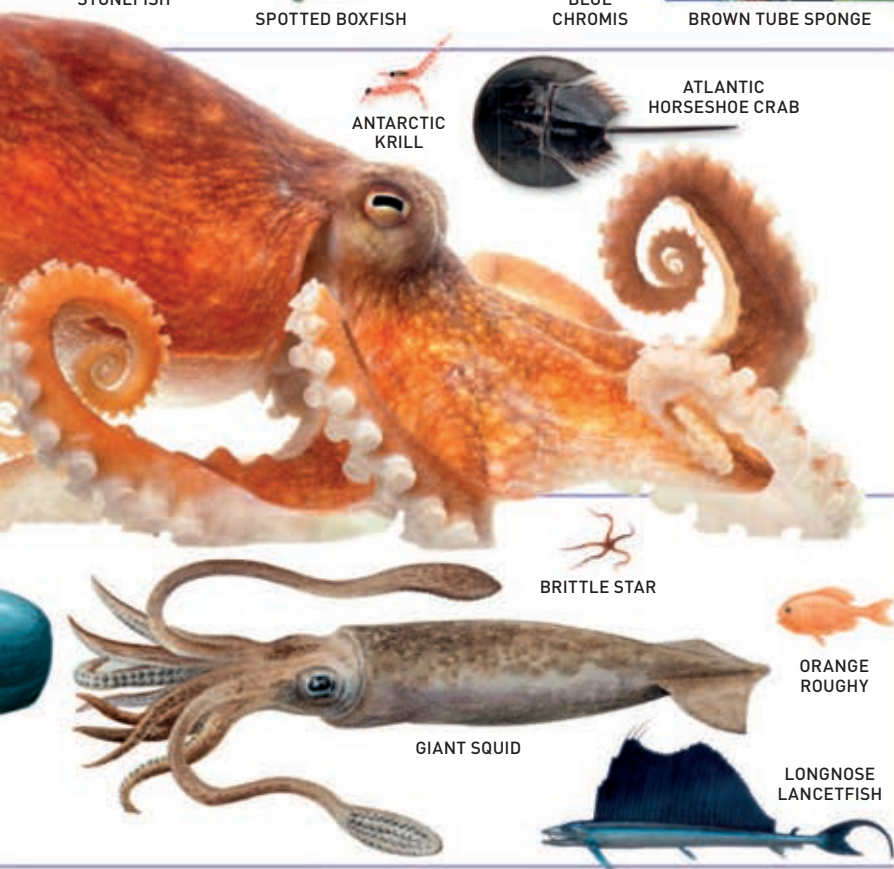
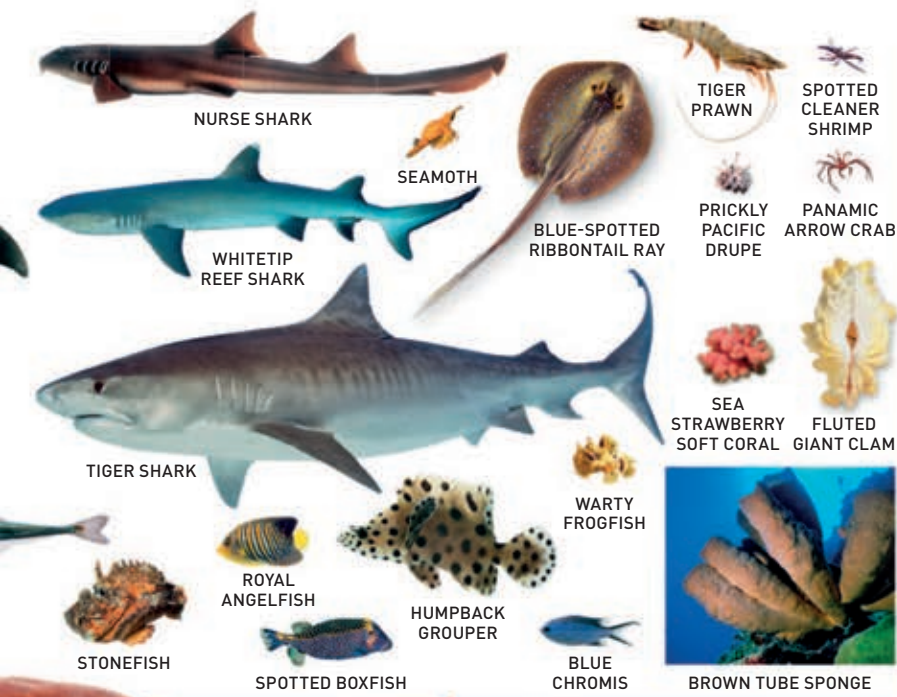
**THE ABYSSAL ZONE IS COLD, DARK, AND THE PRESSURE IS SO INTENSE THAT IT WOULD CRUSH A HUMAN**





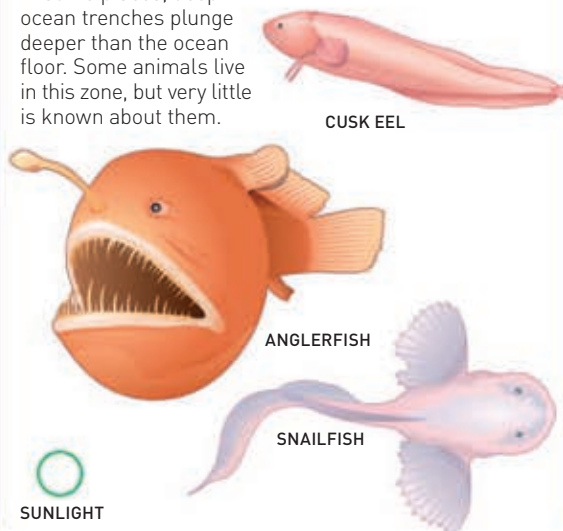
# Ocean

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.



## 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.



## 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 defence, and to stun prey.

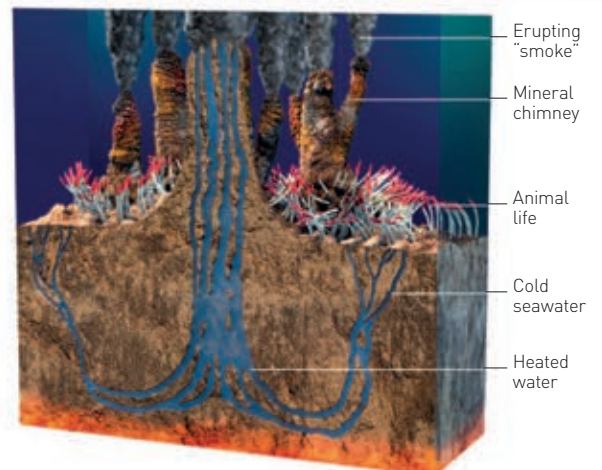
## GROUPS OF FISH

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 some of the deepest parts of the ocean, water seeps into the ocean floor and is heated by hot volcanic rock. The hot water forms a spring on the ocean floor, which erupts. As the hot water hits the cold sea, the minerals turn into solid particles that build up to form smoking "chimneys" up to 55 m (180 ft) high. Amazingly, there are unique animals, including some tubeworms, that can survive this extreme heat.





# 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.

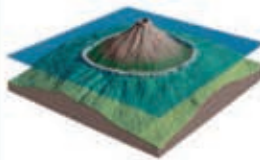
## WHERE IN THE WORLD?

Coral reefs grow in clear, shallow, warm water near tropical shores. Most of them lie in the western Pacific and Indian oceans.



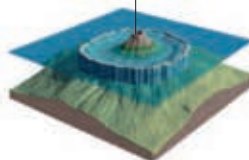
## TYPES OF REEFS

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 upwards. This creates a barrier reef. Eventually, the island sinks from sight, leaving a coral atoll.



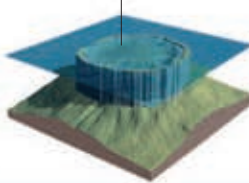
**FRINGING REEF**  
This tropical volcanic island is surrounded by a fringing reef. The extinct volcano slowly starts to sink.

The island sinks, but the coral keeps growing



**BARRIER REEF**  
As the island continues to sink, the reef grows upwards, forming a barrier reef around a ring-shaped lagoon.

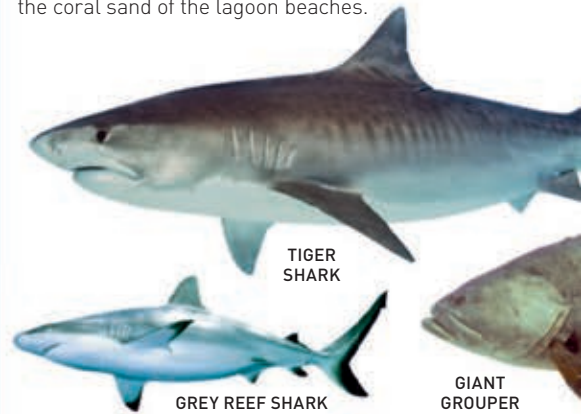
Reef encloses a shallow central lagoon



**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.



TIGER SHARK

GREY REEF SHARK

GIANT GROUPER

## 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.



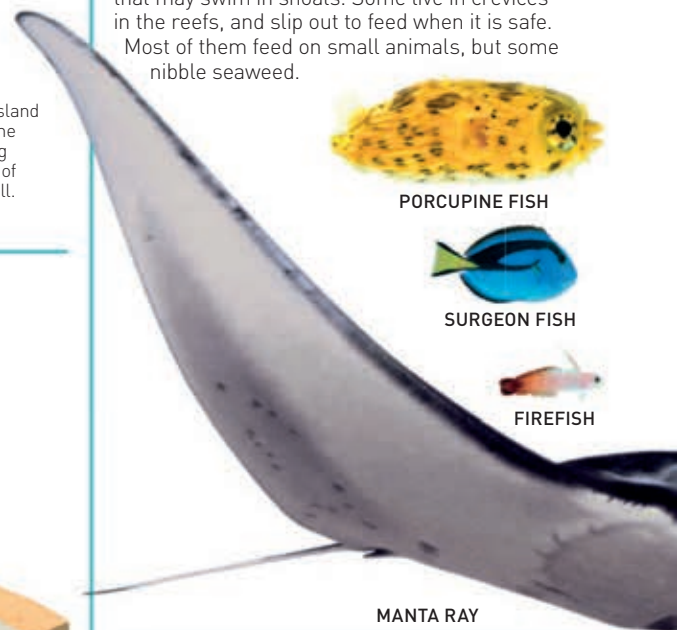
PORCUPINE FISH



SURGEON FISH



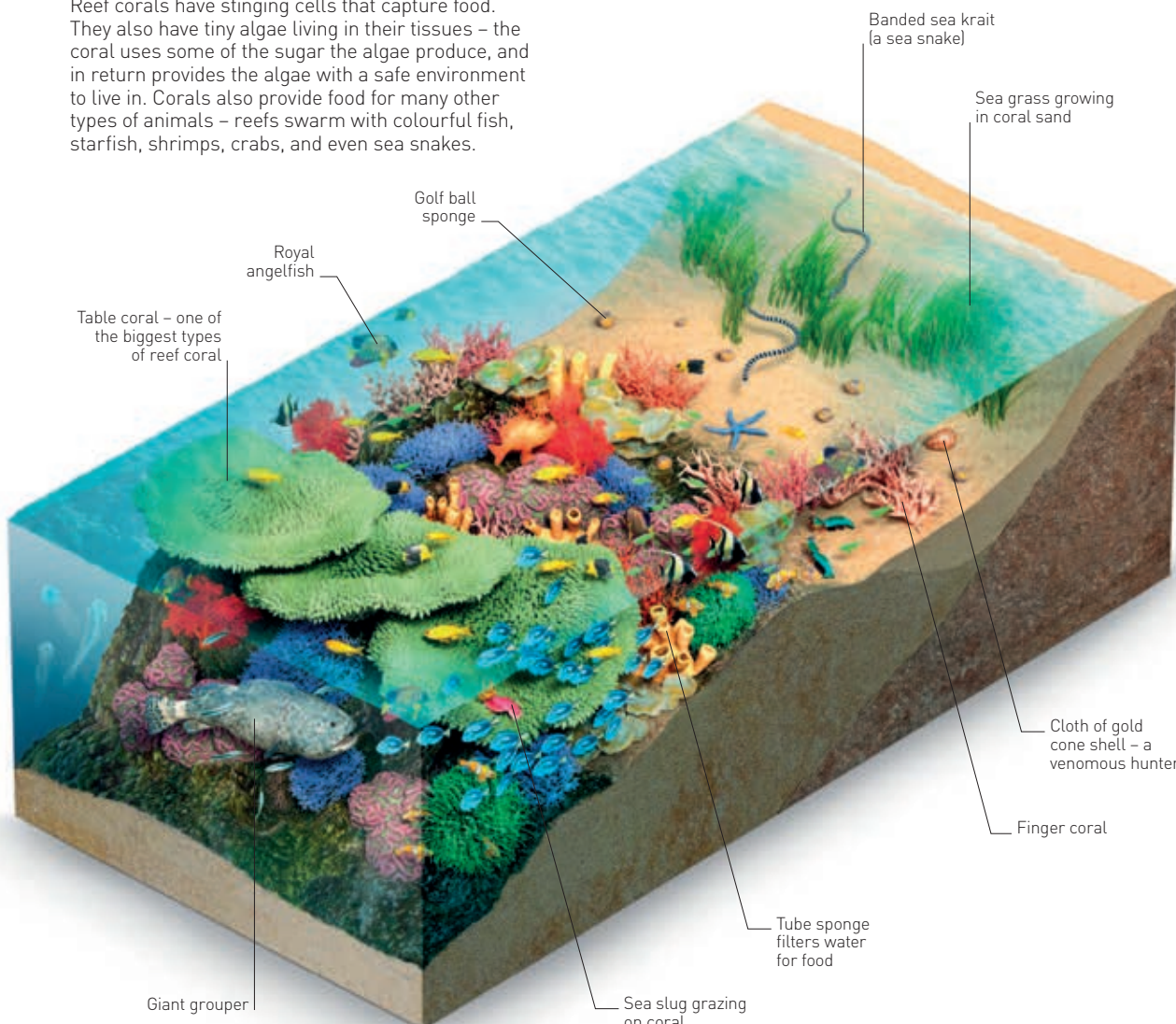
FIREFISH



MANTA RAY

## 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 colourful fish, starfish, shrimps, crabs, and even sea snakes.

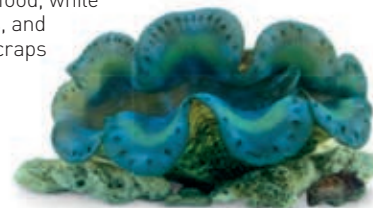


## REEF INVERTEBRATES

As well as corals, many other invertebrates live on the reefs. Sponges, sea squirts, and clams filter the water for food, while sea slugs, shrimps, and crabs search for scraps and living prey.



SCARLET CLEANER SHRIMP



GIANT CLAM

## CORALS

Every coral reef is made up of many different types of coral. They include brain corals, staghorn corals, and sea fans. Each one is a colony of animals sharing a hard, stony skeleton.



MUSHROOM CORAL



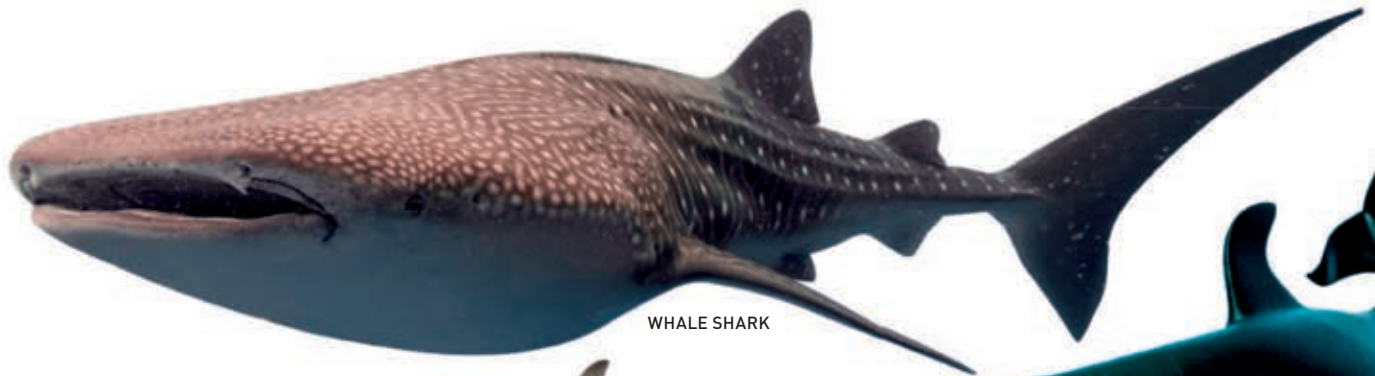
BRAIN CORAL







BLACKTIP REEF SHARK



WHALE SHARK



HAWKBILL TURTLE



BOTTLENOSE DOLPHIN



HAMMERHEAD SHARK



ORCA

**THE DWARF SEAHORSE IS THE SLOWEST FISH IN THE WORLD, WITH A TOP SPEED OF 1.5 M (5.25 FT) PER HOUR**



PARROTFISH



GREAT BARRACUDA



MANDARIN FISH



ELECTRIC RAY



BLUE-SPOTTED RIBBONTAIL RAY



CLOWN TRIGGER FISH



QUEEN ANGELFISH



YELLOW SHRIMP GOBY



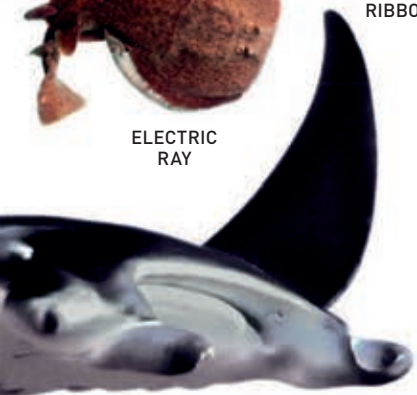
SEAHORSE



DAMSELFISH



LION FISH



CLOWN FISH



CORAL TROUT



THREADFIN BUTTERFLY FISH



YELLOW TANG



JEWELFISH



LONGNOSED HAWKFISH



SEA SQUIRT



RED HERMIT CRAB



SEA SPONGE



SEA SLUG



SOFT CORAL



STAGHORN CORAL

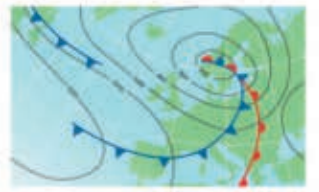
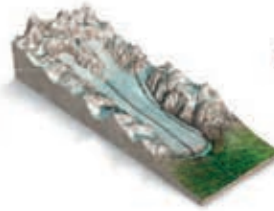


SEA FAN



**CORAL REEF**  
Live coral grows on top of the stony remains of dead coral to build the reef.









# Geography



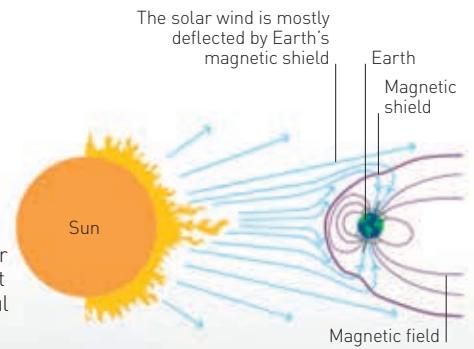


# Earth

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 large areas of dry land 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 shield.



## EARTH'S STRUCTURE

Earth is made up of many different layers. At its centre 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 centre.

### 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

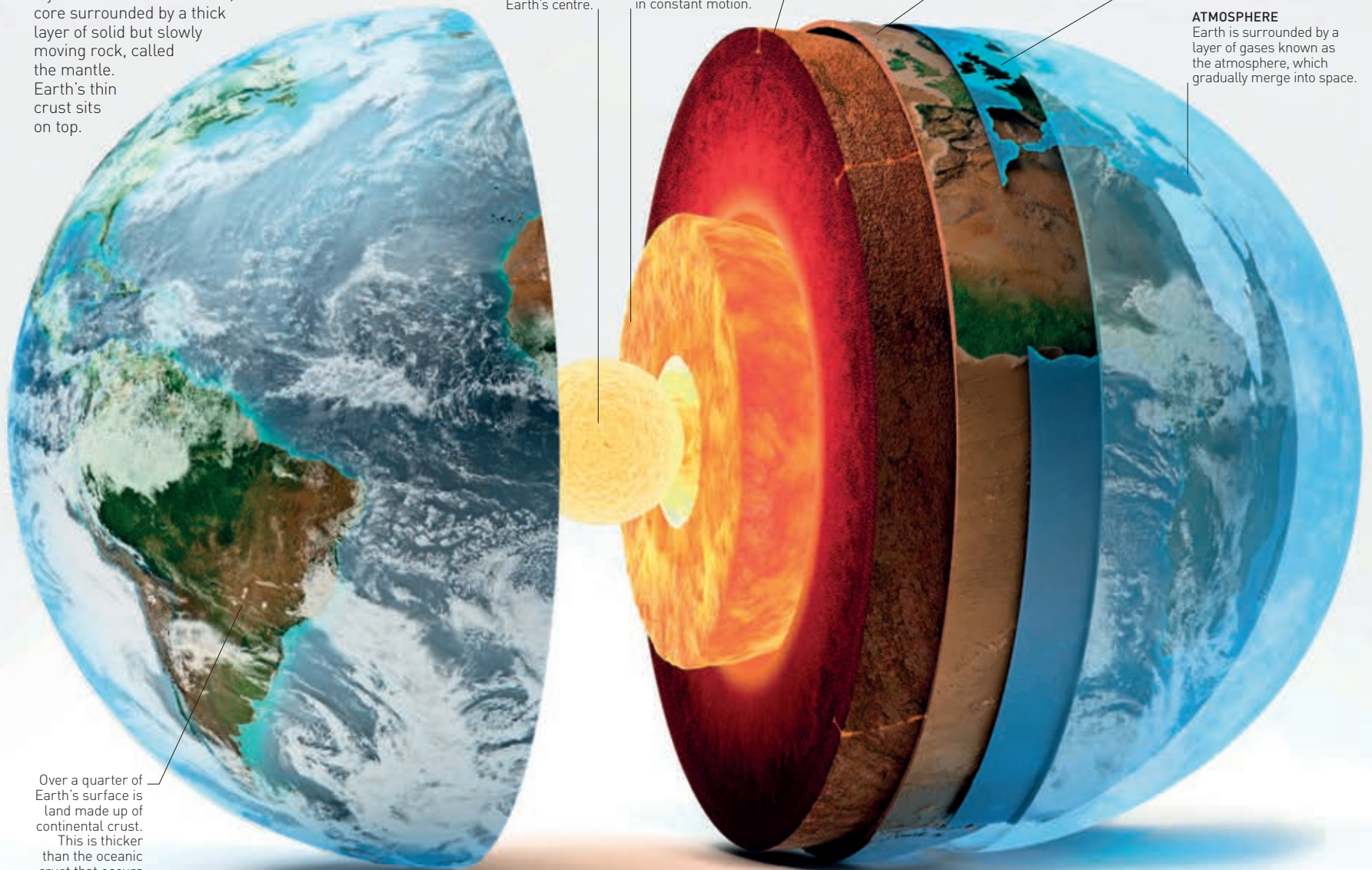
The solid outer layer of Earth is the only part we can see.

### OCEAN

Saltwater oceans cover almost three-quarters of Earth's surface.

### ATMOSPHERE

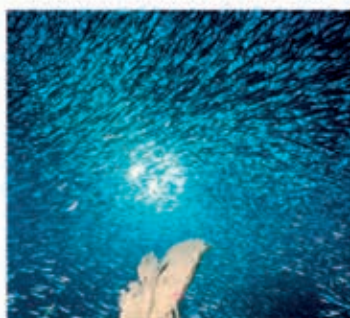
Earth is surrounded by a layer of gases known as the atmosphere, which gradually merge into space.



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 as many as a million types of plants and animals.



### POLAR REGIONS

With freezing temperatures, the Arctic and Antarctic are the most inhospitable places on Earth.



### GRASSLAND

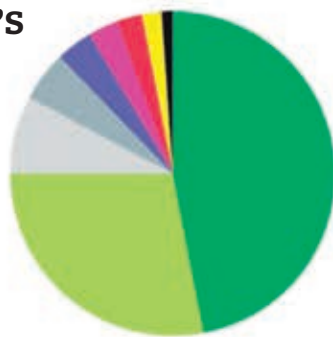
Found on every continent except Antarctica, grassland covers about one-third of Earth's land surface.





## INSIDE EARTH'S CRUST

The rocky crust layer that makes up Earth's continents and ocean floors contains many different chemical elements. Most of the crust is formed of silicon dioxide, which consists of joined-together silicon and oxygen atoms.

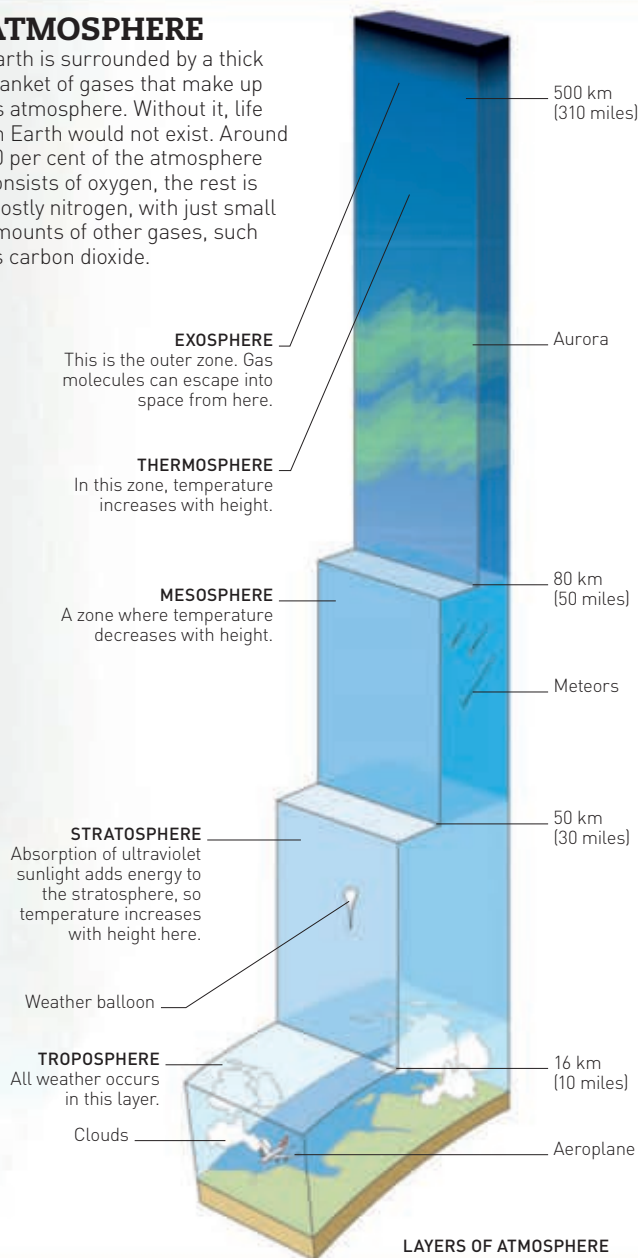


ELEMENTS IN EARTH'S CRUST

- KEY**
- Oxygen 47%
  - Silicon 28%
  - Aluminium 8%
  - Iron 5%
  - Calcium 3.5%
  - Sodium 3%
  - Potassium 2.5%
  - Magnesium 2%
  - All other elements 1%

## ATMOSPHERE

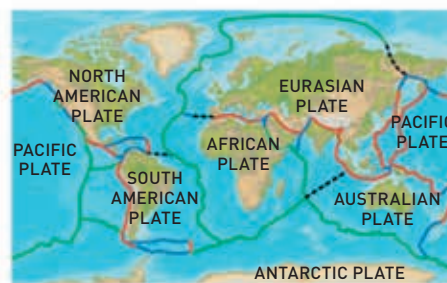
Earth is surrounded by a thick blanket of gases that make up its atmosphere. Without it, life on Earth would not exist. Around 20 per cent of the atmosphere consists of oxygen, the rest is mostly nitrogen, with just small amounts of other gases, such as carbon dioxide.



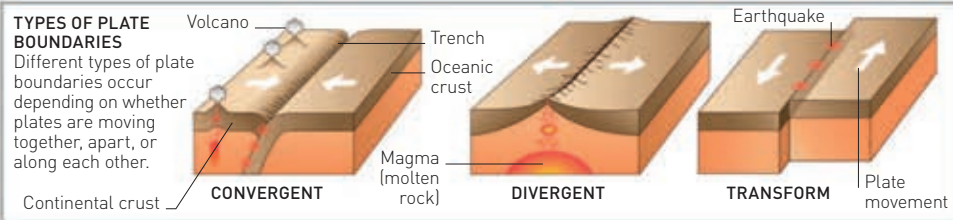
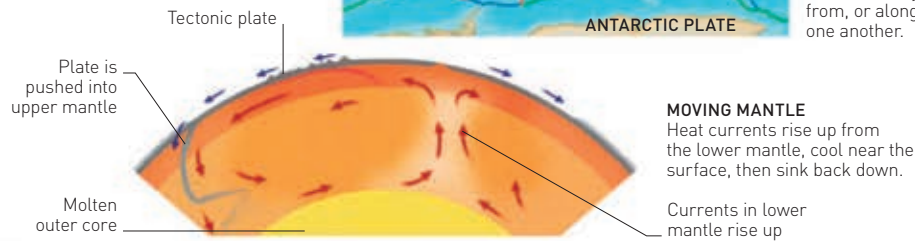
LAYERS OF ATMOSPHERE

## 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.

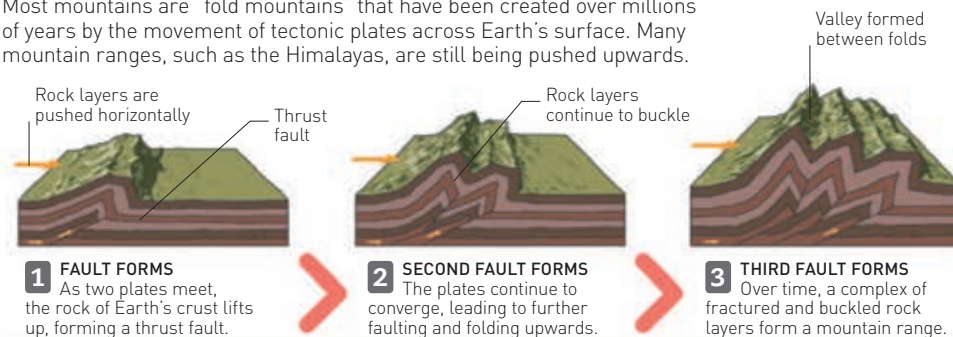


**ON THE MOVE**  
Earth's plates are constantly moving towards, away from, or alongside one another.



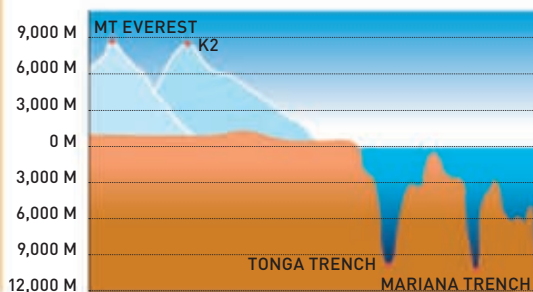
## MOUNTAIN BUILDING

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 upwards.



## HIGHEST AND DEEPEST

At 8,848 m (29,029 ft), the top of Mount Everest, part of the Himalaya mountain range in Asia, is Earth's highest point. By contrast, the Mariana Trench, in the Pacific Ocean, is the deepest, reaching 10,920 m (35,829 ft) 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 one per cent of Earth's surface, freshwater rivers and wetland 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.

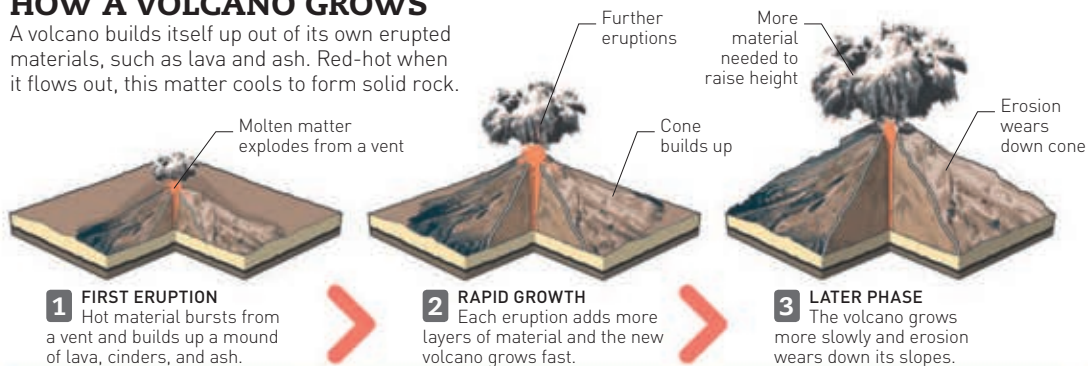


# Volcanoes

Deep inside Earth are pockets of hot, molten rock. Now and then, this fluid surges up to the surface and pours out in a volcanic eruption. Some volcanoes stay active over millions of years, whereas others erupt only for a few years.

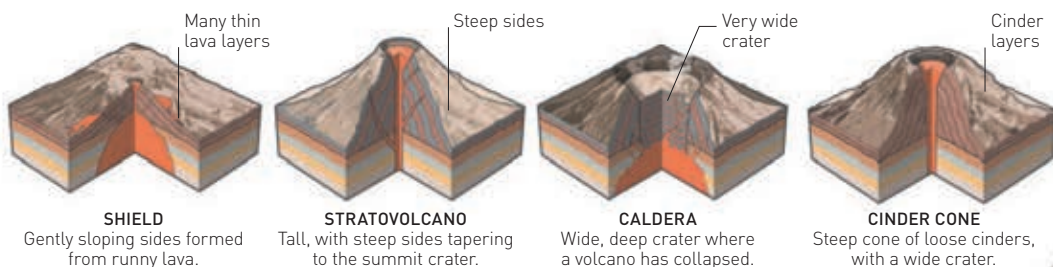
## HOW A VOLCANO GROWS

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.



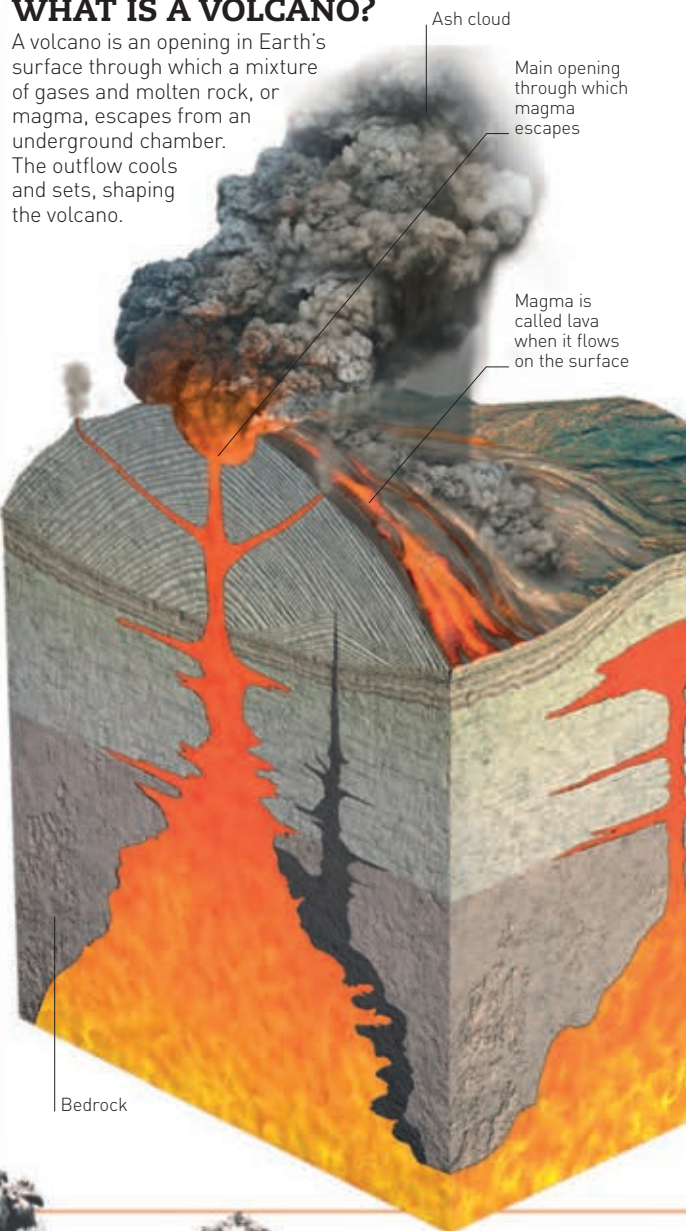
## VOLCANO TYPES

Not all volcanoes have a steep “smoking mountain” shape. Other forms include shield volcanoes – which look like huge, upturned dinner plates – and small cindery 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.

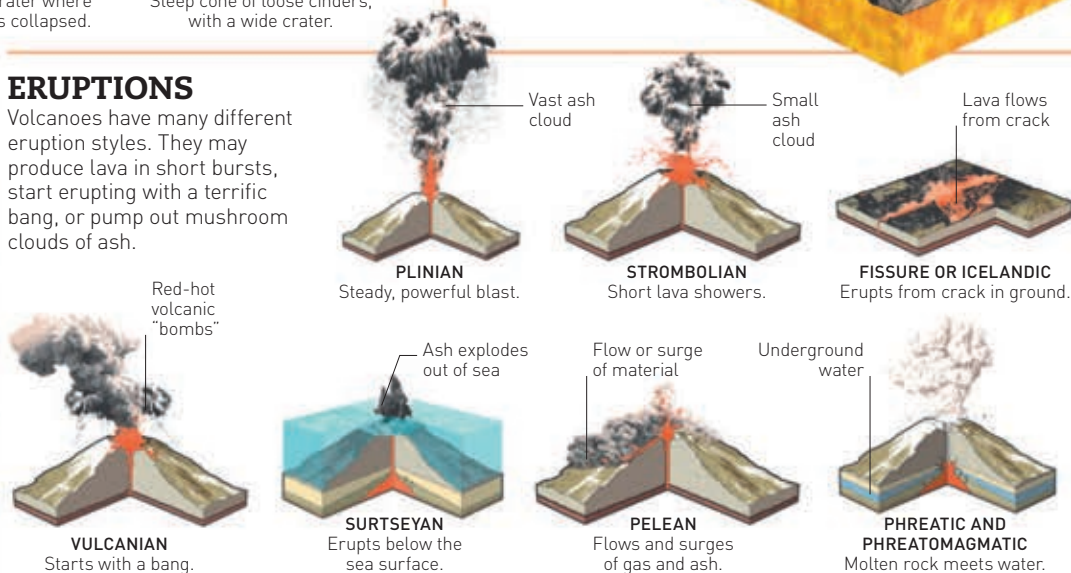


## LARGEST ACTIVE SHIELD VOLCANOES

LOCATION	SHAPE	SUMMIT HEIGHT	MAXIMUM WIDTH OF BASE
Mauna Loa, Hawaii		4,169 m (13,677 ft)	95 km (59 miles)
Erta Ale, Ethiopia		613 m (2,011 ft)	80 km (50 miles)
Sierra Negra, Galápagos		1,500 m (4,921 ft)	50 km (31 miles)
Nyamuragira, Democratic Republic of Congo		3,058 m (10,033 ft)	45 km (28 miles)
Kilauea, Hawaii		1,247 m (4,091 ft)	50 km (31 miles)

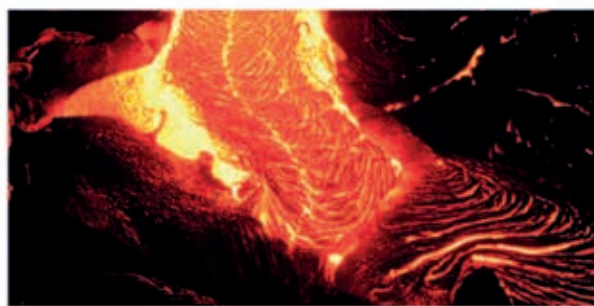
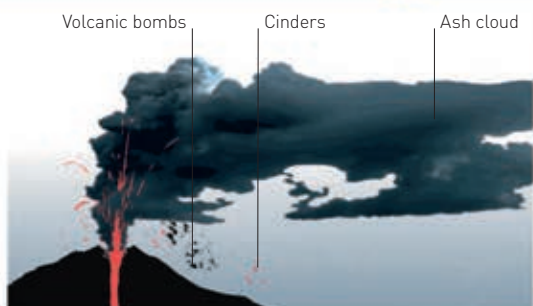
## ERUPTIONS

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 upwards then fall to the ground. Poisonous, suffocating gases are also given off.



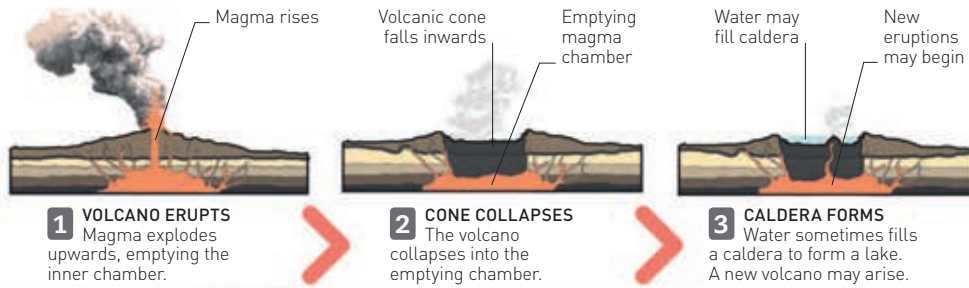
## LAVA

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 thick and sticky, and creep just a short way before coming to a stop.



## CALDERAS

A caldera is a vast bowl in the ground. Calderas form when a volcano comes apart during an 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



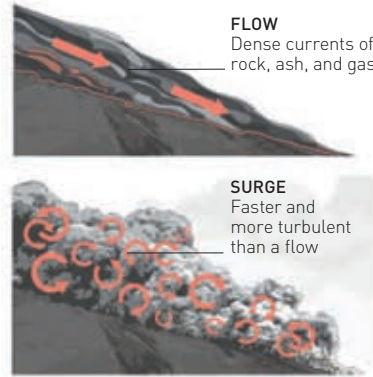
## RED-HOT

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.

Chamber full of molten rock, or magma

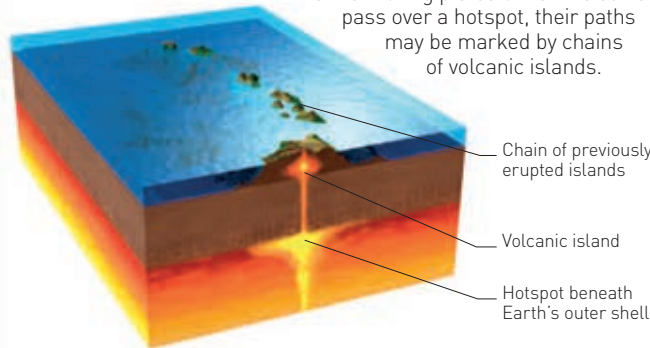
## FLAWS AND SURGES

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.



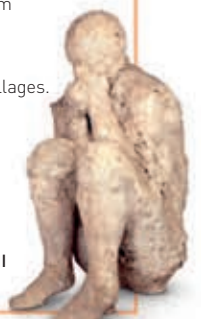
**REFUGEES**  
People lose their homes and livelihoods.



## 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 PELEE, 1902**  
Martinique, Caribbean Islands. Ash and gas flowed at speeds of more than 600 kph (370 mph).
- 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 MARIA, 1902**  
Guatemala. Ash detected 4,000 km (2,500 miles) 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.



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, USA. Makes up much of Yellowstone Park.
- LONG VALLEY CALDERA**  
California, USA. 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?

Volcanoes emerge in clusters in just a few places around the world. There are large numbers in the area called the "Ring of Fire" that circles the Pacific Ocean. Iceland, East Africa, and the Caribbean are big volcanic regions, too.



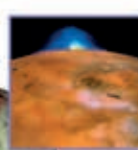
## IN SPACE

Earth is not the only body in the Solar System to have volcanoes. Some of our neighbours 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**  
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 sections, called tectonic plates. These are always on the move, and sometimes shift in ways that cause violent vibrations. Such vibrations are called earthquakes.

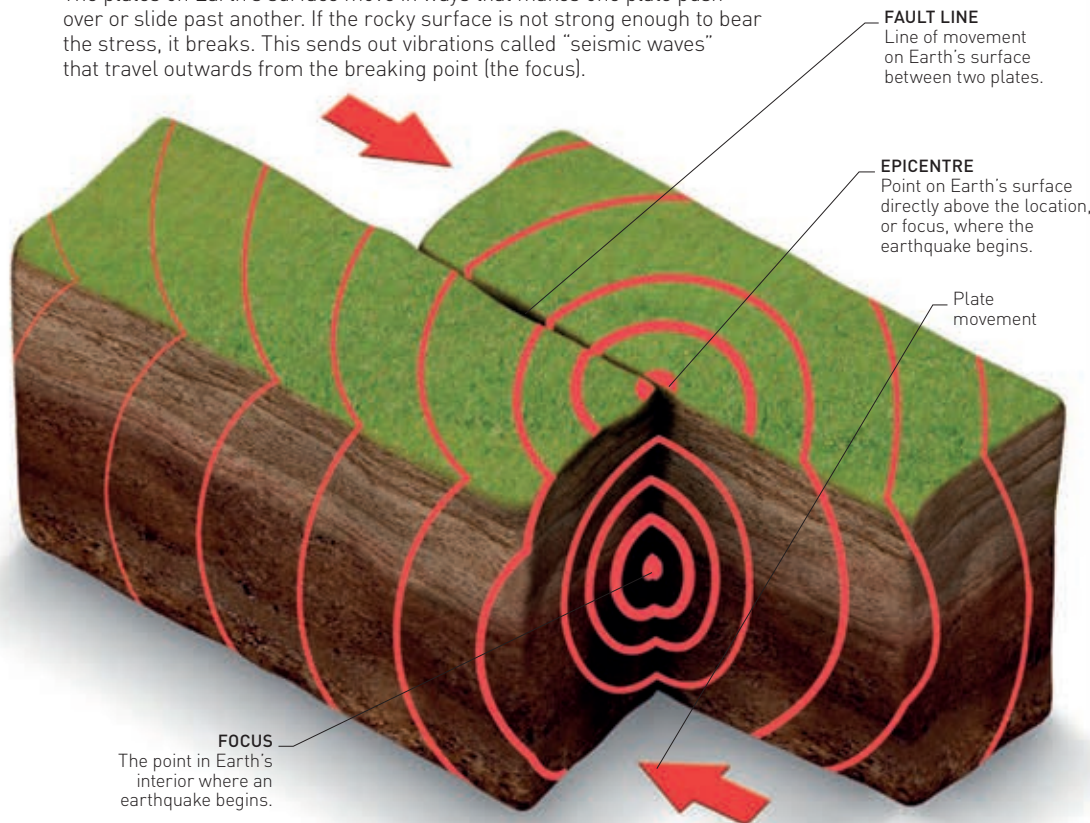
## EARTHQUAKE-PRONE ZONES

Some countries are more affected by earthquakes than others because they lie on the boundaries of tectonic plates. The ten countries shown here have the highest death rates in the world due to violent earthquakes.



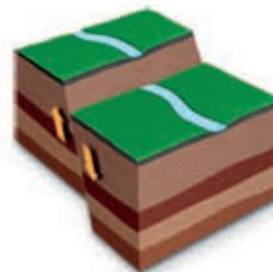
## WHAT CAUSES EARTHQUAKES?

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 outwards from the breaking point (the focus).

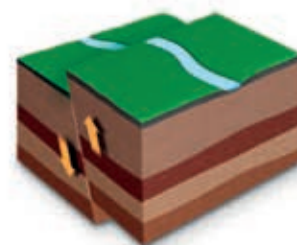


## FAULT TYPES

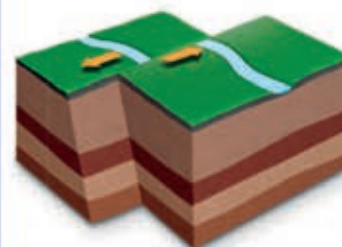
Faults are the boundaries between two moving tectonic plates. They are often the sites of earthquakes. The blocks of rock on either side of a fault can shift and slide past each other in various ways.



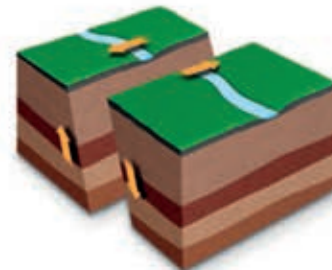
**NORMAL FAULT**  
Rock on one side of the fault moves down, so it is lower than the rock on the other side of the fault.



**REVERSE FAULT**  
One block is pushed up relative to the other, so it ends up at a higher level.



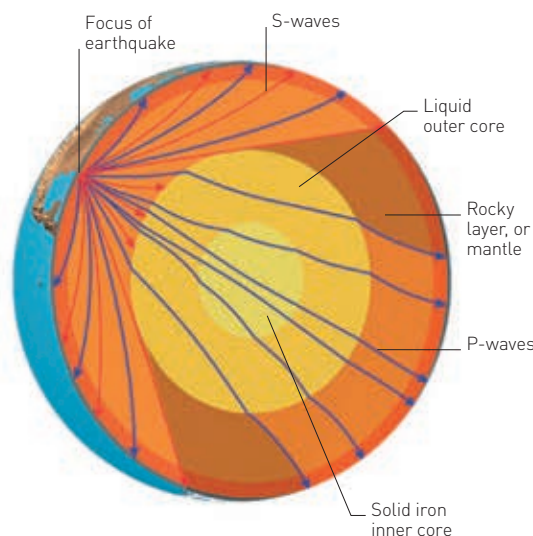
**STRIKE-SLIP FAULT**  
The rocks on either side of the fault move in different directions, scraping side by side.



**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, 22 MAY 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 two million people homeless.
- 2 PRINCE WILLIAM SOUND, ALASKA, 28 MARCH 1964**  
This huge earthquake (magnitude 9.2) caused a tsunami that rose to 67 m (220 ft) and hit Hawaii, Canada, and the USA. In the first day there were 11 aftershocks with magnitudes greater than 6.0.
- 3 NORTHERN SUMATRA, 26 DECEMBER 2004**  
This ruptured the longest fault of any recorded quake, spanning 1,500 km (900 miles) in ten minutes. More than 227,000 people were killed by the resulting tsunami.
- 4 HONSHU, JAPAN, 11 MARCH 2011**  
This 9.0-magnitude earthquake occurred off the coast of Japan and reached depths of 24.4 km (15 miles). The resulting tsunami caused more than 15,800 deaths.
- 5 KAMCHATKA, RUSSIA, 4 NOVEMBER 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, USA.



## MEASURING EARTHQUAKES

Scientists measure earthquake vibrations with an instrument called a seismometer. In various forms, the seismometer has been in use for thousands of years.

**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** Americans Harry Wood and James Anderson's seismometer is precise enough to be used ten 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.



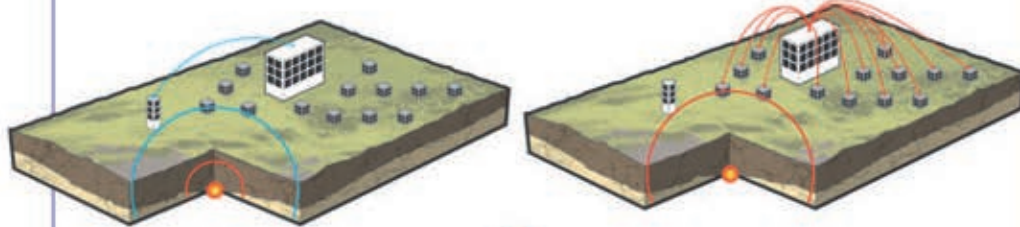
**Wiechert's pendulum**

**1934** American seismologist Charles Richter develops a widely used scale that measures the energy released by an earthquake.

**1979-PRESENT** 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 of 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.



**1 MOVEMENT DETECTED** Early warning systems quickly detect the first signs of an earthquake, estimate the location and magnitude, and calculate areas under threat.

**2 ALERT DISPATCHED** The time between the first alert and the arrival of strong tremors is short. Warnings are transmitted to as many broadcasting stations as possible.

## 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

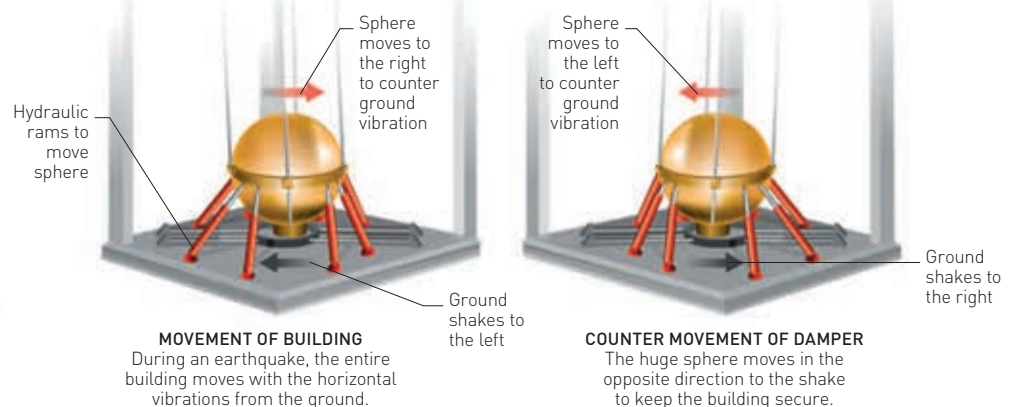
While no structure can be guaranteed completely safe from earthquake damage, the buildings listed here have proven to be very resistant to massive ground shakes.

- **CHECHEN ITZA, MEXICO**  
The Mayan pyramid of El Castillo at Chechen Itza 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 system, sits on rollers, and is made from flexible materials.
- **TRANSAMERICA PYRAMID, USA**  
Rising to 260 m (853 ft), this skyscraper in San Francisco has foundations that reach 16 m (52 ft) into the ground.
- **TAIPEI 101, TAIWAN**  
Stretching twice as high as the Transamerica Pyramid, this relies on a huge mass damper to resist movement.



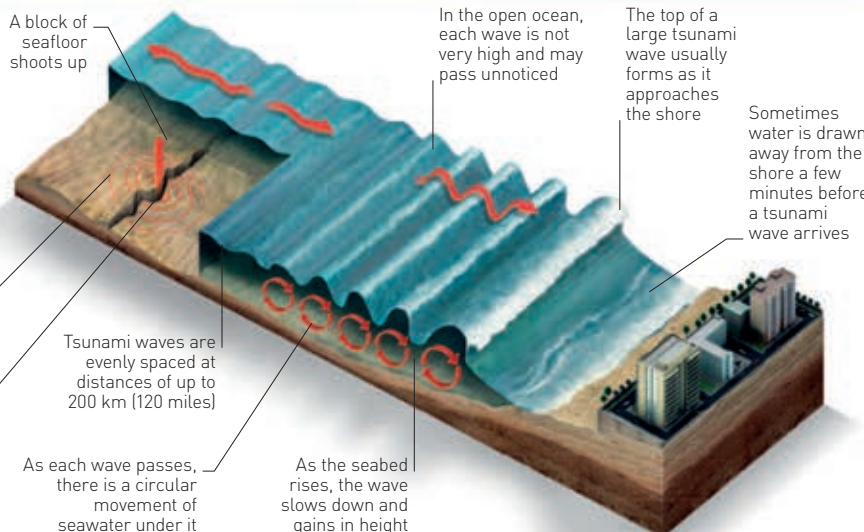
## MASS DAMPER

One way to help skyscrapers cope with an extreme ground shake is to install a mass damper – a huge steel sphere – at the centre, 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 upwards, 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 SUMATRA, INDONESIA, 26 DECEMBER 2004**  
This tsunami's waves reached 50 m (164 ft) and killed more than 227,000 people, affecting 14 countries.
- 2 NORTH PACIFIC COAST, JAPAN, 11 MARCH 2011**  
Travelling at 800 km/h (497 mph), the 10 m (33 ft) high waves of this tsunami forced 450,000 people from their homes.
- 3 PORTUGAL, 1 NOVEMBER 1755**  
Set off by an 8.5-magnitude earthquake, this tsunami hit Portugal, Morocco, and Spain with waves 30 m (98 ft) high.
- 4 KRAKATOA, INDONESIA, 27 AUGUST 1883**  
Caused by the eruption of the Krakatoa Caldera volcano, this tsunami created multiple waves reaching 37 m (121 ft) high.
- 5 ENSHUNADA SEA, JAPAN, 20 SEPTEMBER 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 changes constantly but so gradually we can hardly see it. Wind, waves, moving ice, and other forces wear away rocks and mountains and create valleys. At the same time, Earth's plates move, forming mountains and continents.

## 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 mould 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 MORAIN**  
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.

**RIVERS DUMP ABOUT 20 BILLION TONNES OF SEDIMENT INTO THE SEA EVERY YEAR**

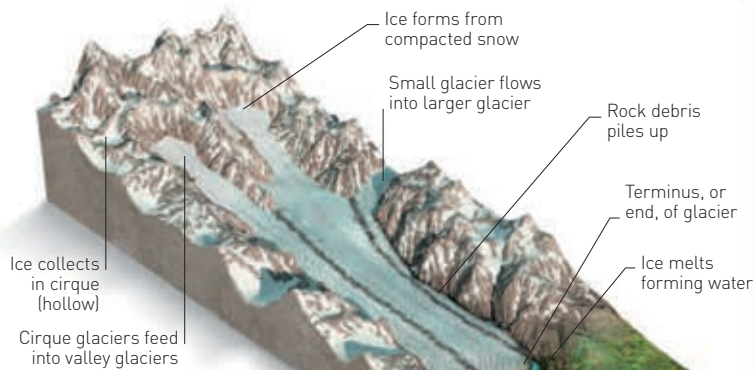
**FLOODPLAIN**  
Sediment deposited by river creates flat floodplain.

**MEANDER**  
River bend caused by erosion on one side and silt deposits on the other.

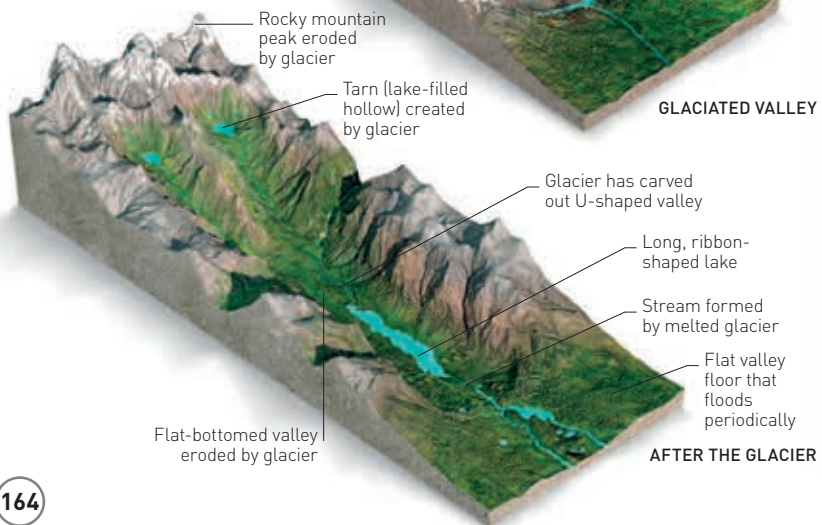
**ARCH**  
Pounding waves form arch in headland.

## GLACIERS

Icy glaciers flow through mountain valleys, reshaping them. They move slowly, usually less than 1 m (3.3 ft) a day, but are so large they carve out vast depressions in the rock and U-shaped valleys.



GLACIATED VALLEY



AFTER THE GLACIER

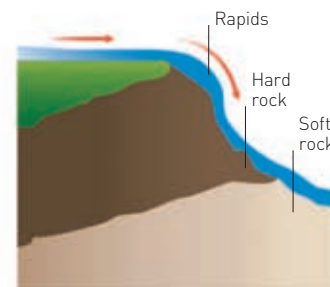
**DELTA**  
A delta forms where a slow-moving river deposits sediment where it meets the sea.

**BEACH**  
Beaches are created from eroded material carried by the sea.

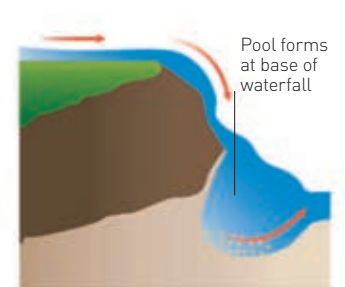
**SAND SPIT**  
On the coast, sandy deposits settle and project out into the sea.

## 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

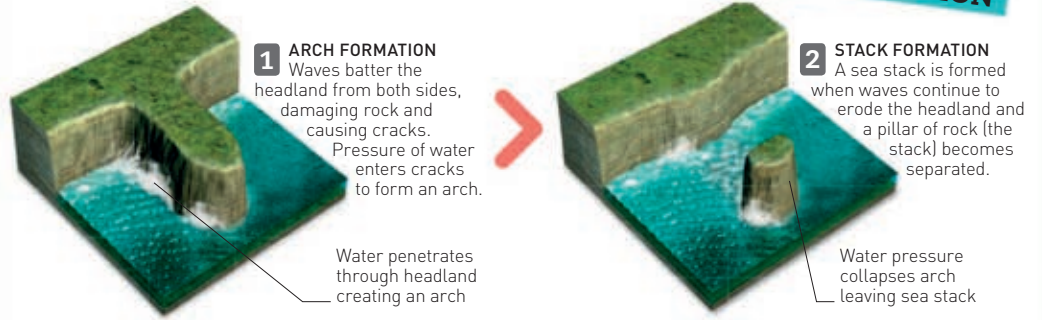
Helped by strong winds, ocean waves batter against coastal landforms. Dislodged rocks and pebbles are ground down and rub abrasively against headlands, cliffs, and standing rocks.



ERODED ROCK, LOCH ARD GORGE, AUSTRALIA

## ARCHES AND STACKS

As waves approach a headland, they curve around, attacking the sides. In a process called corrosion, 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.



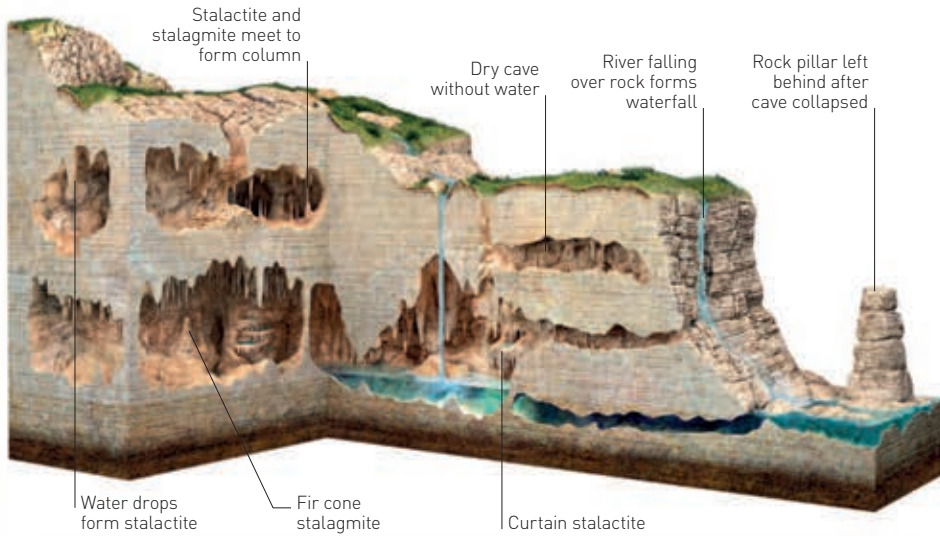
## LIMESTONE LANDSCAPES

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.



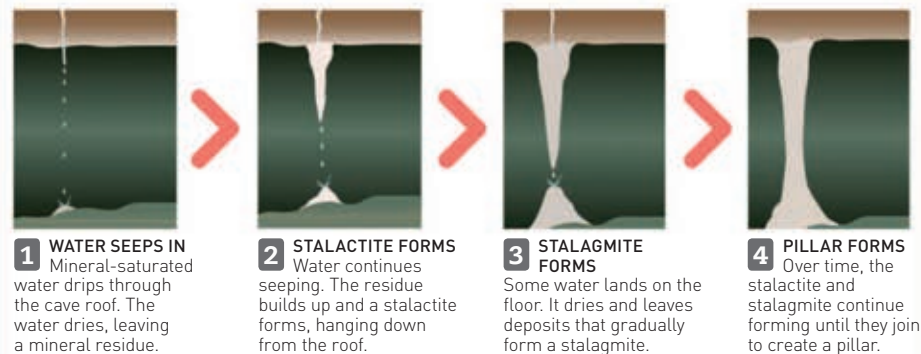
## INSIDE A CAVE

Limestone caves are wondrous places. Over centuries, erosion has created 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 1.5 km (1 mile) 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 form from a mineral in the rocks called calcite that dissolves in drops of water seeping through the roof. Over time, they form fantastic shapes.



## OWBOW LAKES

On low-lying land, snake-like 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, 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, USA

Wind, and the sand particles it carries, erode sedimentary rocks such as sandstone, creating fantastic swirls.

## MUSHROOM-SHAPED ROCKS, EGYPT

Desert winds fling sand about, which causes erosion. The sand blasts against rocks, producing strange shapes.





# Rocks and minerals

The outer layers of Earth are mostly solid rock. This is easy to see where there are mountains or canyons, 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 or water at the surface, or by heat and pressure inside Earth.

## WHAT'S THE DIFFERENCE?

Minerals are natural chemical substances that usually form as solid crystals. Each type can be recognized by its hardness, colour, 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

Formed from volcanic material as it cools down, igneous rocks are of two types. Some, such as pegmatites, form deep underground. Others, such as andesite, form when volcanic lavas cool at Earth's surface.



PUMICE



ANDESITE



OBSIDIAN



PINK GRANODIORITE



RHYOLITE



PORPHYRY



TOURMALINE PEGMATITE

## SEDIMENTARY ROCKS

These rocks form mostly at the bottom of seas and lakes. 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. They usually form from water solutions and molten rock, sometimes deep inside Earth. Some, such as diamonds, are cut and polished to make gemstones.



CHRYSOPRASE



MAGNETITE



ENARGITE



TENNANTITE



HORNBLLENDE



BROOKITE



CHALCOCITE



HALITE



CHALCOPYRITE



NAILHEAD CALCITE



GALENA



CORUNDUM



SULPHUR

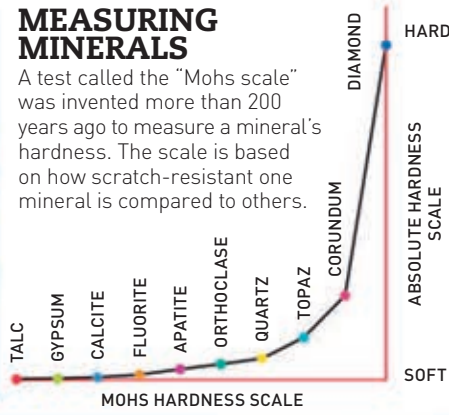


GOLD



## 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

Intense heat or pressure deep inside Earth can change the minerals in rocks from one type to another or may rearrange the mineral grains. This process produces what are called metamorphic rocks.



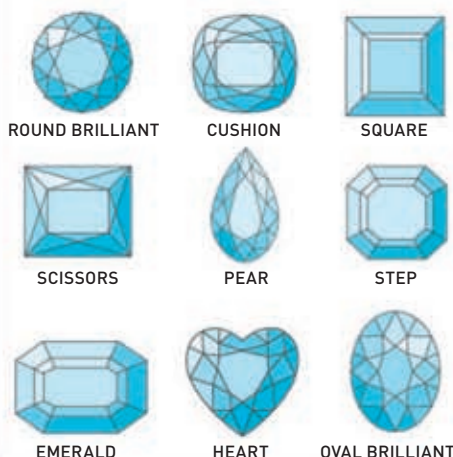


# Gems

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	FEBRUARY	MARCH	APRIL
GARNET	AMETHYST	AQUAMARINE	DIAMOND
EMERALD	PEARL	RUBY	PERIDOT
SAPPHIRE	TOURMALINE	TOPAZ	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 jewellers still find it useful.



## SEMI-PRECIOUS STONES

Gems found in large quantities were once said to be "semi-precious" and had a lower value than rare stones. However, a gem's beauty and popularity are now also considered part of its value. Some "semi-precious" 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 colours 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 the surface into a series of flat, reflective faces called facets.



## MINING

Gemstones are found in different areas across the world. They are sometimes brought to the Earth's surface by volcanic eruptions.



## BIGGEST GEMS

Gemstones can be huge. The Olympic Australis opal weighs 3.45 kg (7.5 lb); the American Golden topaz is 4.57 kg (10 lb); and the largest colourless diamond, the Cullinan, is 10 cm (4 in) 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.



AMBER



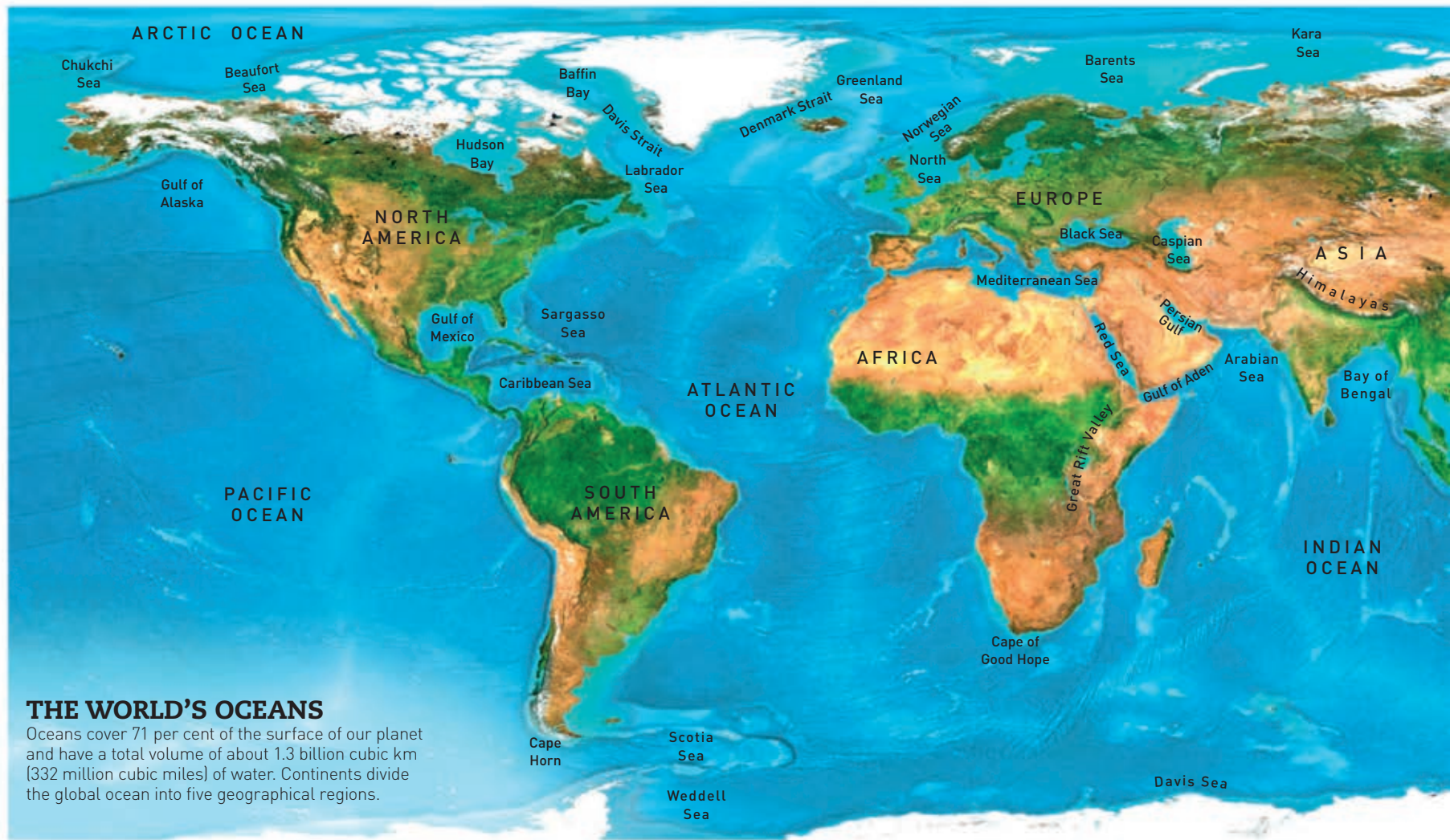
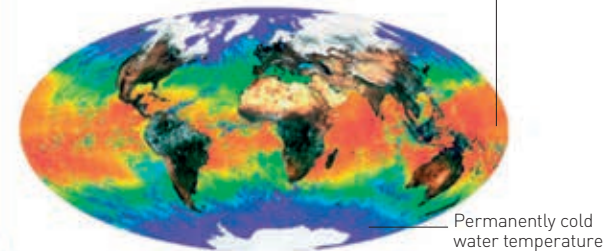
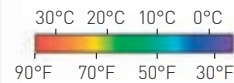
# Water on Earth

**ABOUT 97 PER CENT OF THE WORLD'S WATER LIES IN THE OCEANS**

Water is the most common substance on Earth's surface – it fills the colossal oceans, swirls in clouds as water vapour, and falls as rain on land. It is vital to all life and is why our planet is unique: water vapour and ice may exist on other planets but only Earth has oceans of liquid water.

## 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. But in the polar regions, the Sun is less powerful, resulting in permanently cold water.

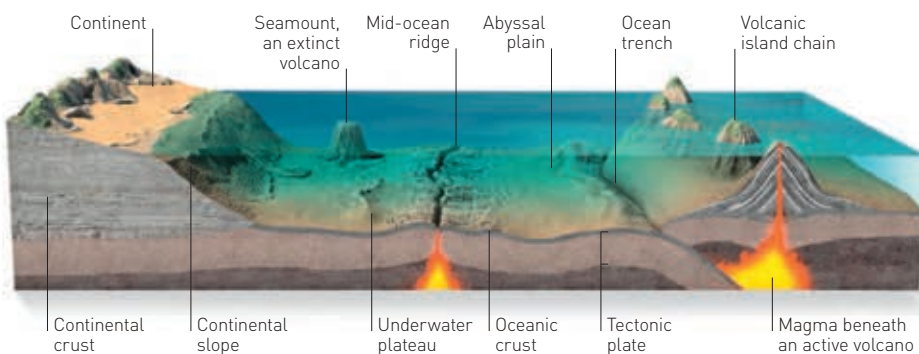


## THE WORLD'S OCEANS

Oceans cover 71 per cent of the surface of our planet and have a total volume of about 1.3 billion cubic km (332 million cubic miles) of water. Continents divide the global ocean into five geographical regions.

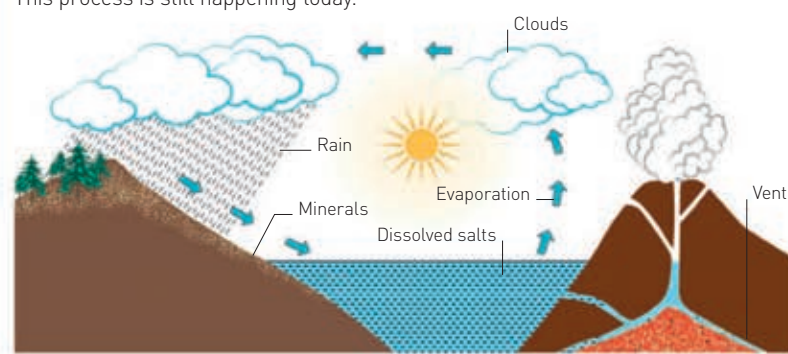
## OCEAN FLOOR

The ocean floor is not just a featureless plain filled with water. Underwater volcanoes, towering mountains, vast plains, and the deepest trenches on Earth lie hidden beneath the waves.



## SALT WATER

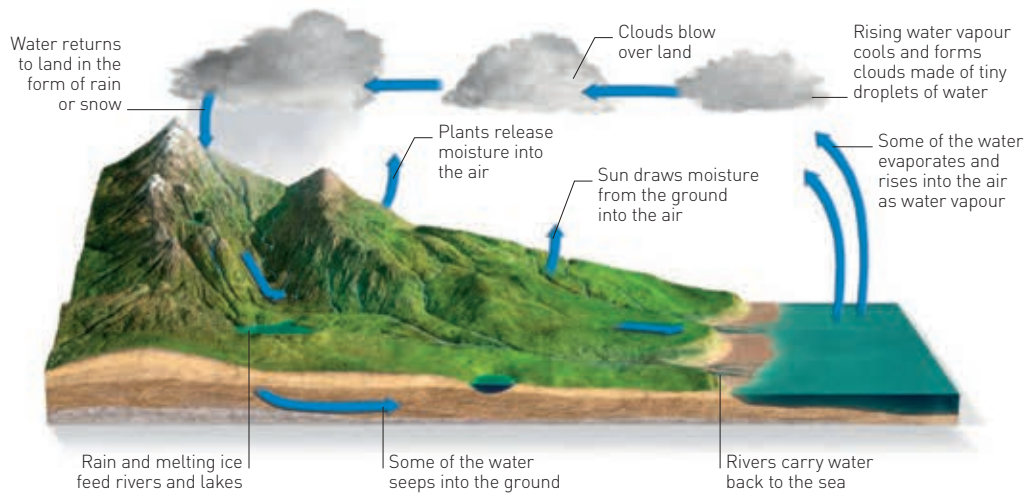
Most of Earth's water is salty. Over millions of years, rain pouring down on the land weathered the rocks and carried dissolved minerals on its journey to the seas. The minerals included sodium chloride (common salt). This process is still happening today.





## WATER CYCLE

Powered by the Sun's heat, the water cycle circulates between sea, air, and land. The Sun-warmed surface water is constantly evaporating (turning into water vapour). The rising vapour cools and condenses, forming clouds that may be carried over land. Here, it falls back as rain or snow, and flows over the land before the water finds its way back to the sea.



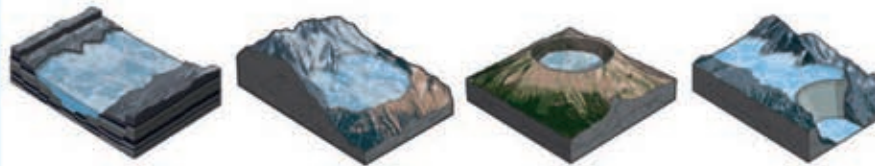
## LARGEST LAKES

Some lakes are just shallow pools that eventually dry out, while others are so vast that they are like inland seas.

- CASPIAN SEA**  
Area: 371,000 sq km (143,000 sq miles) This lake was once part of the Mediterranean Sea; it was cut off when sea levels fell during the last ice age.
- SUPERIOR**  
Area: 82,414 sq km (31,820 sq miles) One of the five Great Lakes of North America, and the largest freshwater lake in the world.
- VICTORIA**  
Area: 69,485 sq km (26,828 sq miles) The waters of Lake Victoria in Africa fill a shallow basin in the centre of a plateau.
- HURON**  
Area: 59,600 sq km (23,000 sq miles) This is the second largest of the North American Great Lakes.
- MICHIGAN**  
Area: 58,000 (22,000 sq miles) Also one of the five Great Lakes but located entirely within the USA.

## 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.



**FAULT LAKE**  
Tectonic movement of Earth's crust creates long hollows, which fill with water. These are among the oldest and deepest lakes on Earth.

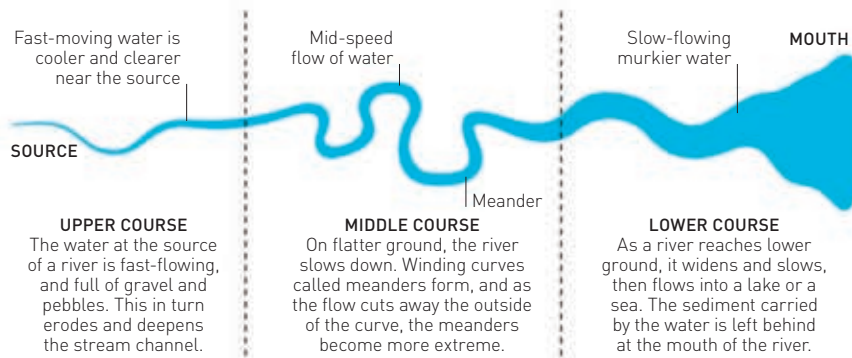
**KETTLE LAKE**  
Depressions left behind when an underground block of ice melts creating a steep-sided circular lake.

**CALDERA LAKE**  
This type of lake forms when rain fills the huge crater left after an eruption has blown away the top of a volcano.

**MAN-MADE LAKE**  
Some lakes are man-made to provide a reservoir of clean water for homes and industry, or to create hydroelectricity.

## RIVERS

Most rivers begin life as small, fast-flowing streams that 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.

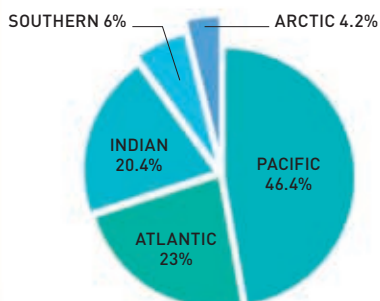


## ARCTIC OCEAN



## 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.



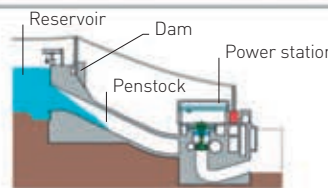
**HYDROELECTRIC**  
Hydroelectric dams are built to convert a river's kinetic energy (energy of movement) into electrical power.



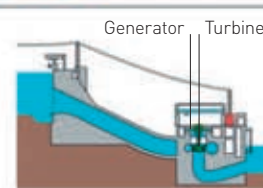
**TIDAL SURGE**  
Tidal barrages work in a similar way to hydroelectric dams, generating power from rising and falling tides.

### HYDROELECTRIC ENERGY

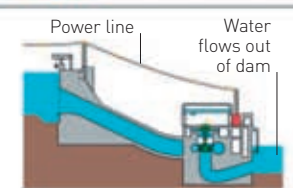
Hydroelectric power stations use the force of moving water to produce electrical energy. The amount of energy created is determined by the flow of water.



**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.

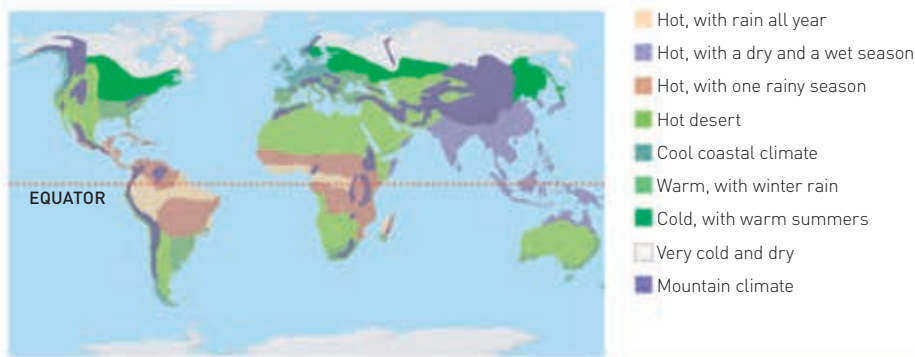


# Climate and weather

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 is what makes up its climate.

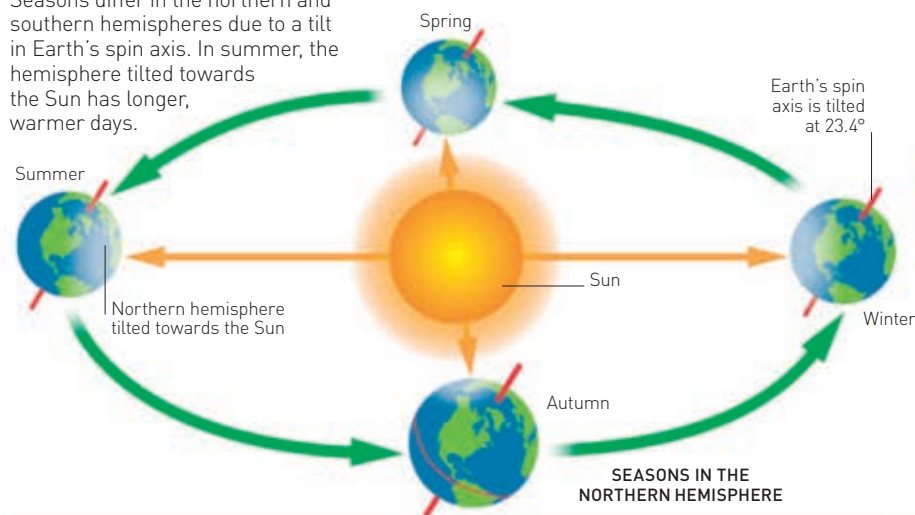
## WORLD'S CLIMATE

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.



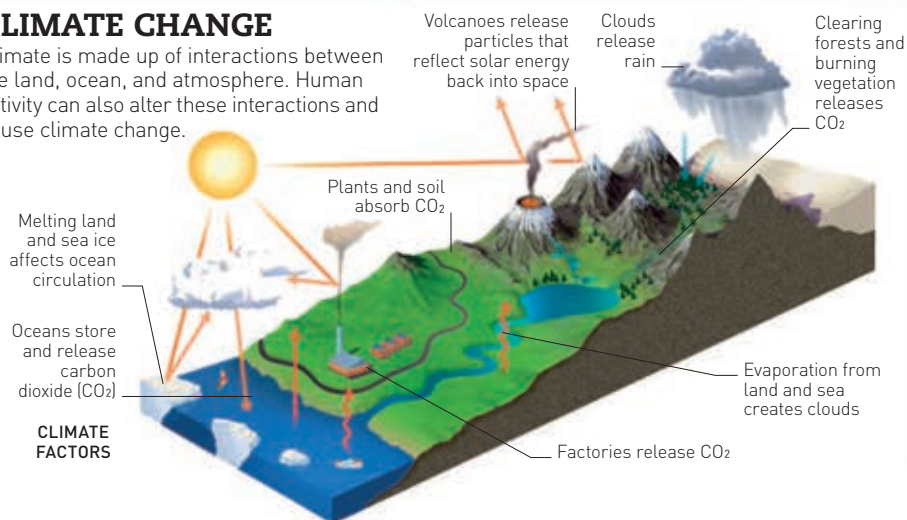
## SEASONS

Seasons differ in the northern and southern hemispheres due to a tilt in Earth's spin axis. In summer, the hemisphere tilted towards 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 further they are from the equator.



**PRECIPITATION**  
There are zones of high and low rainfall around the Earth.

## WEATHER SYSTEMS

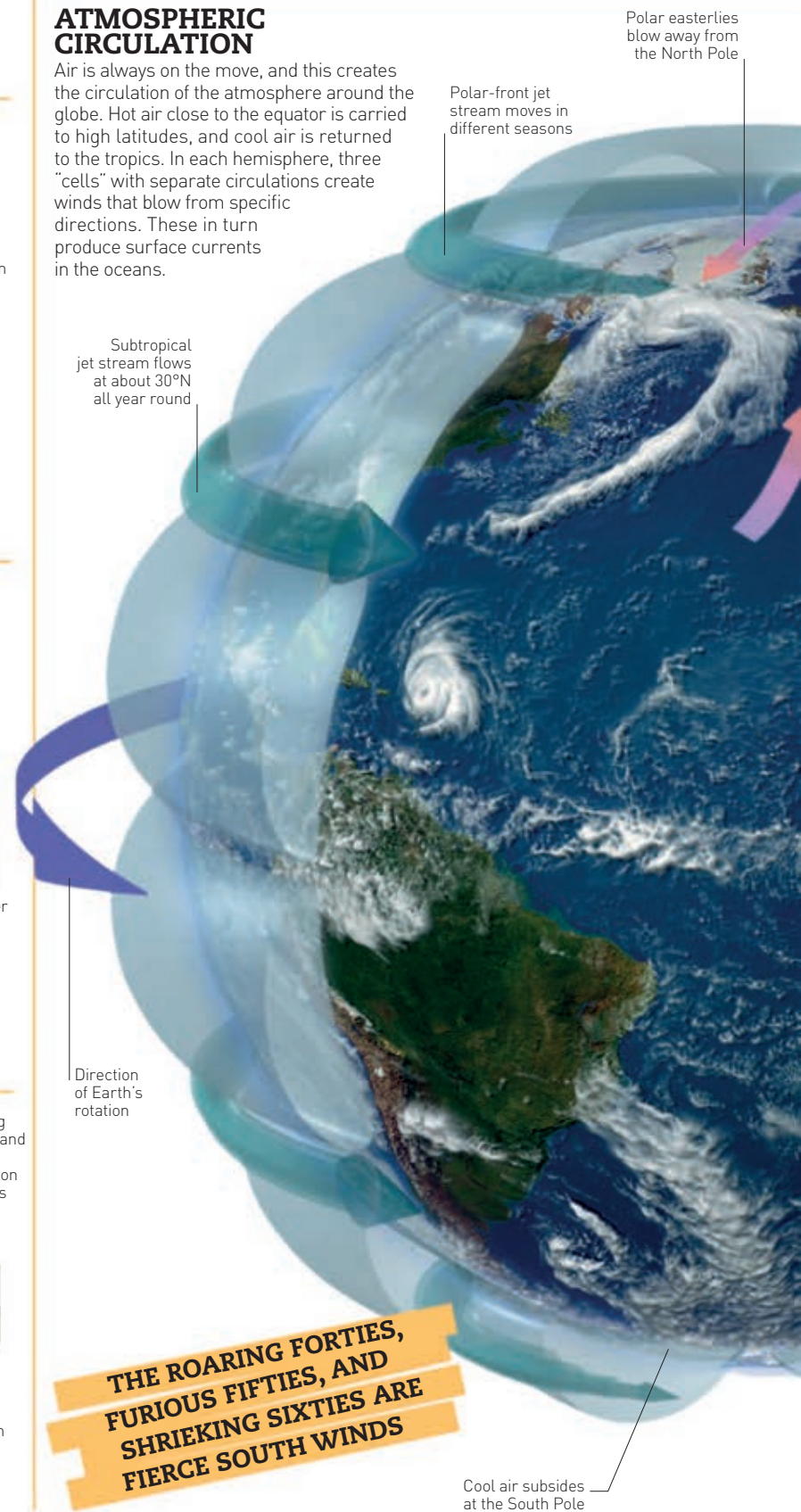
Local air masses have their own temperature, moisture content, density, and pressure. A weather front occurs when one air mass meets another.

**WARM FRONT**  
Cold air is replaced by warm air, which slowly rises to form clouds and then rain as the air cools.

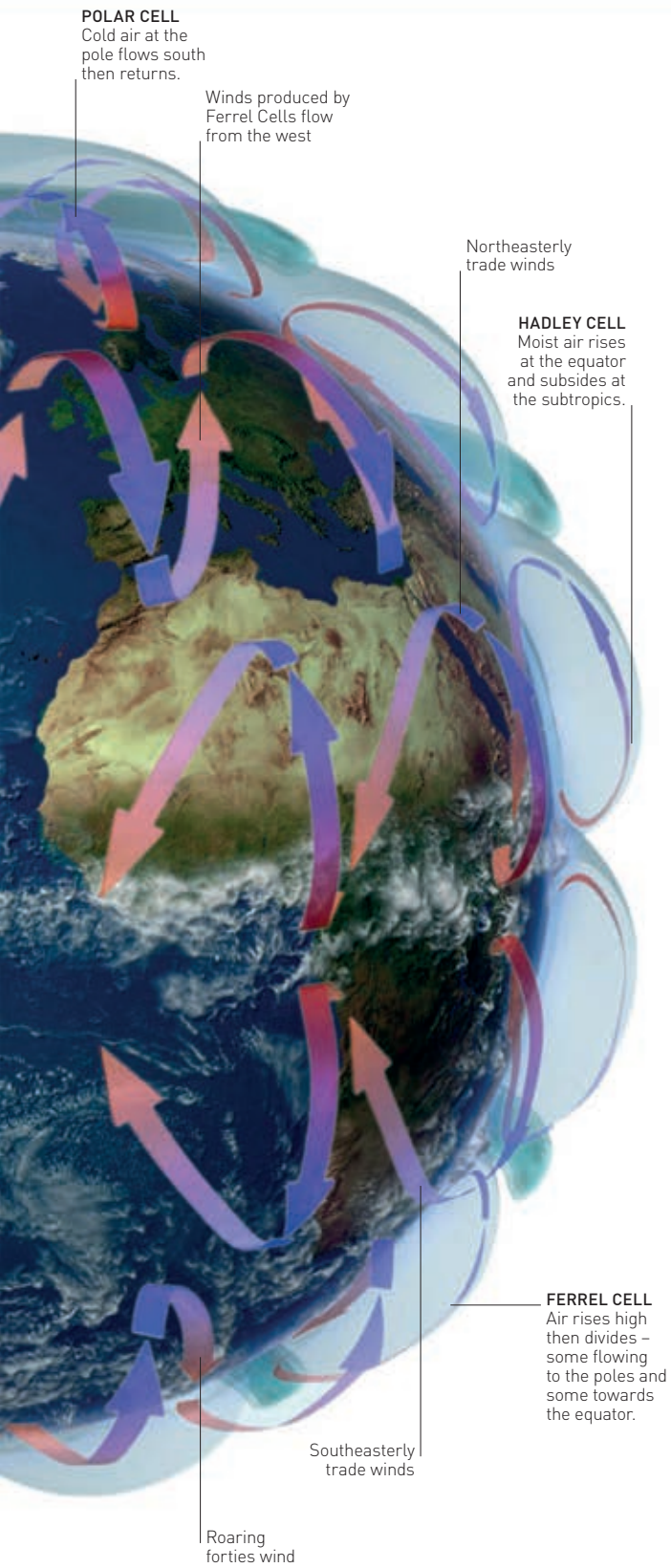
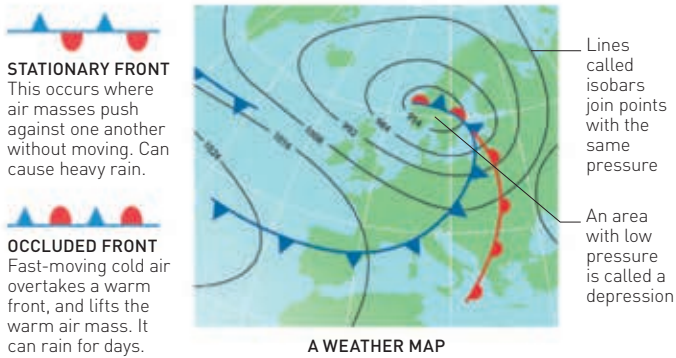
**COLD FRONT**  
Cold air pushes into warm air, forcing it upwards to create storm clouds and heavy rain.

## 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. In each hemisphere, three "cells" with separate circulations create winds that blow from specific directions. These in turn produce surface currents in the oceans.







## PRECIPITATION

All precipitation is simply falling moisture. Whether water falls from a cloud as rain, hail, or snow depends on how cold the air is.



**RAIN**  
Droplets in clouds fall when they are too heavy to float.



**SLEET**  
Sleet is a mix of snow and rain in air above freezing.



**SNOW**  
Snowflakes are clusters of frozen water droplets.



**HAIL**  
Ice pellets form from crystals in storm clouds.



**FOG**  
Fog forms when warm, moist air hits cold ground.

## WIND

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.

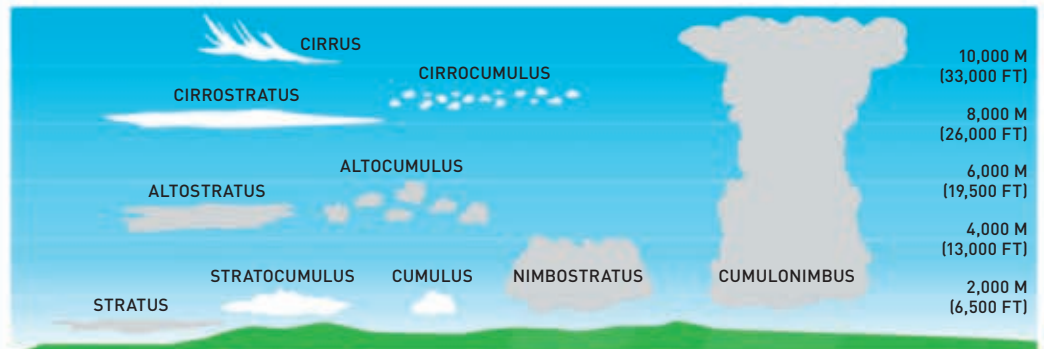


## CLOUDS

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.

### CLOUD NAMES

Clouds are named according to their size, shape, and height.



## HOW CLOUDS FORM



**1 MOISTURE**  
When the Sun shines, moisture in the ground and sea rises into the air as water vapour.



**2 VAPOUR CONDENSES**  
As the vapour rises and cools, it condenses and forms clouds made of tiny water droplets.



**3 CLOUDS RISE**  
During cloud formation, heat is released into the surrounding air and lifts the cloud higher.

## WATCHING THE WEATHER

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.



**DOPPLER RADAR**  
This type of radar uses microwaves to track moving bands of rain.



**WEATHER BALLOON**  
Helium-filled balloons carry sensors high into the atmosphere.



**SATELLITE**  
Satellites orbit from pole to pole or sit above one region.

## RECORD-BREAKING WEATHER

Some places have extreme climates, or weather events that are talked about for years.

### WINDIEST

The fastest wind speed in a tornado was 450 km/h (280 mph), recorded at Wichita Falls, USA, in 1958.

### HOTTEST

The hottest land-surface temperature ever recorded (by satellite measurement) was 70.7°C (159.3°F) in the Lut Desert, Iran, in 2005.

### COLDEST

The coldest recorded temperature was -93°C (-136°F), measured in Antarctica's eastern highlands in 2010.

### WETTEST

The highest rainfall recorded in one day was 18.25 cm (71.9 in) in Foc-Foc, Reunion Island, in the Indian Ocean in 1966, during a tropical cyclone.

### DRIEST

Arica, Chile is the populated area with the lowest average annual rainfall in the world at 0.76 mm (0.03 in).



ARICA, CHILE



# Extreme weather

Tornadoes, hurricanes, and flash floods destroy homes and countryside. Long dry spells cause water shortages and parched 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 0.5°C (0.9°F), 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. Put simply, extreme weather is weather that is windier, hotter, colder, wetter, or more destructive than usual.

**THE USA 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**  
The 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, 15 cm (6 in) 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.

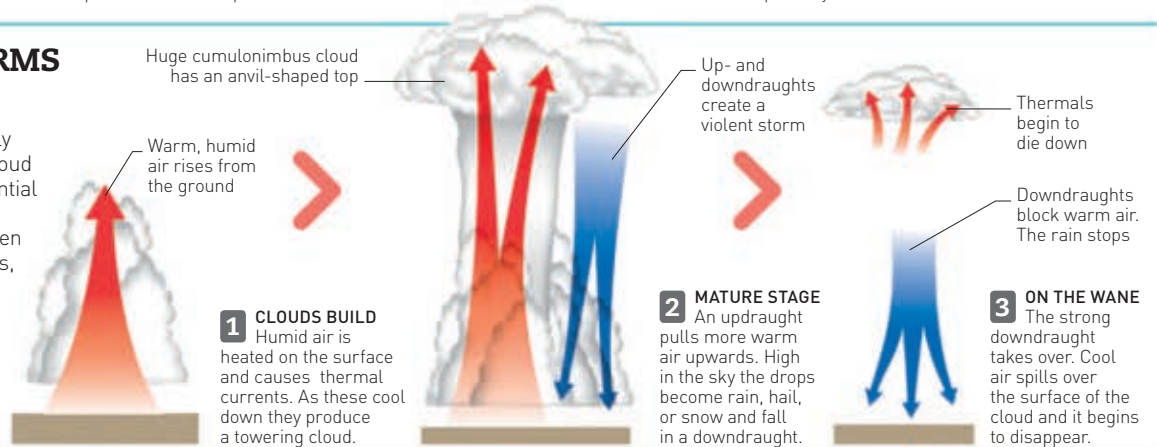


### WINTER

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.

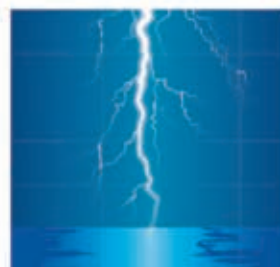


## LIGHTNING STROKES

It takes a huge voltage of electricity to overcome the resistance of the air, but once the process starts, strokes of lightning zig-zag towards 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 whipped up in strong winds and then fall as rain.

### 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, USA, during a July storm in 2010. Hailstones can gather ice layers as winds whip them upwards again and again.

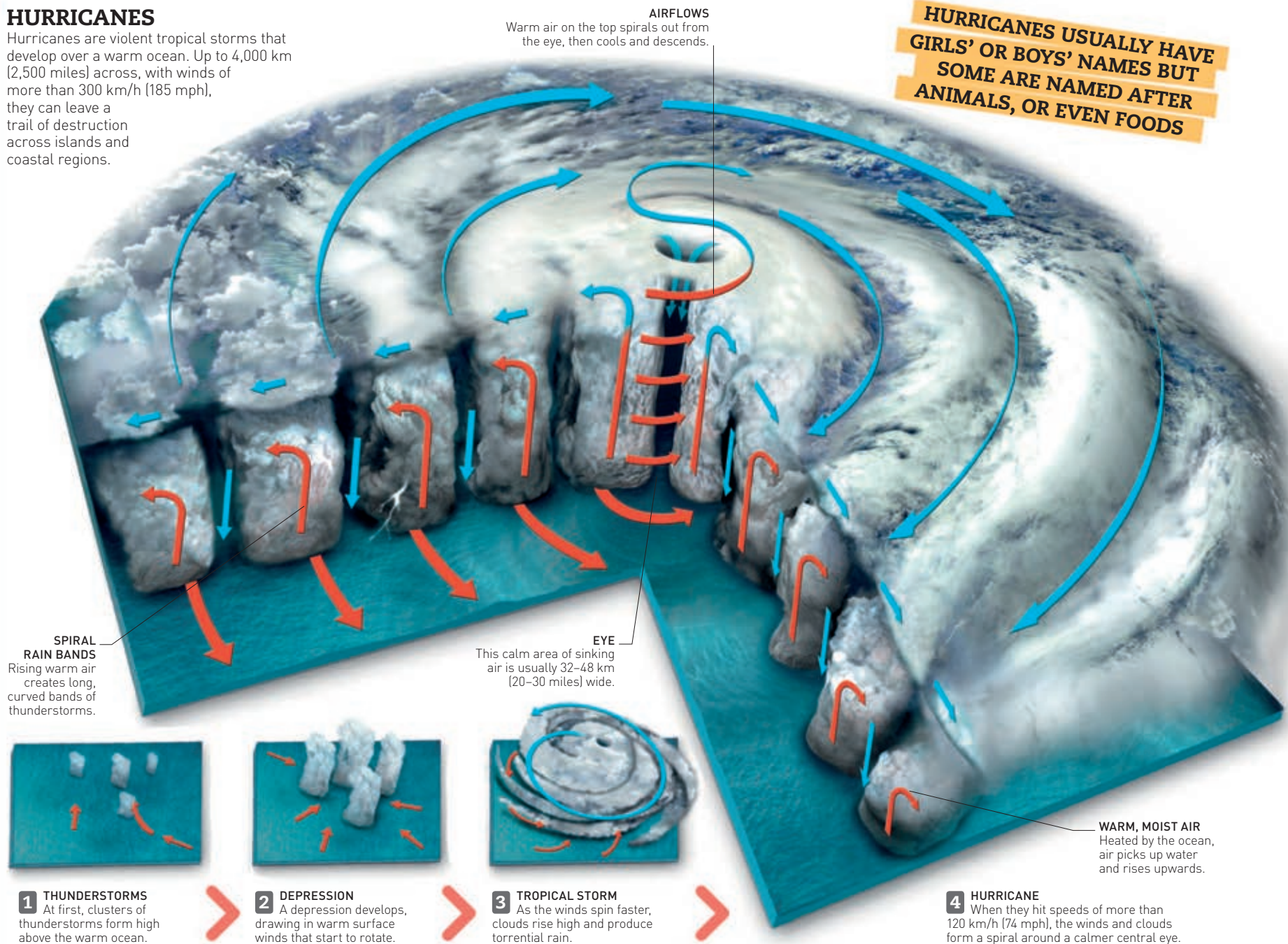


### RECORD HAILSTONE

This hailstone weighed 1 kg (2.2 lb) and was 20 cm (8 in) across – three times the size of a tennis ball.

## HURRICANES

Hurricanes are violent tropical storms that develop over a warm ocean. Up to 4,000 km (2,500 miles) across, with winds of more than 300 km/h (185 mph), they can leave a trail of destruction across islands and coastal regions.



**1 THUNDERSTORMS**  
At first, clusters of thunderstorms form high above the warm ocean.



**2 DEPRESSION**  
A depression develops, drawing in warm surface winds that start to rotate.



**3 TROPICAL STORM**  
As the winds spin faster, clouds rise high and produce torrential rain.

**4 HURRICANE**  
When they hit speeds of more than 120 km/h (74 mph), the winds and clouds form a spiral around a calmer central eye.

## TORNADOES

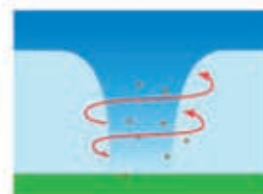
These spinning columns of air reach from the clouds down to the ground. They are shaped like a funnel with a core of air that can spin at anything up to 480 km/h (300 mph). Nicknamed "twisters" in the USA, they form during summer storms and can destroy crops and buildings.



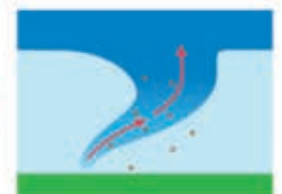
**1 STEADY SPIN**  
As warm air rises from the ground it starts to spin. The base of a cloud forms a funnel.



**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 kilometres 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.

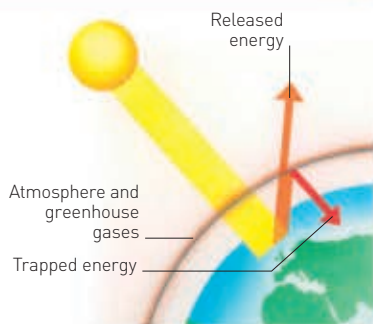


# Environment in danger

Pollution, deforestation, and the burning of fossil fuels are all changing the environment and making it difficult for many species of plants and animals to survive. However, there are plenty of ways to slow down these harmful effects on the environment, 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 like coal and oil releases more greenhouse gases into the atmosphere, warming the planet.

## 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.



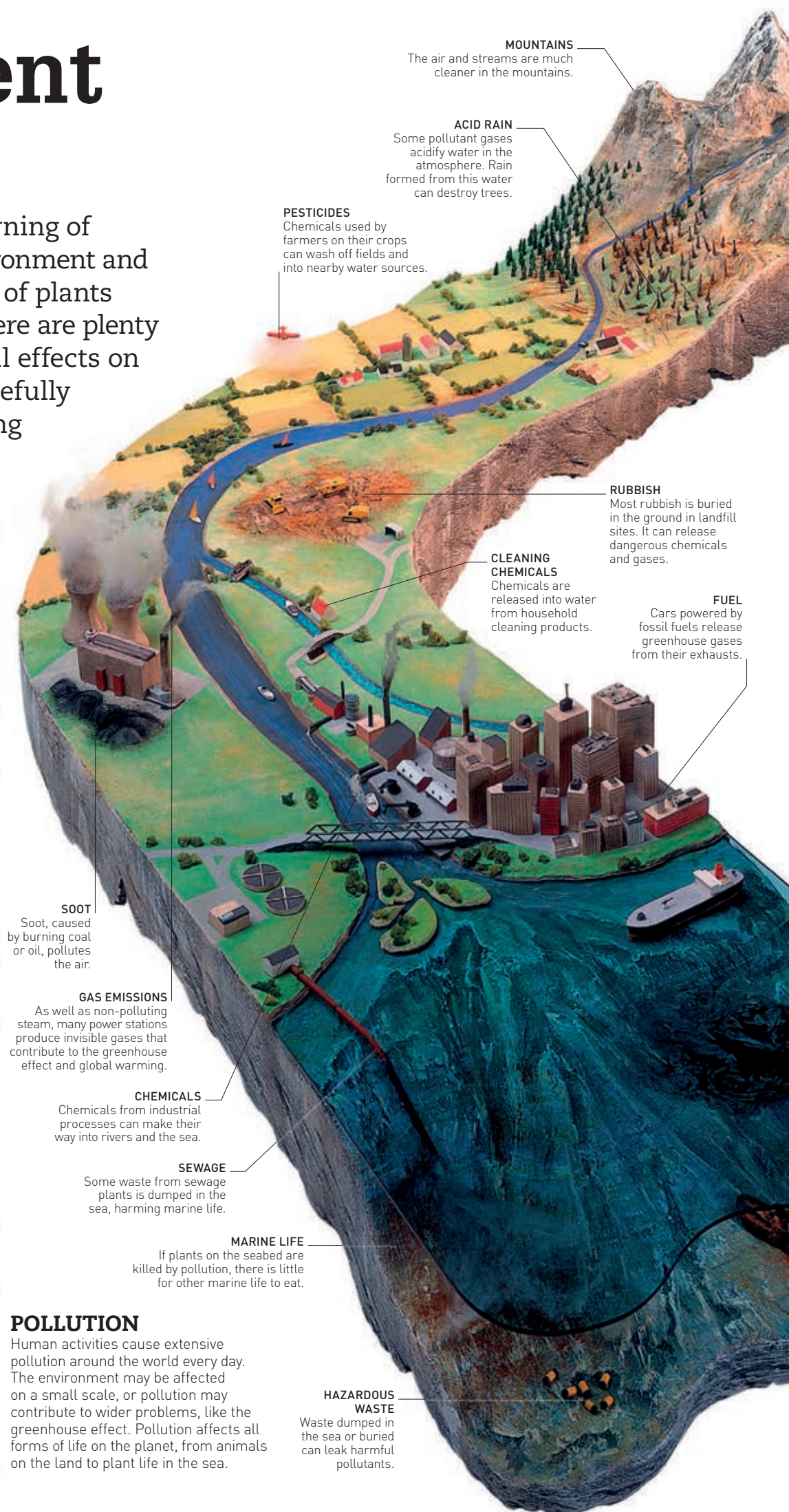
### EXTREME WEATHER

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.



**MOUNTAINS**  
The air and streams are much cleaner in the mountains.

**ACID RAIN**  
Some pollutant gases acidify water in the atmosphere. Rain formed from this water can destroy trees.

**PESTICIDES**  
Chemicals used by farmers on their crops can wash off fields and into nearby water sources.

**RUBBISH**  
Most rubbish is buried in the ground in landfill sites. It can release dangerous chemicals and gases.

**CLEANING CHEMICALS**  
Chemicals are released into water from household cleaning products.

**FUEL**  
Cars powered by fossil fuels release greenhouse gases from their exhausts.

**SOOT**  
Soot, caused by burning coal or oil, pollutes the air.

**GAS EMISSIONS**  
As well as non-polluting steam, many power stations produce invisible gases that contribute to the greenhouse effect and global warming.

**CHEMICALS**  
Chemicals from industrial processes can make their way into rivers and the sea.

**SEWAGE**  
Some waste from sewage plants is dumped in the sea, harming marine life.

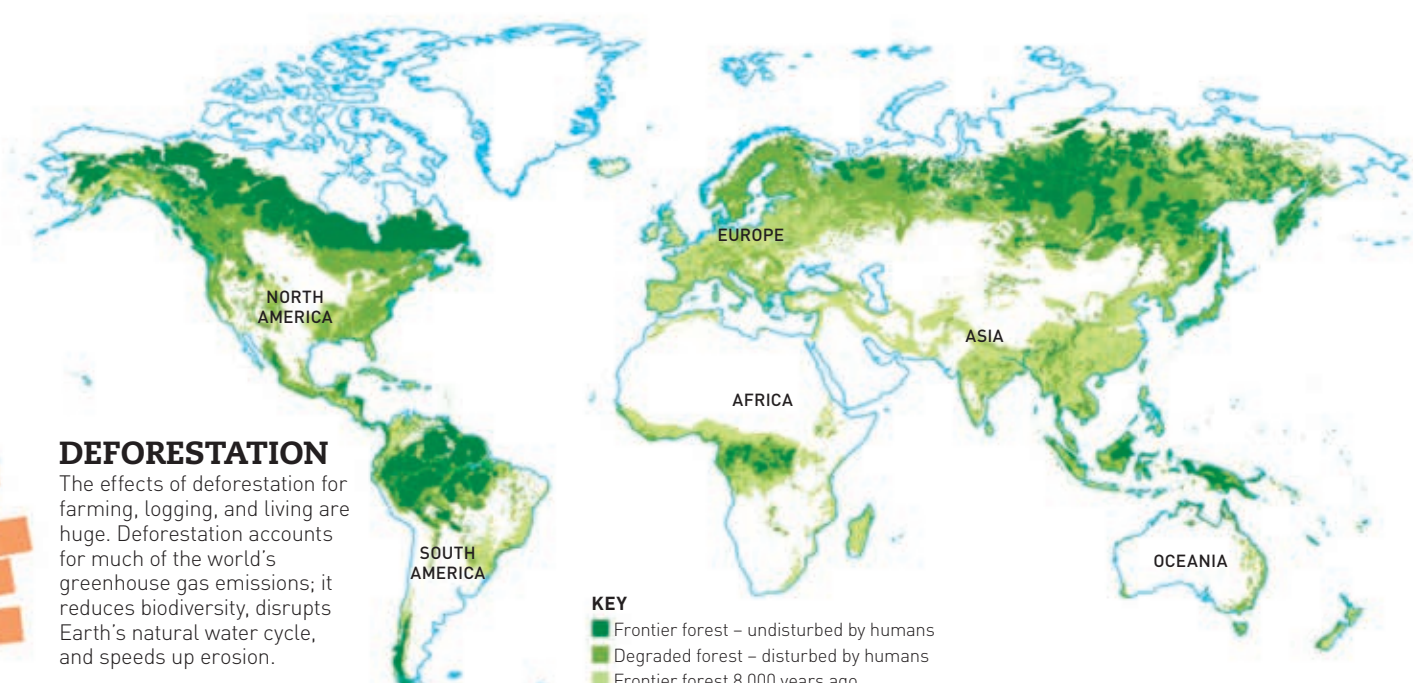
**MARINE LIFE**  
If plants on the seabed are killed by pollution, there is little for other marine life to eat.

## 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, like the greenhouse effect. Pollution affects all forms of life on the planet, from animals on the land to plant life in the sea.

**HAZARDOUS WASTE**  
Waste dumped in the sea or buried can leak harmful pollutants.





**APPROXIMATELY 18 MILLION ACRES OF FOREST AROUND THE WORLD ARE DESTROYED EVERY YEAR**

### DEFORESTATION







The effects of deforestation for farming, logging, and living 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.

					
<b>PLANTS</b> There are more than 10,000 endangered plant species.	<b>REPTILES</b> About half of all turtle species are endangered.	<b>AMPHIBIANS</b> Around 43 per cent of amphibians are threatened.	<b>BIRDS</b> About 13 per cent of bird species are vulnerable.	<b>FISH</b> Millions of sharks are killed for their fins each year.	<b>MAMMALS</b> Around 26 per cent 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 one plastic bag in a shop might seem small, but if other people around the world do this also, the effects on the planet can be huge.

				
<b>COTTON</b> Cotton is treated with pesticides and harmful chemicals.	<b>BATTERIES</b> Batteries can release dangerous chemicals if they are not disposed of safely.	<b>PLASTIC BAGS</b> Millions of marine animals die each year from swallowing plastic bags.	<b>GADGETS</b> Fifty million tonnes of electrical waste is thrown out every year.	<b>THE INTERNET</b> The internet produces about 300 million tonnes of carbon dioxide each year.
				
<b>MEAT</b> Around 18 per cent of all greenhouse gas emissions comes from producing meat.	<b>CHOCOLATE</b> About 25,000 litres of water is needed to make just 1 kg (2.2 lb) of chocolate.	<b>WATER BOTTLES</b> Around 50 billion plastic water bottles are used each year in the USA.		

**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.

			
<b>PLASTIC</b> Plastic can be recycled into park benches, drain pipes, or even fleece jackets.	<b>GLASS</b> Recycling 1 tonne of glass releases 315 kg (695 lb) less carbon dioxide than the production of new glass.	<b>PAPER</b> Recycling paper uses 70 per cent less energy than producing it from raw materials.	<b>ALUMINIUM</b> Recycling aluminium uses just 5 per cent of the energy needed to make new aluminium.

### RENEWABLE ENERGY

Fossil fuels provide most of the world's energy, but this has serious environmental impacts and these fuels will become more scarce. There are other sources of cleaner, renewable energy that can be used instead.

						
<b>WIND</b> Wind can power turbines that convert the wind energy into electricity.	<b>SOLAR</b> Energy from the Sun is caught by solar panels and turned into electricity.	<b>TIDAL</b> As tides rise and fall, they move turbines that convert the movement into energy.	<b>HYDROELECTRIC</b> When water is channelled through a dam, turbines are turned, which creates energy.	<b>GEOHERMAL</b> Cool water is pumped underground through pipes, to absorb the Earth's heat.	<b>BIOFUELS</b> Fuel can be produced from organic matter, like plants, which are burned to provide energy.	<b>WOOD</b> Specially grown wood can be burned for heat and light. Trees must be replanted.

**SHIPWRECK**  
Objects like 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 transport, 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.
- 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 sea, 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.

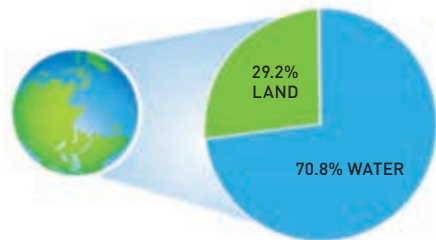


# Our physical world

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, Australasia/Oceania, and Antarctica. The tilt of Earth's axis and its orbit of the Sun means that some places are much hotter and drier than others.

## SURFACE AREA

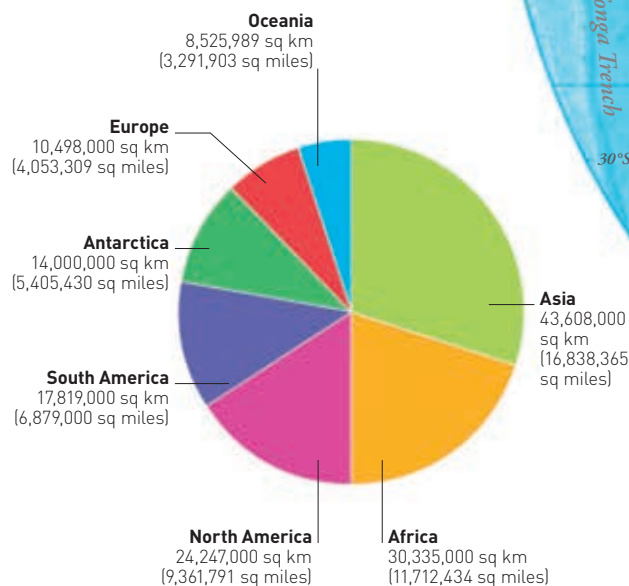
The entire surface of the Earth is 510,066,000 sq km (196,937,000 sq miles). Water makes up more than 70% of the surface area, most of which is salt water in the oceans.



**THE CIRCUMFERENCE OF THE EARTH AROUND THE EQUATOR IS 40,075 KM (24,901 MILES)**

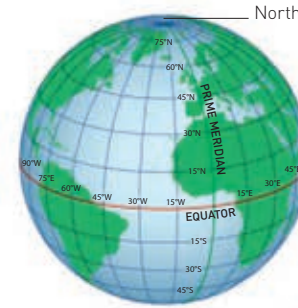
## CONTINENT SIZES

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.

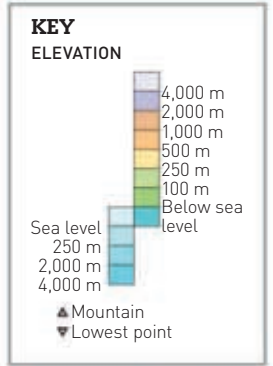


## LATITUDE AND LONGITUDE

The equator is an imaginary line that divides the 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, England.



**COORDINATES**  
Combining latitude and longitude gives every location a coordinate. New York City, for example, is 40.7° N, 74° W.





## EXTREME PLACES

The place with the hottest average temperature on Earth is Dallol in Ethiopia, at 24.4°C (93.9°F). The place with the coldest average temperature, measuring -58.3°C (-72.9°F), 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 1,187 cm (467 in). 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**



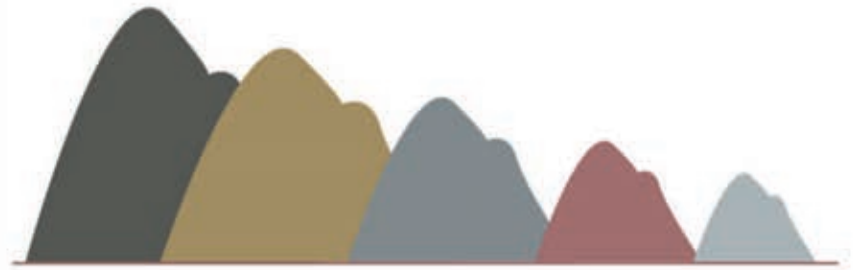
**HOTTEST PLACE: DALLOL, ETHIOPIA**



**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 ten highest mountains in the world. The longest mountain range is the Andes in South America, stretching for 7,200 km (4,500 miles).



MT EVEREST	K2	KANGCHENJUNGA	LHOTSE 1	MAKALU 1
8,848 m (29,029 ft)	8,611 m (28,251 ft)	8,586 m (28,169 ft)	8,485 m (27,838 ft)	8,462 m (27,766 ft)

TOP FIVE TALLEST MOUNTAINS



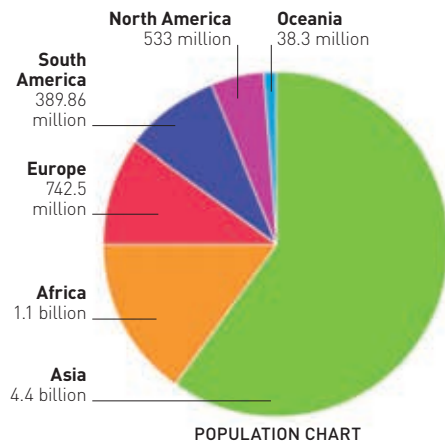


# Our political world

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 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 2040 range from about 8 to 9.7 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.



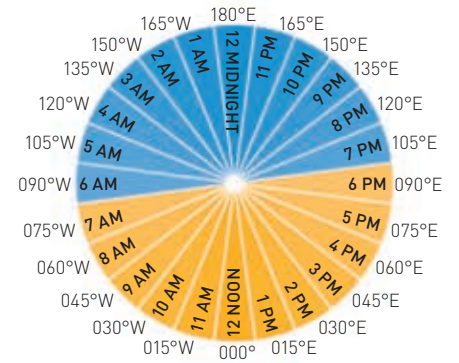
## MEGACITIES

A megacity is an urban area with more than 10 million inhabitants. The top five megacities by population are in Asia.

- TOKYO**  
Japan: 37,843,000 
- JAKARTA**  
Indonesia: 30,539,000 
- NEW DELHI**  
India: 24,998,000 
- MANILA**  
Philippines: 24,123,000 
- SEOUL**  
South Korea: 23,480,000 

## TIME ZONES

The world is divided into more than 24 time zones. 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 a day is about 12 hours year round. Moving away from the equator, the day can increase to 24 hours or decrease to zero, depending on the time of year. 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 centre of the Catholic Church, is located within the Italian city of Rome and is the world's smallest country.

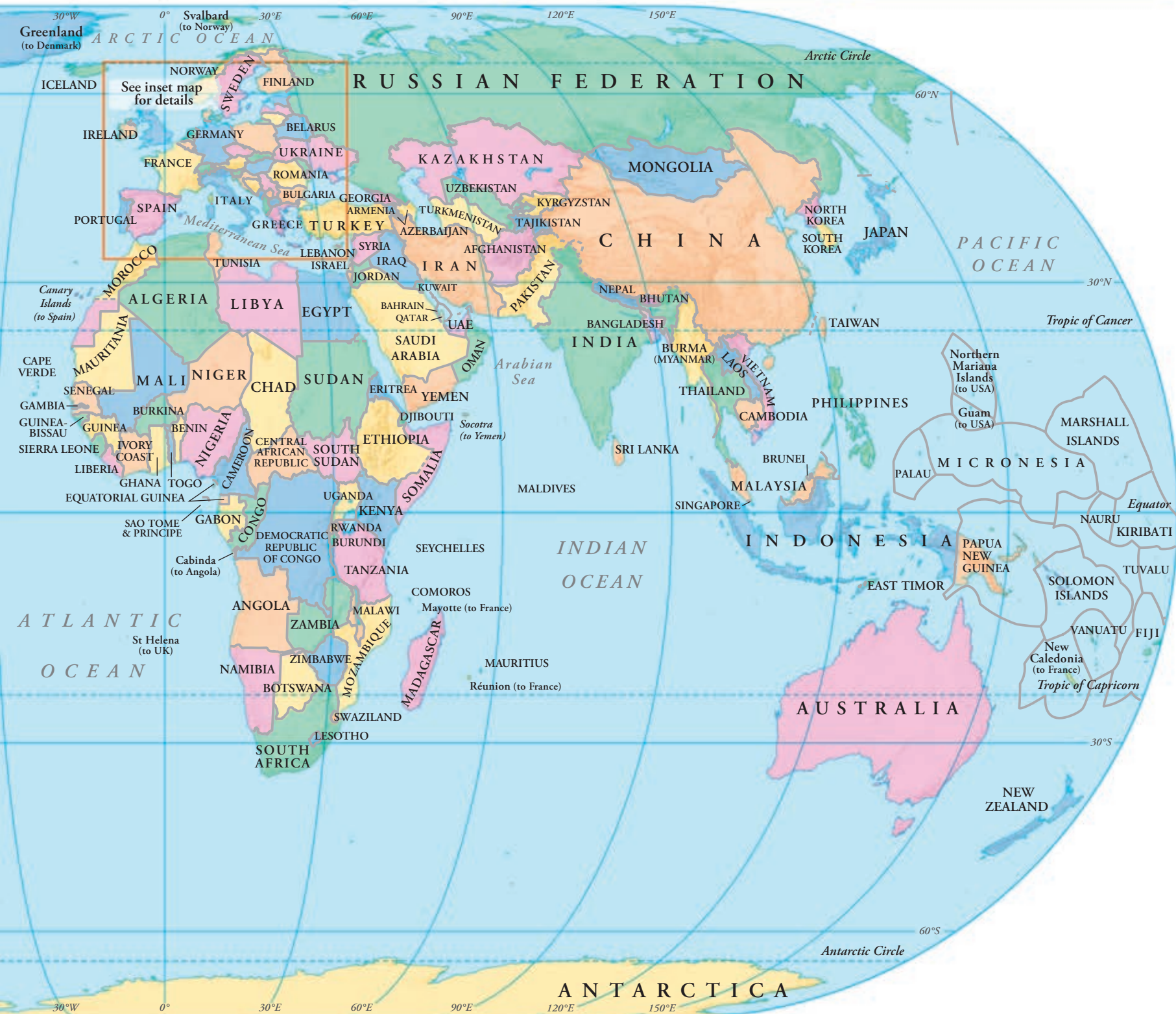
### BIGGEST COUNTRIES

- 1 RUSSIAN FEDERATION**  
17,098,242 sq km (6,601,668 sq miles)
- 2 CANADA**  
9,984,670 sq km (3,855,103 sq miles)
- 3 UNITED STATES**  
9,629,091 sq km (3,717,813 sq miles)
- 4 CHINA**  
9,598,094 sq km (3,705,845 sq miles)
- 5 BRAZIL**  
8,514,877 sq km (3,287,612 sq miles)



### SMALLEST COUNTRIES

- 1 VATICAN CITY**  
0.44 sq km (0.17 sq miles)
- 2 MONACO**  
2 sq km (0.7 sq miles)
- 3 NAURU**  
21 sq km (8 sq miles)
- 4 TUVALU**  
26 sq km (10 sq miles)
- 5 SAN MARINO**  
61 sq km (24 sq miles)







# Asia

The largest of Earth's seven continents, Asia occupies one-third of the world's total landmass. It claims both the lowest and the highest points on the planet's surface. 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 centre, this unique city was carved into the pink sandstone rock face more than 2,000 years ago. Rediscovered in 1812, the entrance today is through 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 of Angkor Wat is covered with exquisite carvings. Part of a vast complex of sacred monuments spread over 400 sq km (155 sq miles), it was constructed between the 9th and 14th centuries. Parts of the complex are now grown over by trees.



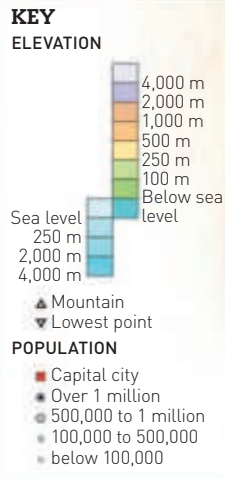
**HINDU COSMOS**  
The temple is an earthly representation of the Hindu cosmos. Its five towers, shaped like lotus buds, form a pyramidal structure symbolizing the mythical Mount Meru, home of the Hindu gods.

## 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.



## TAJ MAHAL

The Taj Mahal was commissioned by Mughal emperor Shah Jahan in 1632 to house the tomb of his beloved wife Mumtaz Mahal.

**MARBLE MONUMENT**  
Made of white marble, the colour of the building appears to change depending on the time of day.



**IT TOOK 22 YEARS AND MORE THAN 20,000 CRAFTSMEN 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 colour. It is thought that the blossoms help us to remember that lives should be lived to the full.



**BLOSSOMING SOUTH TO NORTH**  
The cherry blossom season begins in Okinawa in January and moves northwards 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 outside of the wall was built with stones and fired bricks and the inside filled with stones and mud. Sections were up to 7.5 m (25 ft) wide and stretched for thousands of kilometres.

## MOUNT EVEREST, NEPAL

At 8,848 m (29,029 ft) 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 4,000 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 4 mm (0.16 in) 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:**  
43,608,000 sq km (16,838,365 sq miles)
- **POPULATION:**  
4,426,683,000
- **NUMBER OF COUNTRIES:**  
49
- **LARGEST COUNTRY BY AREA:**  
Russian Federation 17,075,400 sq km (6,592,846 sq miles)
- **LARGEST COUNTRY BY POPULATION:**  
China 1,340,000,000
- **LARGEST CITY BY POPULATION:**  
Tokyo, Japan 38,000,000
- **HIGHEST POINT:**  
Mount Everest 8,848 m (29,029 ft)
- **LOWEST POINT:**  
Dead Sea, Israel -413 m (-1,378 ft)
- **LONGEST RIVER:**  
Yangtze, China 6,299 km (3,915 miles)





# North America

North America is the third largest of the continents. It is a hugely diverse land with mountains, plains, deserts, and ice. To the north is Greenland, the world's largest island. To the southeast are the tropical islands of the Caribbean and central American rainforests.

## DENALI NATIONAL PARK

This national park in Alaska is 19,187 sq km (7,408 sq miles) of tranquil wilderness with taiga forest, alpine tundra, and snowy mountains. Grizzly and black bears roam, and more than 100 bird species call the park home for the summer.



### MOUNT MCKINLEY

Situated near the Pacific Ocean and the Arctic Circle, Mount McKinley, known locally as Denali, 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.



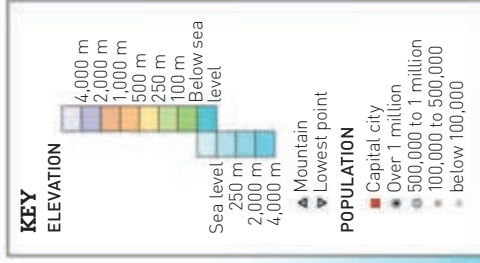
### FANTASTIC FALLS

Around 567,811 litres (150,000 US gallons) 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:** 24,247,000 sq km (9,361,791 sq miles)
- **POPULATION:** 533,000,000
- **NUMBER OF COUNTRIES:** 23
- **LARGEST COUNTRY:** Canada 9,984,670 sq km (3,854,082 sq miles)
- **LARGEST COUNTRY BY POPULATION:** USA c.315,000,000
- **LARGEST CITY BY POPULATION:** Mexico City, Mexico 8,700,000
- **HIGHEST POINT:** Mount McKinley, Alaska 6,194 m (20,320 ft)
- **LONGEST RIVER:** Mississippi 3,969 km (2,466 miles)
- **LARGEST LAKE:** Lake Superior, Canada, USA 82,103 sq km (31,700 sq miles)





## YELLOWSTONE

This national park is best known for its collection of thermal features, more than 500 of which are geysers, and the active super-volcano and 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 446 km (277 miles) long, up to 29 km (18 miles) wide, and 1.6 km (1 mile) deep.



## NATURAL WONDER

Erosion has exposed many colourful rock layers, creating an inspirational landscape.



## GOLDEN GATE

One of the top construction achievements of the 20th century, the Golden Gate Bridge opened in San Francisco in 1937. It is 2.7 km (1.7 miles) 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.

## CHICHEN ITZA

The native American Maya people built temples and monumental cities, such as Chichen Itza, in the jungles of the Yucatán Peninsula in Mexico from c.200 CE.



## EL CASTILLO

This pyramid temple stands in the centre of Chichen Itza.

**THE MAYA'S ASTRONOMICAL SKILLS WERE SO ADVANCED THEY COULD EVEN PREDICT SOLAR ECLIPSES**

## 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 coloured Metalmark butterfly.



## IN THE PINK

Flamingos turn pink from the colour pigments in the algae and shrimp they eat.



## WILDLIFE WATCHING

Alligators, turtles, and egrets are just some of the wildlife that can be seen.



## AMERICAN CROCODILE

## FLORIDA EVERGLADES

The Everglades are a vast area of semi-tropical wetland, home to mangrove, mahogany, bay, and eucalyptus trees. The swampy conditions are perfect for alligators and crocodiles.





# South America

Most of the continent of South America lies south of the equator. Its different climates and habitats mean it is home to many unique animal species.

## GALAPAGOS 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

These huge reptiles can weigh as much as 300 kg (660 lb) and grow up to 1.2 m (4 ft) in length.



### 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 979 m (3,212 ft). 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.



### FRIGATEBIRD

Male frigatebirds have impressive red throat pouches, which they inflate to attract females.

## FAST FACTS

Most of the population of South America live around the coast. The wild inland areas are sparsely populated.

- **AREA:** 17,819,000 sq km (6,879,000 sq miles)
- **POPULATION:** 389,860,000
- **NUMBER OF COUNTRIES:** 12 independent countries  
3 dependent territories
- **LARGEST COUNTRY:** Brazil 8,511,965 sq km (3,286,469 sq miles)
- **LARGEST COUNTRY BY POPULATION:** Brazil 195,632,000
- **LARGEST CITY BY POPULATION:** São Paulo, Brazil 11,821,873
- **HIGHEST POINT:** Cerro Aconcagua, Andes Mountains, Argentina 6,959 m (22,833 ft)
- **LONGEST RIVER:** Amazon 6,439 km (4,001 miles)
- **LARGEST LAKE:** Lake Titicaca, Bolivia/Peru 8,340 sq km (3,220 sq miles)





## LAKE TITICACA

Situated between Peru and Bolivia, Lake Titicaca is the world's highest navigable lake, lying at a height of 3,812 m (12,507 ft) 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 per cent 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 7,250 km (4,505 miles), the Andes form the longest continental mountain range in the world. They contain the world's highest volcanoes.



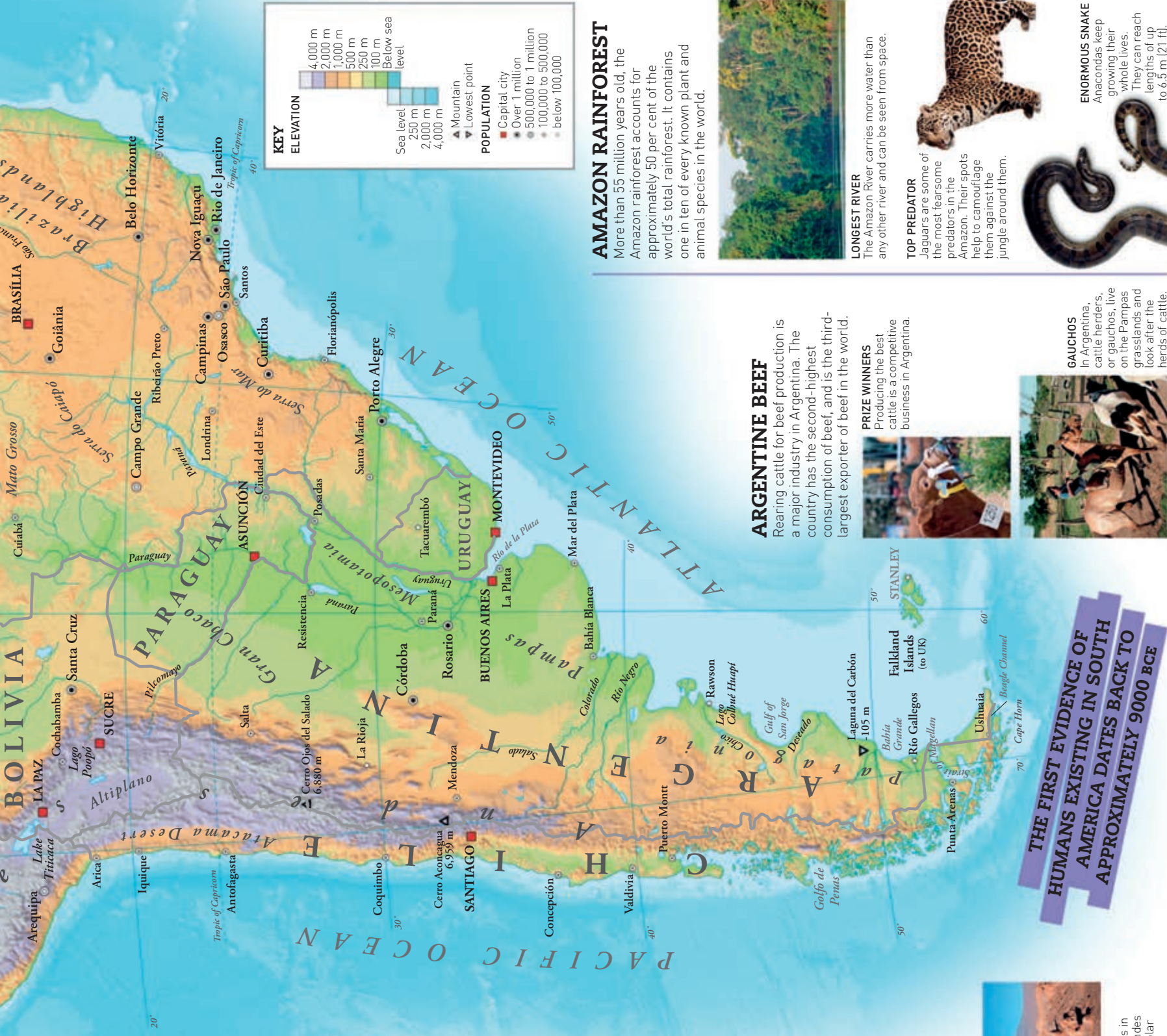
### WOOLLY WONDERS

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 non-polar desert in the world.



## AMAZON RAINFOREST

More than 55 million years old, the Amazon rainforest accounts for approximately 50 per cent of the world's total rainforest. It contains one in ten 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.

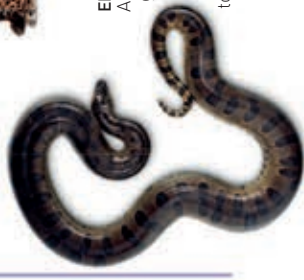
### TOP PREDATOR

Jaguars are some of the most fearsome predators in the Amazon. Their spots help to camouflage them against the jungle around them.



### ENORMOUS SNAKE

Anacondas keep growing their whole lives. They can reach lengths of up to 6.5 m (21 ft).



## 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.







# 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 47 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:**  
10,498,000 sq km  
(4,053,309 sq miles)
- **POPULATION:**  
742,452,000
- **NUMBER OF COUNTRIES:**  
47
- **LARGEST COUNTRY BY AREA:**  
Russian Federation 3,960,000 sq km (1,528,560 sq miles)
- **LARGEST COUNTRY BY POPULATION:**  
Russian Federation 110,000,000
- **LARGEST CITY BY POPULATION:**  
Istanbul, Turkey (14,377,000)
- **HIGHEST POINT:**  
Mount El'brus, Russian Federation  
5,642 m (18,510 ft)
- **LONGEST RIVER:**  
Volga, Russian Federation  
3,690 km (2,293 miles)
- **LARGEST LAKE:**  
Lake Ladoga, Russian Federation  
18,390 sq km (7,100 sq miles)



### KEY

- ELEVATION**
- 4,000 m
  - 2,000 m
  - 1,000 m
  - 500 m
  - 250 m
  - 100 m
  - Below sea level
- Sea level
- 250 m
  - 2,000 m
  - 4,000 m
- ▲ Mountain  
▼ Lowest point
- POPULATION**
- Capital city
  - Over 1 million
  - 500,000 to 1 million
  - 100,000 to 500,000
  - below 100,000





## NORWAY'S FJORDS

Norway's fjords (steep-sided waterways) were created by the movement of ice and rock during successive ice ages. When the glaciers retreated, seawater flooded these U-shaped valleys. Norway has the highest concentration of fjords in the world.



**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 1,200 km (750 miles) 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 4,810 m (15,781 ft).



**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 2,850 km (1,770 miles) to the Black Sea, passing through ten countries on the way.



**RIVERSIDE CITIES**  
The Danube flows through four capital cities: Vienna, Bratislava, Budapest (shown here), and Belgrade.



**GREAT WHITE PELICAN**  
More than 50 per cent 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 324 m (1,063 ft) high.



**RECORD-HOLDER**  
The tower was the world's tallest man-made structure for 41 years until the Chrysler Building in New York City was built in 1930.

## ROME, ITALY

Once the centre 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, re-enactments 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 honour 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.



**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 appeared on Earth.

## 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 modelled on a mythical animal with the head of a human and the body of a lion.



**BUILDING BLOCKS**  
The construction methods of the Pyramids are unknown. More than 2 million blocks of stone were used just to make the largest, the Great Pyramid.

## SAHARA DESERT

The Sahara covers much of North Africa and is the world's largest hot desert. Constantly shaped by the wind, around 25 per cent 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 (3,145 m/11,294 ft) in the Tibesti Mountains.



**SAHARA TRANSPORT**  
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 per cent of Earth's land mass. It contains the world's longest river – the Nile.

- **AREA:** 30,335,000 sq km (11,712,434 sq miles)
- **POPULATION:** 1,136,239,000
- **NUMBER OF COUNTRIES:** 54
- **LARGEST COUNTRY:** Algeria 2,381,741 sq km (919,595 sq miles)
- **LARGEST COUNTRY BY POPULATION:** Nigeria 177,155,754
- **LARGEST CITY BY POPULATION:** Lagos, Nigeria 21,000,000
- **HIGHEST POINT:** Mount Kilimanjaro, Tanzania 5,895 m (19,336 ft)
- **LONGEST RIVER:** Nile River 6,695 km (4,160 miles)
- **LARGEST LAKE:** Lake Victoria, Uganda, Kenya, Tanzania 68,880 sq km (26,560 sq miles)





## MAASAI MARA

Between July and October, wildebeest migrate to the Maasai Mara nature reserve in Kenya from Tanzania's Serengeti. 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 region of Botswana that is dry for much of the year, this large inland delta attracts lots of wildlife.



## CAPE TOWN

One of the most popular African cities for tourists to visit, Cape Town is famous for its huge harbour. The big, flat-topped Table Mountain overlooks the city.



**ACTIVE HARBOUR**  
Cape Town harbour 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 108 m (360 ft) 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 5,895 m (19,336 ft). It is a dormant volcano with three volcanic cones. Around 25,000 visitors trek up its slopes each year.



**AFRICA'S PEAK**  
The snow-capped summit of Mount Kilimanjaro is surrounded by dry, flat scrubland.

**MINERAL RICH, ABOUT 65% OF THE WORLD'S DIAMONDS COME FROM AFRICA**

## 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.







# 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 quite 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.



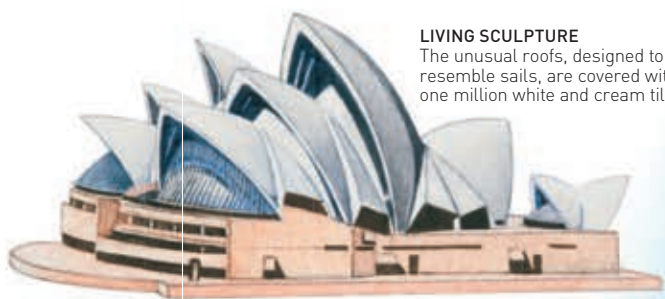
**ROCK ART**  
Some of the oldest Aboriginal paintings are more than 20,000 years old.



**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 centre designed by Danish architect Jorn Utzon in 1957. It opened in 1973, and today is visited by more than seven million people every year.



**LIVING SCULPTURE**  
The unusual roofs, designed to resemble sails, are covered with one 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 and birds, many of which are not found anywhere else in the world. Some birds, like the emu and kiwi, evolved into flightless species due to the lack of predators.



TASMANIAN DEVIL  
Australia

KOALA  
Australia

EMU  
Australia

PLATYPUS  
Australia

KANGAROO  
Australia



KIWI  
New Zealand

**A JOEY (BABY KANGAROO) STAYS IN ITS MOTHER'S POUCH FOR UP TO TEN MONTHS**

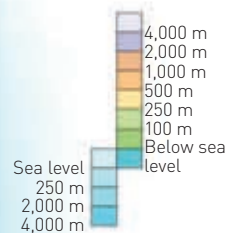


## FAST FACTS

A widespread area, there are 28 languages spoken across Oceania.

- **AREA:**  
8,525,989 sq km (3,291,903 sq miles)
- **POPULATION:**  
38,304,000
- **NUMBER OF COUNTRIES:**  
14
- **LARGEST COUNTRY BY AREA:**  
Australia 7,617,930 sq km (2,941,283 sq miles)
- **LARGEST COUNTRY BY POPULATION:**  
Australia 23,788,274
- **LARGEST CITY BY POPULATION:**  
Sydney, Australia 4,576,433
- **HIGHEST POINT:**  
Mount Wilhelm, Papua New Guinea 4,509 m (14,795 ft)
- **LONGEST RIVER:**  
Murray-Darling, Australia 2,520 km (1,570 miles)
- **LARGEST LAKE:**  
Lake Eyre, Australia 8,884 sq km (3,430 sq miles)

### KEY ELEVATION



- ▲ 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 a natural theme park full of 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 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 so big it can be seen from space.





# Antarctica

The continent of Antarctica sits under huge masses of ice called ice sheets. This ice holds 90 per cent of Earth's fresh water. Beneath it lies a continent of valleys, mountains, and lakes but only about 2 per cent 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 180 km (111 miles) 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



BANJO, SHACKLETON'S EXPEDITION



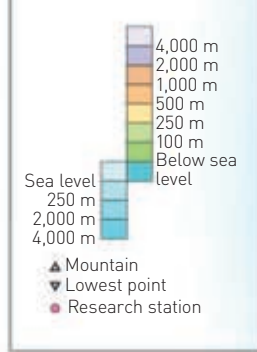
### KEY

- Amundsen's route
- Scott's route
- Ice shelves

### RACE TO THE POLE

The Norwegian Roald Amundsen beat the Englishman Robert Falcon Scott by 33 days, to reach the South Pole on 15 December 1911.

### KEY ELEVATION



## ICY FEATURES

Antarctica is covered in ice. It has huge masses of glacial ice that are known as ice sheets. Where the ice sheets meet the ocean floating areas of ice form, which are called ice shelves. 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.

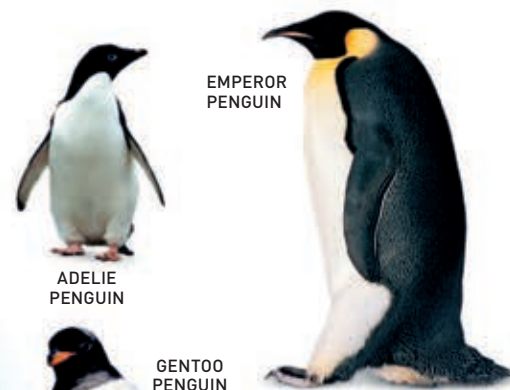


**DRIVING CONDITIONS**

Vehicles built to withstand extreme temperatures over long distances are used in Antarctica.

**WILDLIFE**

The Antarctic continent is quite inhospitable to life. The sea, rather than the land, supports the most wildlife. The Antarctic is the true home for the Emperor and Adélie penguins, and three other types breed on the northern tip of the Antarctic Peninsula.



ADELIE 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:** 14,000,000 sq km (5,405,430 sq miles)
- **POPULATION:** No permanent residents
- **HIGHEST POINT:** Vinson Massif, 4,897 m (16,066 ft)
- **LONGEST RIVER:** Onyx 40 km (25 miles)
- **LARGEST KNOWN LAKE:** Lake Vostok, 15,690 sq km (6,100 sq miles)



# Flags

Every country in the world has a unique flag. Each nation picks its own patterns and colours, 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 colour. 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. Cloth was first used by the Romans.

Decorative shape for carrying legion's badge

Symbol of legion

Silver ornaments



### ROMAN FLAG

This is a modern copy of a flag once carried by a Roman legion.

## 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 his ship without a fight. The flags belonging to four famous pirates are shown here.



HENRY EVERY



"BLACK SAM" BELLAMY



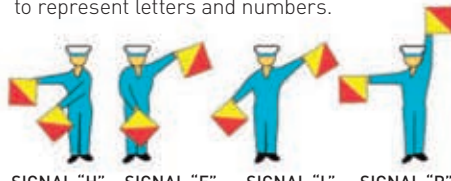
"CALICO JACK" RACKHAM



BLACKBEARD

## FLAG SIGNALS

Before modern technology, ships at sea "talked" to one another by signalling with flags. They used semaphore, a code in which flags are held in different patterns to represent letters and numbers.



SIGNAL "H" SIGNAL "E" SIGNAL "L" SIGNAL "P"



ANSWERING SIGN SIGNAL ERROR SIGNAL END OF WORD SIGNAL NUMBERS FOLLOW SIGNAL

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 men on 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 men to stand on top of Mt Everest, planted the flags of the United Kingdom, United Nations, Nepal, and India.



## EUROPE



## ASIA



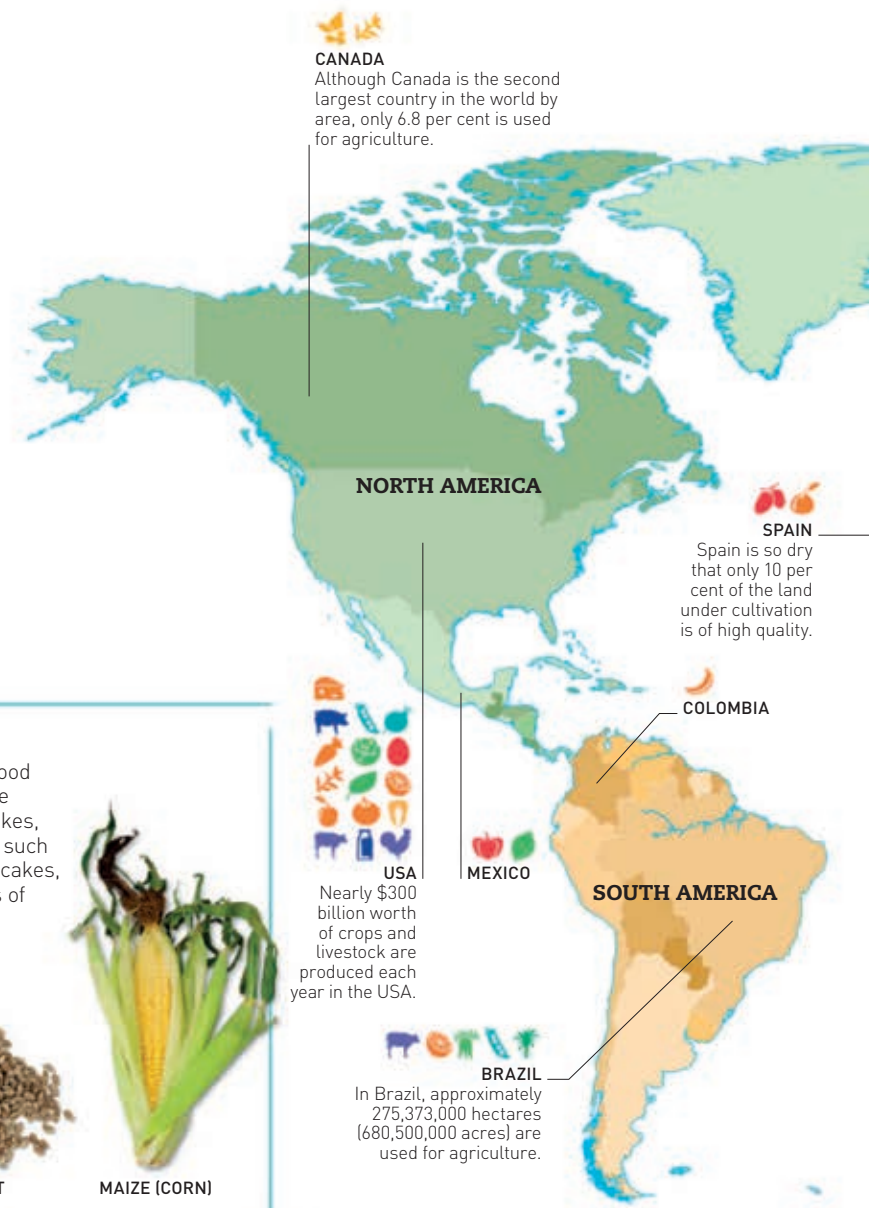
## OCEANIA





# Where food comes from

Long ago, people only ate what could be 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 like rapeseed 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 eaten as it is but more often is used to sweeten other foods.



**SUGAR BEET**  
The sugar syrup extracted from sugar beet is used in many products, including drinks, feed for animals, and even fuels known as biofuels.



**SOYA BEANS**  
A great source of protein and vitamins, soya beans can be used to make milk, textured vegetable protein, tofu, and flavourings such as soy sauce.



**RAPESEED**  
Fields of yellow rape produce rapeseed, 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 like 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 like 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 porridge, or bread, cakes, and biscuits. Many are ingredients of what we call breakfast cereals.



RICE



WHEAT



MAIZE (CORN)



MILLET



OATS



TRITICALE



SORGHUM



BARLEY



RYE

## 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

## VEGETABLES

Although many people like to grow vegetables in their garden, most of us buy them in greengrocer shops and supermarkets. Potatoes are popular in many parts of the world because they can be used in many ways. Vegetables like 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

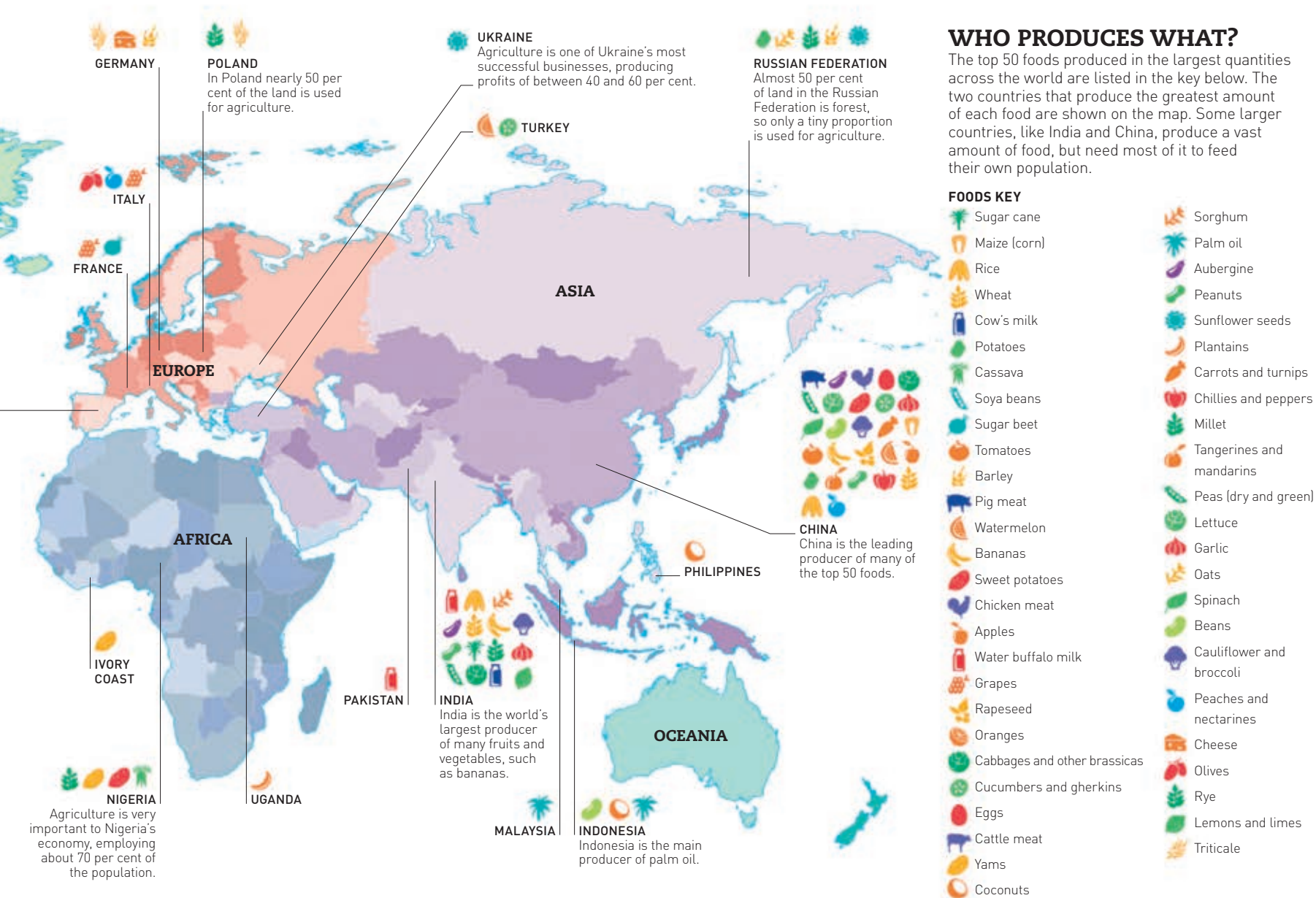


SPINACH



GARLIC





## MEAT

For thousands of years, animals have been reared to provide meat. Most large farms specialize in just one type of animal, raising cattle (cows and bulls) for beef, pigs for pork, sheep for lamb and mutton, and deer for venison. Pigs are the most popular because their meat can be used in many ways.



## FRUIT, NUTS, AND SEEDS

Tropical fruit like bananas and coconuts, and Mediterranean fruit like oranges, lemons, and limes need sunshine and warmth to grow. These major crops in warm countries are exported (sent abroad) to colder places that do not have the right climate to grow them. Fruit can be picked and eaten straight away, used to make juices, or added to recipes. Grapes are also harvested to make wine, and olives to make oil for salads and cooking.



**THE FIRST RECORD OF A WATERMELON HARVEST DATES FROM NEARLY 5,000 YEARS AGO IN EGYPT**









# Culture





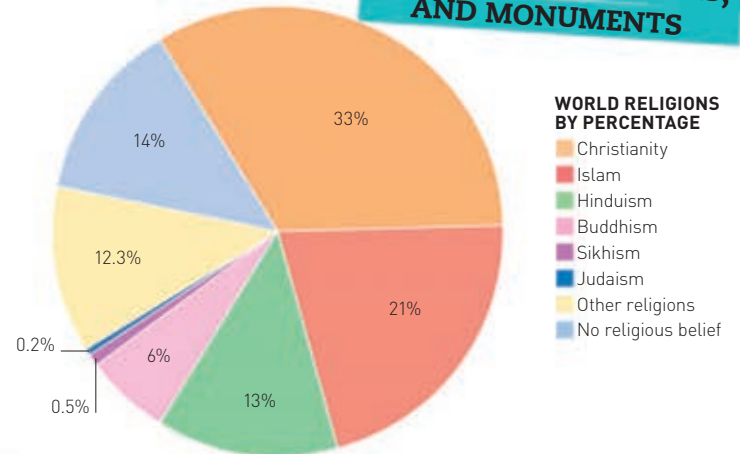
# World religions

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 saviour 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. Their religion includes many gods and goddesses, the greatest being Brahma. Hindus believe in reincarnation: the cycle of life, death, and rebirth that continues until the soul is set free. Most of them worship by saying individual prayers, and do not attend communal services, although they join together at festivals.

### GANESH

Elephant-headed  
Ganesh is the Hindu god of learning and new ventures.



### NADI TEMPLE

Hindu temples are built in many styles. This one is the Nadi temple 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**  
The mosque is the centre 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

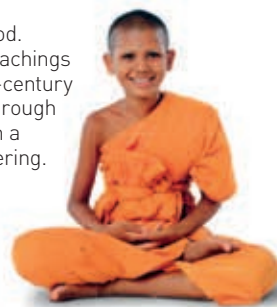
## BUDDHISM

Buddhists do not worship a single, creator god. They follow a way of thinking based on the teachings of Siddhartha Gautama, born a prince in 5th-century India, 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 seven years may enter Buddhist monasteries as trainees, or novices.



**PRAYER FLAGS**  
Buddhist flags, fluttering in the mountains of Nepal, carry prayers into the wind.





**SYMBOL**  
Hand and wheel



**JAIN LAL MANDIR TEMPLE**  
Built in 1658, 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**  
Nine-pointed star



**LOTUS TEMPLE**  
Built in the shape of a lotus flower, the Baha'i Temple in New Delhi, India, is open to people of all faiths.

## BAHA'I

One of the world's newest religions, Baha'i began in Persia (now Iran) in the mid-19th century. The aim of the faith is to achieve world peace and to strive for justice and equality among people of all religions.



**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 honour 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**  
Yin and Yang  
(two opposites)

## TAOISM

Tao means "the way" – the natural force or power that controls the Universe. According to Taoism, people must accept this power, while trying to lead peaceful and unselfish lives. Believers hope they will eventually be able to free their spirits and become immortal.



**TAO FESTIVAL**  
People gather outside a colourful Chinese Taoist temple in Thailand to celebrate the Vegetarian Festival.



**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.



**GOLDEN TEMPLE**  
Built in the state of Punjab, northern India, at the beginning of the 17th century, this famous Sikh temple is sited in the middle of a lake.

**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.



**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

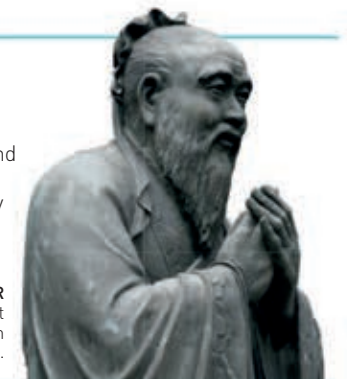
Founded by Zoroaster, a prophet who lived in ancient Persia (now Iran), Zoroastrianism is more than 2,500 years old. Followers believe in Ahura Mazda, the Supreme Creator of the world, and the eternal struggle between good and evil. Their holy book is called the Avesta. Zoroastrians worship in temples, 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 5th-century Chinese thinker and reformer. Kindness, honourable behaviour, 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 honour 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 or have historic links to the farming seasons. Often, a festival is a joyful holiday with music, processions, delicious food and, sometimes, gifts.



**FESTIVAL OF THE PIG, FRANCE**  
One of the funniest festivals is found in the French Pyrenees. People dress as pigs, race piglets, and challenge each other to make the most lifelike pig noises.

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.

**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 tonnes of squashy tomatoes.



**EDINBURGH FESTIVAL**  
Drama, dance, music, and comedy are just some of the events at this Scottish cultural festival.

## JANUARY

On 1 January, people around the world are eager to party as they welcome in a new year. In Rajasthan, India, it is 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 colourfully decorated bridle, a camel waits to perform. Camels are a much-valued part of everyday life in Rajasthan.

## FEBRUARY

There is a lot of extravagant dressing up, with two big carnivals this month in Brazil and in Venice, Italy. It's also Chinese New Year, with two weeks of celebrations and family gatherings.



**RIO CARNIVAL, BRAZIL**  
Costume parades, dancing competitions, loud music, and feasting last for five riotous days.

## AUGUST



**INDEPENDENCE DAY, USA**  
Decorated with the American Stars and Stripes flag, a festive cake takes centre table at a 4th 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.

## JULY

Heading the festivals is Independence Day on 4 July. This celebrates the day in 1776 when America declared its independence from Great Britain. In Siena, Italy, a historic horserace takes place. A body-painting festival in Austria is a popular modern event.



**PALIO HORSERACE, SIENA**  
Bareback riders race through the streets of Siena. Each wears colours representing a district of the city.

**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.



## SEPTEMBER

Mid-autumn 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**  
Fruit and flowers decorate a Christian church for Harvest Festival.



**MOON FESTIVAL, CHINA**  
Rich pastries known as mooncakes are made for the autumn 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 Mid-autumn 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 31 October, 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 honour the dead.







**CHINESE NEW YEAR**  
Hidden beneath the costume of a fantastic lion with huge swivelling 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 17 March. The day of Holi, the Hindu spring festival, changes each year. The Jewish holiday of Purim varies, too, according to the Hebrew calendar.



**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 coloured 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 1 April, 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.



**POISSON D'AVRIL (APRIL FISH)**  
On 1 April, children in France pin pictures of fish on their friends' backs for a joke.

**PASSOVER**  
This festival remembers the freeing of the Jewish people from slavery 3,000 years ago. People eat a special meal including an egg, herbs, and a lamb bone.

**EASTER**  
The Christian holiday celebrates Jesus Christ's resurrection after his crucifixion. Gifts of chocolate or sugar eggs symbolize rebirth.



## JUNE

In northern regions, midsummer's day falls between 20 and 22 June. Many people mark the date with celebrations at sunrise. The start of the Muslim holy period of Ramadan can be in late June – the date depends on the rising of a new moon.



**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.

## MAY

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, revellers 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 1 May. The ribbons are wound round the pole as part of a dance.

**MAY DAY WAS FIRST CELEBRATED BY THE ANCIENT ROMANS IN HONOUR 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 the Day of the Dead – a time for happy memories.

**DAY OF THE DEAD, MEXICO**  
During this festival on 2 November, 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.

**CHRISTMAS**  
A tree has been part of traditional Christmas celebrations for possibly hundreds of years.



**HANUKKAH**  
One candle is lit on each day of this eight-day Jewish festival.





# World languages

Spoken and written language allows us to communicate with one another. Around 6,000 languages are spoken across the world, and many people speak more than one language.

## LANGUAGES

The three most widely used languages are spoken by nearly one quarter of the world.

- 1 **MANDARIN**  
848 million speakers worldwide
- 2 **SPANISH**  
339 million speakers worldwide
- 3 **ENGLISH**  
335 million speakers worldwide
- 4 **HINDI**  
260 million speakers worldwide
- 5 **ARABIC**  
242 million speakers worldwide



## 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.

**您好**  
*nee-how, MANDARIN*

**سلام**  
*salaam, PASHTO*

**你好**  
*lee-ho, MIN NAN*

**xin chào**  
*sin-chow, VIETNAMESE*

**Sampurasun**  
*Sum-poo-rah-soon, SUNDANESE*

**မင်္ဂလာပါ**  
*min-ga-la-ba, BURMESE*

**侬好**  
*nong hao, WU*

**नमस्कार**  
*nômoshkar, BENGALI*

**سلام**  
*salaam, PERSIAN*

**helo**  
*hello, MALAY*

**你好**  
*ngi-ho, HAKKA*

**नमस्कार**  
*nuh-mus-kāra, ORIYA*

**مرحبا**  
*marr-hah-bah, ARABIC*

**നമസ്കാരം**  
*nuh-mus-kāram, MALAYALAM*

**สวัสดี**  
*sawasdee, THAI*

**ନମସ୍ତେ**  
*nuh-mus-kāra, ORIYA*

**السلام عليكم**  
*as-salām-alaykum, URDU*

**नमस्कार**  
*nuh-mus-kār, MARATHI*

**你好**  
*néih-hóu, CANTONESE*

**வணக்கம்**  
*vanakkam, TAMIL*

**你好**  
*Ni Hao, JIN*

**नमस्ते**  
*nuh-muh-stay, GUJARATI*

**ನಮಸ್ಕಾರ**  
*namaskara, KANNADA*

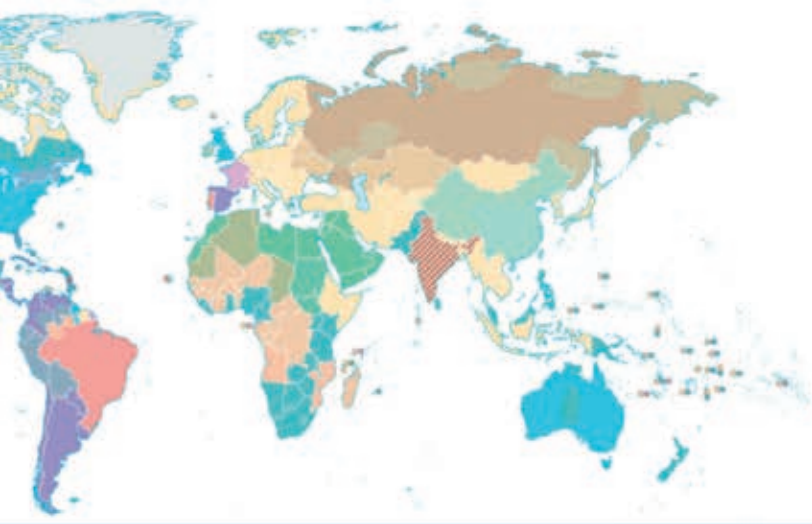
**merhaba**  
*mehr-hah-bah, TURKISH*

**你好**  
*li hao, XIANG*

**प्रणाम**  
*pra-naam, BHOJPURI*

**こんにちは**  
*konnichiwa, JAPANESE*





## WHO SPEAKS WHAT?

Some languages are spoken in many countries around the globe. There are also many variations of major languages (dialects).

### KEY

- Chinese (Mandarin, Cantonese, etc)
- Spanish
- Arabic
- Hindi
- English
- French
- Russian
- Portuguese
- English/Spanish
- Spanish/other
- Arabic/French
- French/other
- English/other
- Arabic/other
- Hindi/English/other
- Chinese/other
- Russian/other
- English/French
- Portuguese/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**

හැලෝ

halo, **JAVANESE**

السلام عليكم

as-salām-alaykum, **SINDHI**

assalamu alaykum  
as-salam alay-keum, **UZBEK**

안녕하세요

ahn-nyeong-ha-se-yo, **KOREAN**

నమస్కారం

namaskārām, **TELUGU**

ਸਤਿ ਸ੍ਰੀ ਅਕਾਲ

sat-siri-akal, **PUNJABI**

salam əleyküm  
salām-alaykum, **AZERBAIJANI**

प्रनाम

pra-naam, **MAITHILI**

cześć!

cheshch, **POLISH**

akkam

ak-kam, **OROMO**

olá

oh-lah, **PORTUGUESE**

hello

ENGLISH

kumusta

coo-moos-tah, **TAGALOG**

Привіт

priveet, **UKRAINIAN**

здравствуйते

zdrast-wui-tyeh, **RUSSIAN**

kedu

kay-doo, **IGBO**

bonjour

boh-zhoo, **FRENCH**

hallo

ha-low, **GERMAN**

jambo

ja-m-boh, **SWAHILI**

no ngoola daa

no-ngoola-daa, **FULA**

ciao

chao, **ITALIAN**

ጥና ድስታልኛ

tena-yste-lle'gn, **AMHARIC**

salut

sah-loot, **ROMANIAN**

hola

o-la, **SPANISH**

bawo ni

bah-wo nee, **YORUBA**

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.30,000–2500 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 jewellery makers in Mesopotamia, one of the oldest, and longest lasting, civilizations in our distant past.



GOLD ORNAMENT

GOLD AND BEAD WREATH

## ▶ c.500–1400

### 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.



BYZANTINE ALTAR MOSAIC



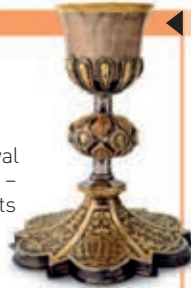
MOSAIC OF VIRGIN MARY, ISTANBUL



FRENCH TAPESTRY



ILLUMINATED MANUSCRIPT



SILVER CUP

## ▶ c.324–1450

### 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.



THE GREAT MOSQUE, SPAIN



ISLAMIC BUILDING, ISRAEL

## ▶ c.1 CE–PRESENT

### NATIVE AMERICAN

In Native American tribes, practical items like blankets and bags were so skilfully 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

## ▶ c.1350–1600

### RENAISSANCE

Beginning in Italy, the Renaissance was a time when every form 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 centre for exquisite glasswork.



MONA LISA BY LEONARDO DA VINCI



PORTRAIT BY TITIAN



ITALIAN GOBLET



RENAISSANCE PENDANT



PIETA SCULPTURE BY MICHELANGELO

## ▶ c.1600–1800

### BAROQUE AND ROCOCO

Baroque painting was all about drama. Artists painted realistic emotional scenes with intense colour 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 colour 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 had 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 colourful scenes of everyday life. Temples in Ancient Greece were decorated with marble friezes showing processions and beautifully carved columns.



FRESCO OF A LEAPING BULL



DORIC, IONIC, AND CORINTHIAN COLUMNS



DECORATIVE VASE

**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. Colourful 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".



HINDU TEMPLE, INDIA



HOKUSAI PRINT, JAPAN



STONEWARE LION, MING DYNASTY, CHINA



HEAD OF THE BUDDHA, JAPAN



ORNATE FIGURE OF AN ELEPHANT, CHINA

**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 jewellery, decorated pottery, and ornate glassware. The finest houses were decorated with mosaic floors and panels, and painted frescoes.



TERRACOTTA (CLAY) BUST

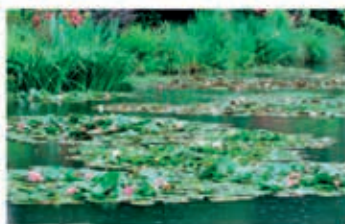


BEWARE OF THE DOG MOSAIC, POMPEII

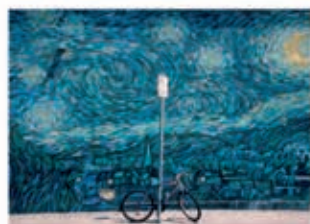


FRESCO ON VILLA WALL, POMPEII

**1880–1905**



**MONET'S GARDEN**  
Monet's paintings of his lily ponds captured changes in the light and seasons.



MURAL INSPIRED BY VAN GOGH'S THE STARRY NIGHT

**POST-IMPRESSIONISM**

Painting got bolder, brighter, and freer in this period. Vincent Van Gogh poured his feelings into swirling landscapes created with thick brushstrokes and heavy paint. Others developed new techniques. Seurat's pointillist pictures were painted with millions of tiny dots of colour that blended together.



**FIGURE BY RODIN**  
Rodin produced life-like 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 colours 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 express their personalities. Surrealist art turned the world upside down. Artists produced dream-like paintings and absurd objects like furry teacups and spiky irons.

**"IF YOU UNDERSTAND A PAINTING BEFOREHAND YOU MIGHT AS WELL NOT PAINT IT"**

SALVADOR DALI, SURREALIST ARTIST

**1907–1960s**

**MODERN ART**

Cubism was the beginning of modern art. Leading artist Picasso created startling figures with angular shapes that broke all the rules about colour, form, and perspective. Many years later in the United States, abstract expressionist artists 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



# 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.

## 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		

## 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.



## 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 button-like valves that are pressed down to alter notes.



## INTERNATIONAL INSTRUMENTS

Round the world, music-making involves a huge variety of traditional instruments. Many are unique to particular countries or cultures.





## PERCUSSION

A percussion instrument is struck or shaken to keep a rhythm or create a tune. Percussionists usually play more than one instrument.



TAMBOURINE

TRIANGLE

GLOCKENSPIEL

XYLOPHONE

GONG

SNARE DRUM

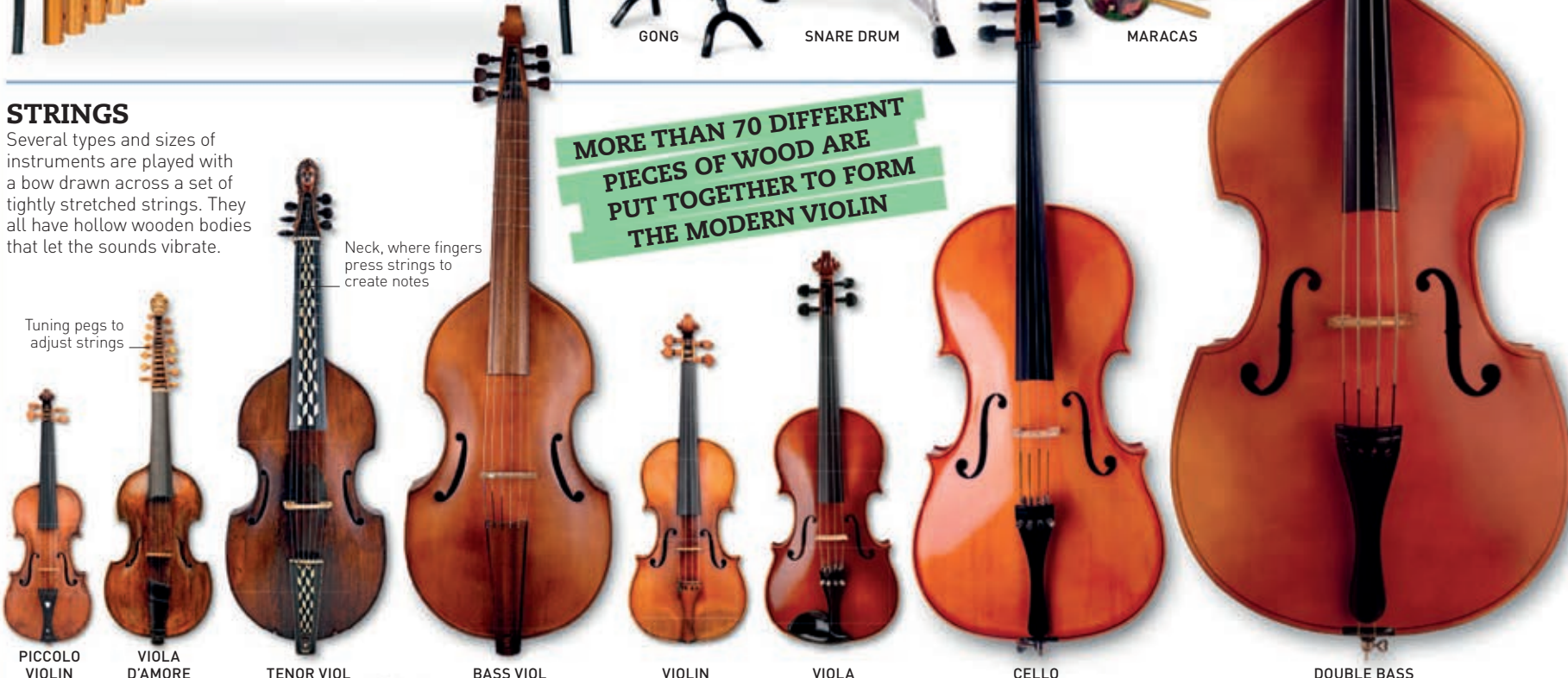
TIMPANI

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.

**MORE THAN 70 DIFFERENT  
PIECES OF WOOD ARE  
PUT TOGETHER TO FORM  
THE MODERN VIOLIN**



Neck, where fingers press strings to create notes

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

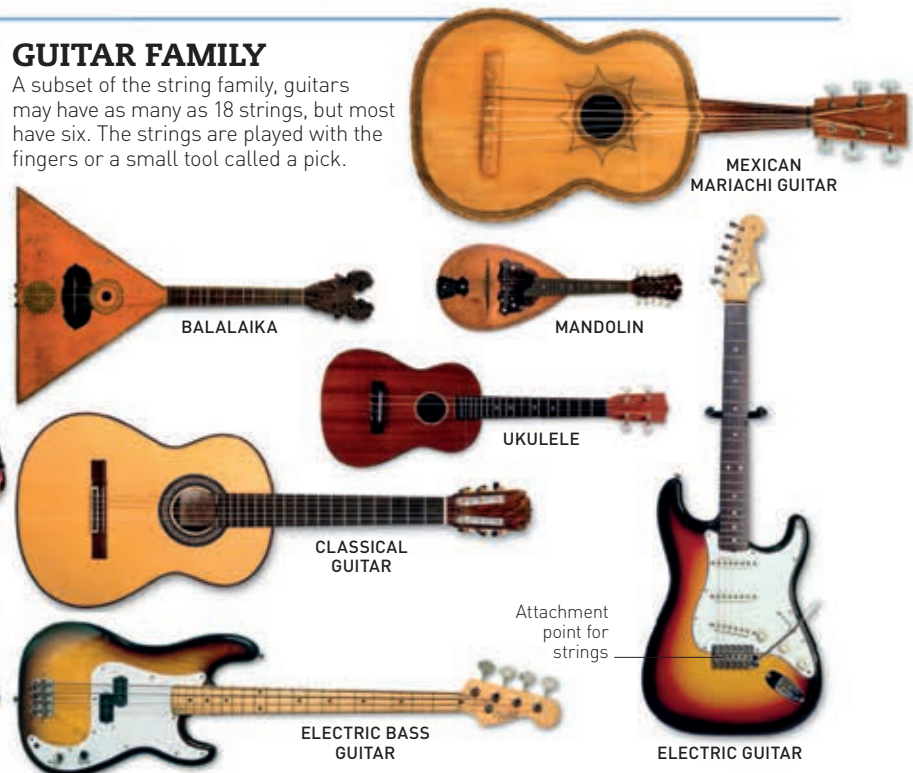
ACCORDION



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

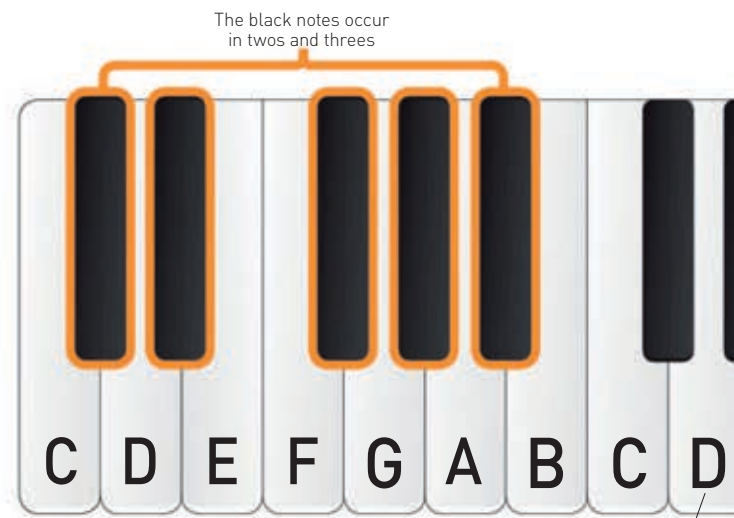


# How music works

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 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

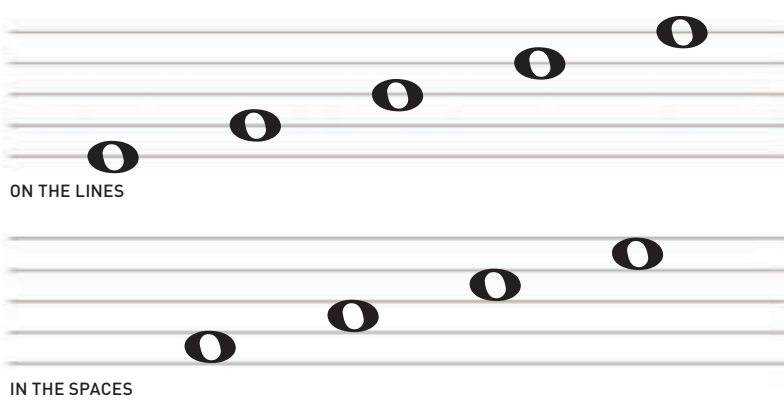
With its unique layout, the piano is a useful instrument for learning music theory. The pattern of black and white keys shows the relationships between notes.

The white note between a pair of black notes grouped in twos is always D

## 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 FIRST KNOWN MUSIC WAS WRITTEN IN AN ANCIENT LANGUAGE CALLED CUNEIFORM, 3,400 YEARS AGO**



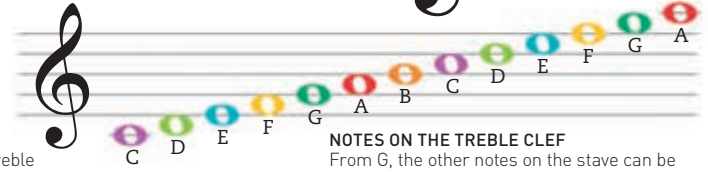
## CLEFS

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.



### THE G CLEF

The centre of the treble clef shows where G sits on the staff.



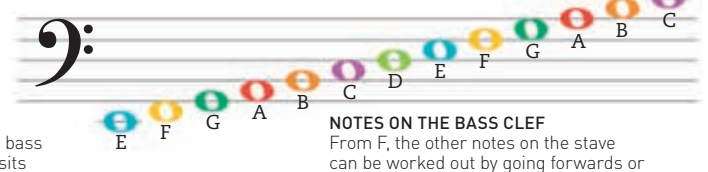
### NOTES ON THE TREBLE CLEF

From G, the other notes on the staff can be worked out by going forwards or backwards through the musical alphabet.



### THE F CLEF

The two dots of the bass clef show where F sits on the staff.



### NOTES ON THE BASS CLEF

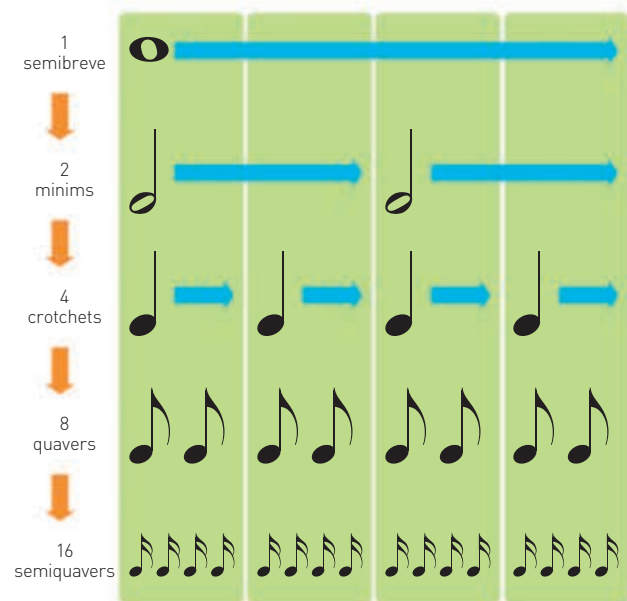
From F, the other notes on the staff can be worked out by going forwards or backwards through the musical alphabet.

## 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: semibreve, minim, crotchet, quaver, and semiquaver.

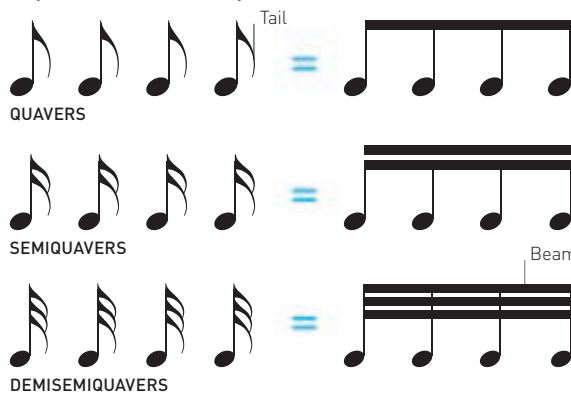
## TIME VALUES

The chart below shows how the note values relate to each other. Each column represents one crotchet, so a semibreve lasts as long as four crotchets.



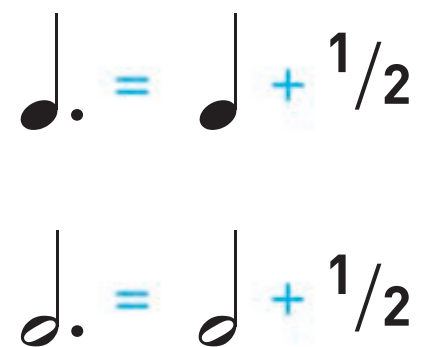
## BEAMS

Two or more consecutive quavers can be joined together with a thick line called a beam, which replaces the individual tails. Semiquavers or demisemiquavers 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 crotchet below is 1½ times longer than a crotchet, and the dotted minim is 1½ times longer than a minim.

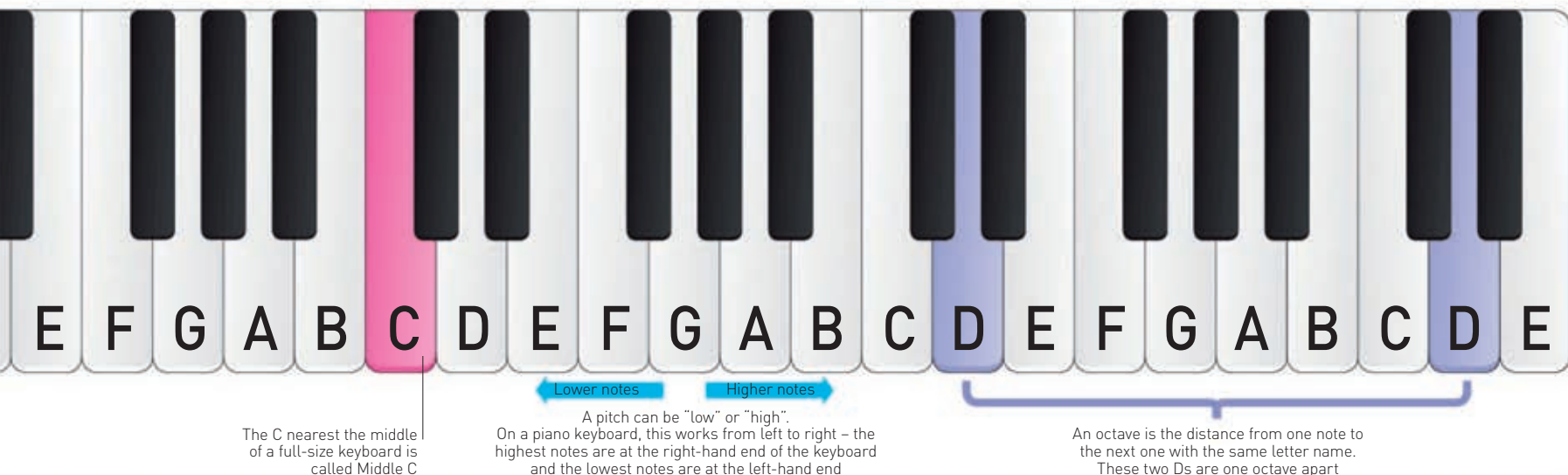


## TIME SIGNATURES

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 = minim, 4 = crotchet, 8 = quaver, and 16 = semiquaver.

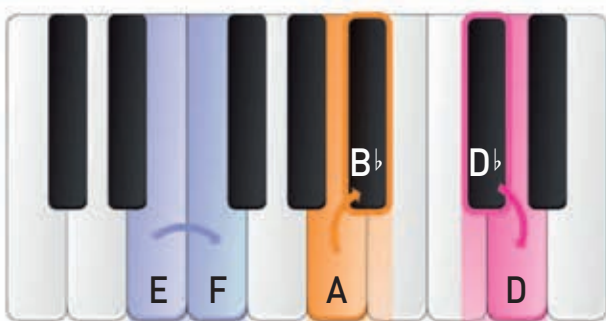
$\frac{2}{4}$ Two crotchet beats to the bar	$\frac{4}{4}$ Four crotchet beats to the bar	$\frac{3}{2}$ Three minim beats to the bar	$\frac{9}{8}$ Nine quaver beats to the bar
$\frac{3}{4}$ Three crotchet beats to the bar	$\frac{2}{2}$ Two minim beats to the bar	$\frac{6}{8}$ Six quaver beats to the bar	$\frac{12}{8}$ Twelve quaver beats to the bar



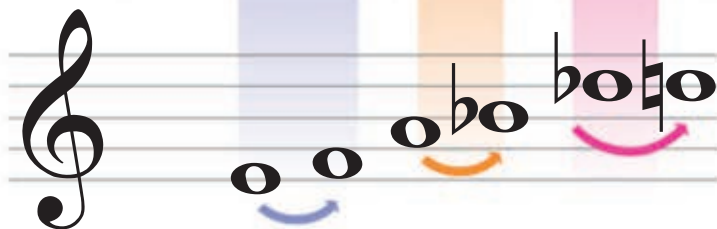


### SEMITONES

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.

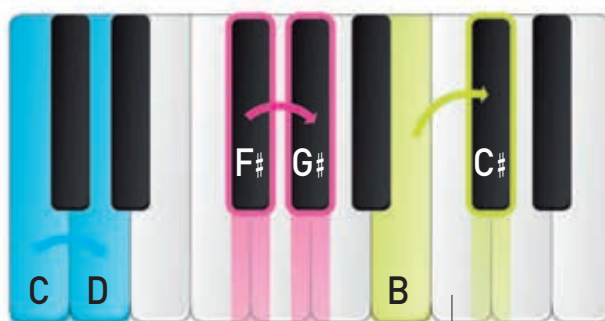


**ON THE STAVE**  
This is how the three semitones shown on the keyboard are written on the stave.



### 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.



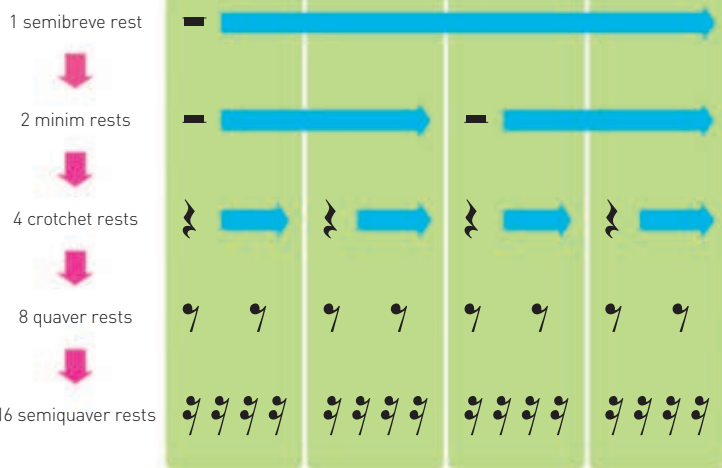
**ON THE STAVE**

This is how the three tones shown on the keyboard are written on the stave.



### 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 playing or writing music, the rests are as important as the notes.

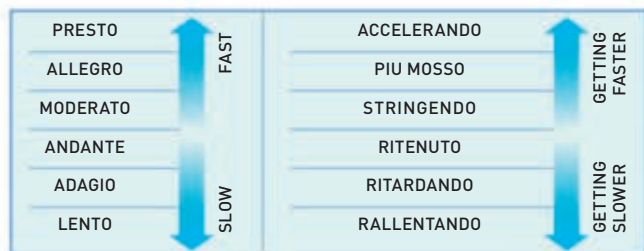


**TIME VALUES**

The chart shows rests and how their time values relate to each other.

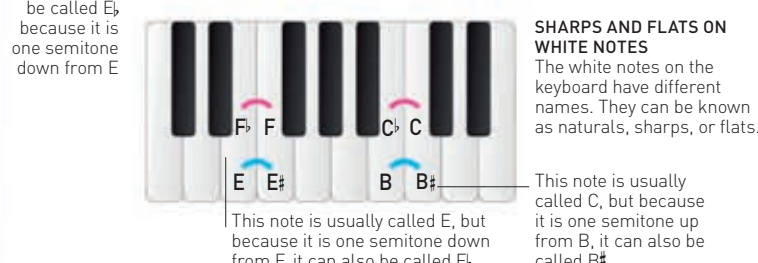
### TEMPO

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.





# 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 sport, 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

These Ancient Greek priests danced and drummed in armour.



### 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.



### SIVA NATARAJA

Hindu god Siva 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.



### EGYPTIAN DANCING

Ancient Arabic 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, wave-like movements.



### KATHAKALI

South Indian dance-drama performed in elaborate make-up.



### KABUKI

Japanese theatrical dance performed in colourful 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 USA 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 on their own.

### LINE DANCING

Dancers line up in a row and perform a pattern of steps together to country music. Line dancing started in the USA 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 STYLE

Bollywood films 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 borrows from the many different folk and classical styles of India.

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 Punjabi folk dance, usually accompanied by a strong drum beat.

Both arms are raised during the dance

Kicks and jumps are often used



## 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

Bharatanatyan costumes are based on Hindu temple sculptures.



### BELLY DANCER

The *bedlah* consists of fitted bikini top, hip belt, and long skirt.



### BALLROOM

Long dress with full, flowing skirt to enhance a dancer's movements.

## 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

## 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.



### 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.

**THE SAMBA IS TRADITIONALLY DANCED AT THE RIO CARNIVAL, A FAMOUS FESTIVAL IN BRAZIL**

## 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 round 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



### ARABIC

Arabic dance uses quick, vibrating movements of the body and requires a lot of stamina.

Intricate hand movements



### TRADITIONAL BOLLYWOOD

Early Bollywood dance routines focused on acting out the lyrics of a song.



### DANDIYA

A Gujarati folk dance where dancers hit dandiya (sticks) together.

**BEFORE MATCHES, THE NEW ZEALAND RUGBY TEAM PERFORMS A MAORI WAR DANCE CALLED A HAKA**

## SPORTING 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.

**1500**

## 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 theatres of France, Italy, Russia, Scandinavia, and England.

**1653**  
King Louis XIV dances the role of Apollo, the Sun god, in *Le Ballet de la Nuit* (The Dance of the Night).



**Statue of Louis XIV of France**

**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**

## 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 (*corps de ballet*). The best dancers might progress to become a soloist or principal dancer.



**BEGINNER**  
Dancers begin around age five, 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, then progresses to 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 BALLETS

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.

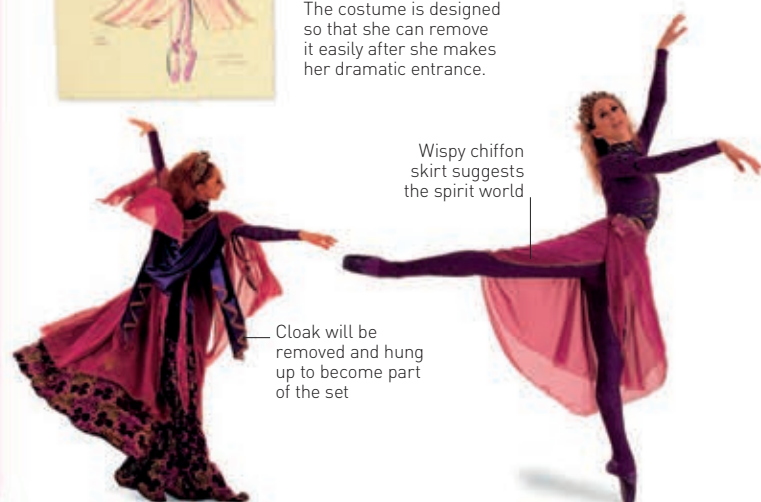
- **SWAN LAKE, 1877**  
A handsome prince falls in love with a mysterious girl, only to discover that an evil magician has cast a spell on her.
- **GISELLE, 1841, ADAPTED 1884**  
A young girl is betrayed by the man she loves. She dies of grief, then comes back as a ghost and saves the life of the man who broke her heart.
- **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 Kostchée.
- **COPPELIA, 1871**  
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.
- **THE NUTCRACKER, 1891**  
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.

## 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.



**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

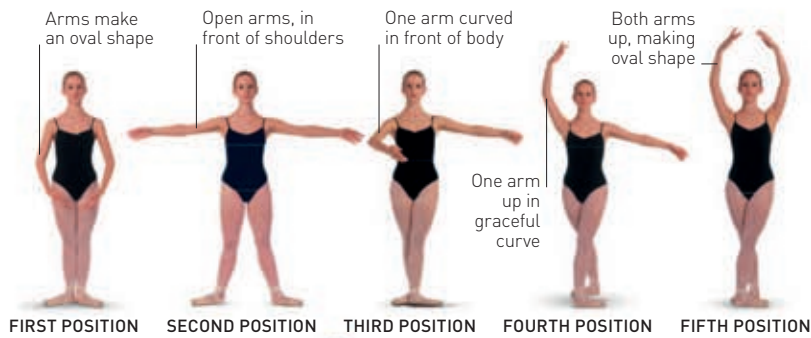
Cloak will be removed and hung up to become part of the set

**ONLY MEN PERFORMED BALLET UNTIL 1681, WHEN MADEMOISELLE DE LAFONTAINE BECAME THE FIRST BALLERINA**



## 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 foot positions, the feet are flat on the floor and turned out (pointing in opposite directions).



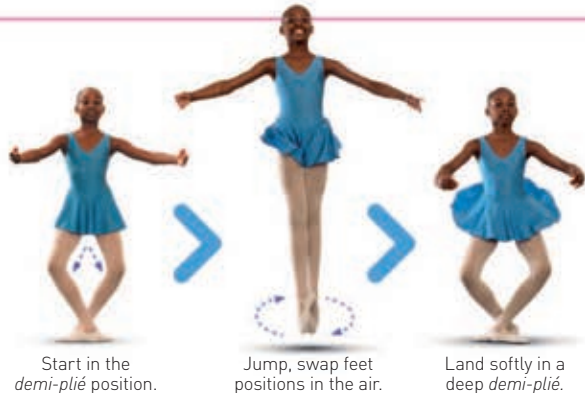
## AT THE BARRE

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.



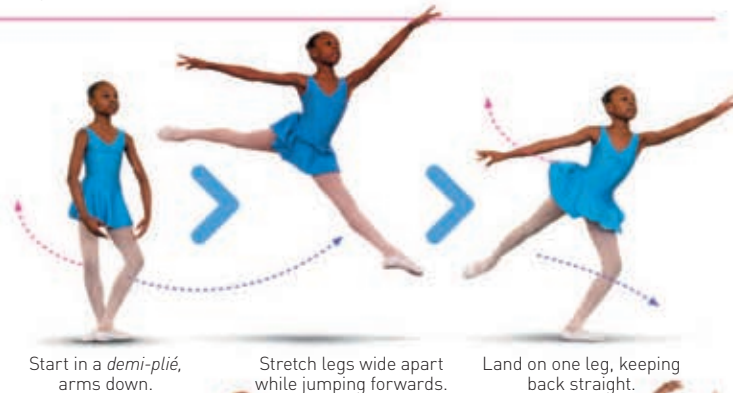
## CHANGEMENT

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*. Practise several in a row to build up a stronger jump.



## SISSONE OUVERT EN AVANT

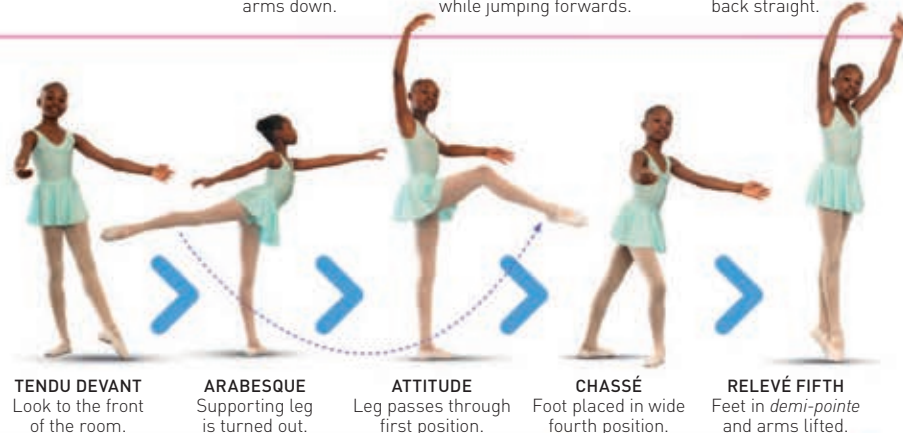
A *sissonne* is a jump starting from two feet. There are different kinds, but in this version, the legs open wide in the air, and then the dancer lands on one leg.



**A PRINCIPAL BALLERINA CAN GET THROUGH UP TO 12 PAIRS OF POINTE SHOES EVERY MONTH**

## ADAGE

*Adage* means "moving smoothly". Dancers put together a series of positions to make an exercise that improves balance and strengthens muscles.



## 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.



## 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.



Male dancers always gaze at the ballerina

Strong knees and thighs are essential for supporting and lifting

**EXPRESSING EMOTION**  
The *pas de deux* often portrays a romantic vision of love.



# 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.

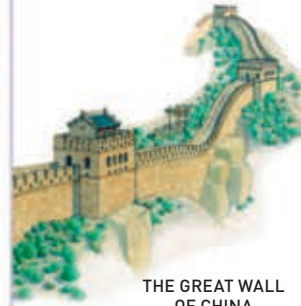


THE GREAT PYRAMID AND SPHINX AT GIZA, EGYPT

▶ c.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 21,197 km (13,170 miles).



THE GREAT WALL OF CHINA

▶ c.1900 BCE

## PALACE OF KNOSSOS

This was the largest centre 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

◀ 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 centre 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 jewelled tomb for the beloved wife of Mughal emperor Shah Jahan. 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.



EMPIRE STATE BUILDING, NEW YORK CITY, USA

▶ 1959

## SYDNEY OPERA HOUSE

A multi-venue performing arts centre, Sydney Opera House was designed by Danish architect Jorn Utzon in a style called Modern Expressionism. The building's distinctive look comes from its one million self-cleaning, glazed white tiles.



SYDNEY OPERA HOUSE, AUSTRALIA

▶ 1971

## POMPIDOU CENTRE

Housing a library, museum of modern art, and a centre for music research, the Pompidou is a high-tech arts centre. The different coloured 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 sculpture-like.



THE GUGGENHEIM, BILBAO, SPAIN



▶ **440s BCE**

**PARTHENON**

Its 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 amphitheatre 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 lifts to allow animals and men to appear from beneath the ground.



THE COLOSSEUM, ROME, ITALY

▶ **537 CE**

**HAGIA SOPHIA**

The cathedral church of Constantinople (now Istanbul), was the largest in the world for 1,000 years. It 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**

**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, colourful, 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 Ancient 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, GRANADA, SPAIN

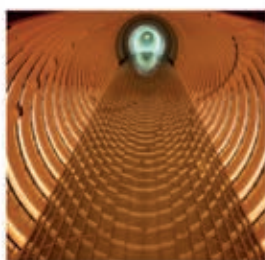
▶ **1994**

**JIN MAO TOWER**

Traditional Chinese and modern Western architectural styles are combined in this Shanghai skyscraper. Each tier flares outwards 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**

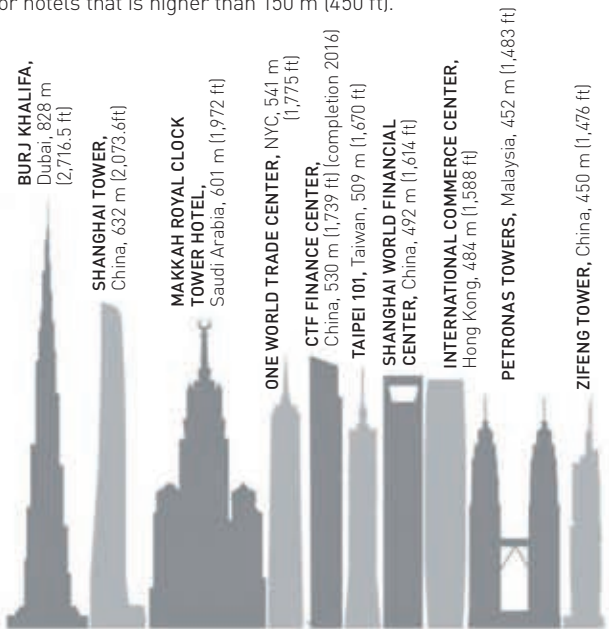
With 163 floors, Burj Khalifa is the world's tallest building. It is topped with a spiral minaret, like those on mosques. Its 24,348 windows are machine-cleaned, but the top of the spire is cleaned by hand, with the workers dangling from ropes.



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 150 m (450 ft).





# Great books

Thousands of years ago, stories were simply spoken aloud or told with pictures. As writing developed, tales were inscribed on stone, and 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 thought to be the first piece 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.

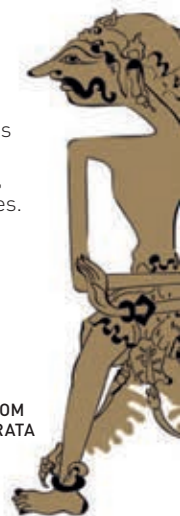


A PAGE FROM THE BOOK OF THE DEAD

▶ **C.4TH-2ND CENTURY BCE**

## INDIAN EPICS

*Mahabharata* by Vyasa and *Ramayana* by Valmiki are important Sanskrit poems that began as spoken songs. 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 graverobbers, 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



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 Depression in the USA. George tries to look out for his strong, slow-witted friend Lennie who dreams of farming rabbits.



LENNIE’S MOUSE

▶ 1937

## 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

▶ 1943



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.

▶ 1945

## 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 badly wrong after Napoleon the pig seizes power.



NAPOLEON THE PIG

▶ 1947

## 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



▶ c.2ND CENTURY BCE

### INVENTION OF PAPER

Before the invention of paper by a resourceful Chinese civil servant called Cai Lun, writers used parchment, papyrus, or palm leaves.



PAPER AND BRUSH

▶ c.700–1500 CE

### ARABIAN NIGHTS

*Arabian Nights* (also called *One Thousand and One Nights*) is a collection of captivating stories compiled over many centuries. Two of the best known are *Ali Baba and the Forty Thieves* and *Sinbad the Sailor*.

“Open Sesame!”

(*Ali Baba and the Forty Thieves*)

▶ c.750–1000

### BEOWULF

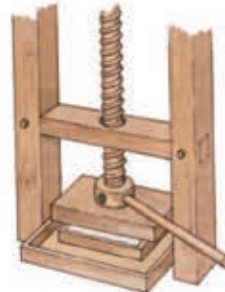
*Beowulf* is an Old English poem about good and evil. The hero, Beowulf, destroys a terrible monster and then a dragon, but is killed during his last battle.

“When a chance came, he caught the hero in a rush of flame and clamped sharp fangs into his neck.”

▶ 1440

### THE PRINTING PRESS

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.



THE PRINTING PRESS

▶ c.1595

### ROMEO AND JULIET

William Shakespeare wrote 37 brilliant plays and many sonnets. One of his most famous plays, *Romeo and Juliet*, tells the tragic story of two young lovers whose families are fierce rivals.



ROMEO'S POISON AND DAGGER

“O Romeo, Romeo, wherefore art thou Romeo?”

◀ 1831

### THE HUNCHBACK OF NOTRE DAME

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.



NOTRE DAME CATHEDRAL

◀ 1813

“Angry people are not always wise.”

### PRIDE AND PREJUDICE

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 romance.

◀ 1812

### GRIMMS' FAIRY TALES

The Brothers Grimm wrote many gruesome fairy tales with wicked characters that still frighten and thrill children today. *Little Snow White* and *Little Red Riding Hood* are two of the most famous.

“Mirror, mirror, on the wall, who in this land is the fairest of all?”

(*Little Snow White*)

◀ 18TH CENTURY



A TRADITIONAL CHINESE FAN

### DREAM OF THE RED CHAMBER

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.

◀ 1605

### DON QUIXOTE

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.

“Can we ever have too much of a good thing?”

▶ 1950



THE WARDROBE

### THE LION, THE WITCH AND THE WARDROBE

C S Lewis set his adventures in Narnia – the mysterious world of ice and snow that four children discover through a door at the back of a wardrobe.

▶ 1952

### CHARLOTTE'S WEB

Wilbur the pig is saved from slaughter by a supportive spider called Charlotte who weaves flattering messages about him in her web. E B White's heart-warming story has been a favourite for more than 60 years.



CHARLOTTE IN HER WEB

▶ 1960



THE MOCKINGBIRD IS A SYMBOL OF INNOCENCE

### TO KILL A MOCKINGBIRD

Two children learn harsh lessons about equality in Harper Lee's explosive novel set in Alabama, USA. Their lawyer father defends a black man who is accused of a crime he did not commit.

▶ 1988

### THE ALCHEMIST

Paulo Coelho's young shepherd, Santiago, tries to fulfil his Personal Legend by hunting for treasure. He learns valuable lessons on his journey.



SANTIAGO SEEKS TREASURE AT THE PYRAMIDS

▶ 1997

### HARRY POTTER AND THE PHILOSOPHER'S STONE

The *Harry Potter* series by J K Rowling is about the adventures of a special young wizard called Harry and his schoolfriends. In this first story, an evil wizard hunts for the Philosopher's Stone so he can live forever.



THE SORTING HAT TELLS STUDENTS WHICH SCHOOL HOUSE THEY WILL BE IN

▶ 2005



BURNING BOOKS

### THE BOOK THIEF

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.



# 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 honour the gods.

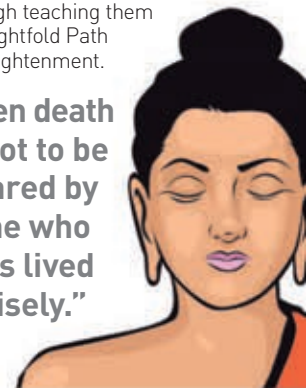


▶ c.563–483 BCE

## 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.”

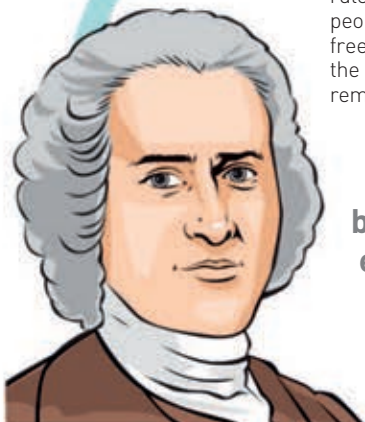


◀ 1712–78

## JEAN-JACQUES ROUSSEAU

Rousseau said 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.”



◀ 1711–76



## DAVID HUME

Hume was a founder of “sceptical” philosophy, saying 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 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 USA, who based the American Constitution of 1787 in part on Locke’s ideas.

“Where there is no law, there is no freedom.”

◀ 1596–1650

## RENE DESCARTES

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.”

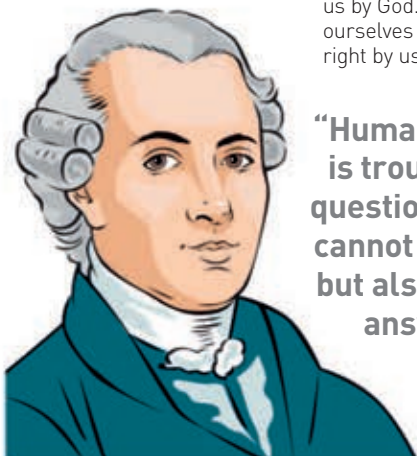


▶ 1724–1804

## 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.”



▶ 1759–97

## MARY WOLLSTONECRAFT

An English 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.



▶ 1806–73



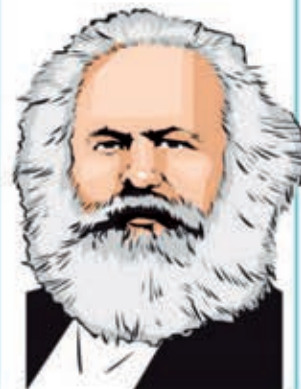
## JOHN STUART MILL

English 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.

▶ 1818–83

## KARL MARX

A revolutionary economist and thinker, 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 individual people.



▶ 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 neighbours, honour 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



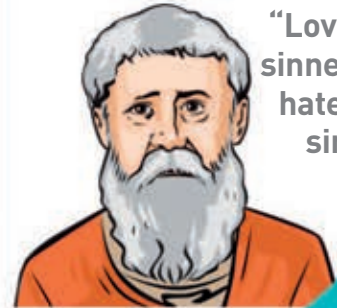
**ARISTOTLE**

Plato’s pupil, Aristotle, is often called the first scientist. He believed that we should base our theories on what we have seen and experienced, rather than what we feel is true.

► 354–430 CE

**AUGUSTINE OF HIPPO**

Born in North Africa, Augustine was a Christian leader and thinker. He tried to explain why there is so much evil in our world, when God, who created it, is perfectly good.



“Love the sinner and hate the sin.”

◀ 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

**NICCOLO 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.”

◀ 1225–74



**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.

◀ 1126–98

**IBN-RUSHD (AVERROES)**

A Muslim philosopher from Cordoba 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 six she saw visions that seemed to be from God, and she wrote about them in many books.



► 1868–1963

**W E B DUBOIS**

An African-American historian, author, and campaigner, Dubois 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.



► 1889–1951



**LUDWIG WITTGENSTEIN**

One of the 20th century’s most influential thinkers. He was especially interested in logic, and the connection between language and the world. He taught that we can only talk or write properly about things that exist.

► 1905–80

**JEAN PAUL SARTRE**

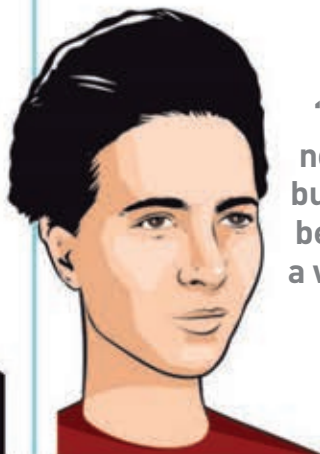
French writer and existentialist thinker. He believed that there is no God, and people have not been invented for any particular purpose: we must choose for ourselves what to do with our lives.



► 1908–86

**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.”

► 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 colourful, spicy rice dishes.



TAMALES, BELIZE



TOSTONES, VENEZUELA



ARROZ CON POLLO, COLOMBIA



FEIJOADA, BRAZIL



PASTELS, BRAZIL



ACARAJE, BRAZIL



BLACK BEAN AND PUMPKIN SOUP, BRAZIL



EMPANADAS, BRAZIL



PUDIM DE ABOBORA, BRAZIL



ROAST GUINEA PIG, PERU



PORK BEAN STEW, BRAZIL



YERBA MATE, PARAGUAY



ICE CREAM WITH DULCE DE LECHE SAUCE, PARAGUAY



CEVICHE, PERU



KIBBEH, 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, USA



HAMBURGER, USA



HOT DOG, USA



SWEETCORN CHOWDER, USA



ROAST TURKEY, USA



FAJITAS, MEXICO



## AFRICA

Food on this huge continent is full of flavours 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 HALVA, MOROCCO



TAGINE, MOROCCO



HARIRA, ALGERIA



COUSCOUS, TUNISIA



FERAKH MAAMER, MOROCCO



ZAHLOUK, MOROCCO



BSTILLA BIL DJAJ, MOROCCO



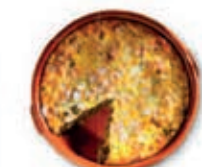
BABA GANOUSH, EGYPT



BOEREWORS, SOUTH AFRICA



GALINHÁ AFRICAN, MOZAMBIQUE



BOBOTIE, SOUTH AFRICA



BILTONG, SOUTH AFRICA



FUL MEDAMES, EGYPT





## 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 enjoying English fish and chips or spicy German sausage.



BLUEBERRY PIE, USA



FISH AND CHIPS, UNITED KINGDOM



ROAST BEEF, UNITED KINGDOM



LIMBURGSE VLAAI, THE NETHERLANDS



STOLLEN, GERMANY



WALDORF SALAD, USA



ECLAIRS, FRANCE



QUICHE, FRANCE



COQ AU VIN, FRANCE



MOULES FRITES, BELGIUM



SAUERKRAUT, GERMANY



PICKLED HERRINGS, GERMANY



GUMBO, USA



PAELLA, SPAIN



GAZPACHO, SPAIN



STRUDEL, AUSTRIA



GOULASH, HUNGARY



BAKLAVA, GREECE



BURRITOS, MEXICO



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 flavoured 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



PANEER WITH DAHL, INDIA



SAMOSA, INDIA



KERALA FISH STEW, INDIA



BANH MI, VIETNAM



PHO GA, VIETNAM



ALOO GOBI, INDIA



RINGRAH NA BHAJIA, 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 like Peach Melba are popular too. In the Pacific Islands, cooks use Asian flavours and lots of fruit and fish.



COCONUT CHICKEN CURRY, MICRONESIA



BARBEQUED CHICKEN, AUSTRALIA



COCONUT, FIJI



ANZAC BISCUITS, AUSTRALIA



PEACH MELBA, AUSTRALIA



KIWI FRUIT SALAD, NEW ZEALAND



PAVLOVA, NEW ZEALAND

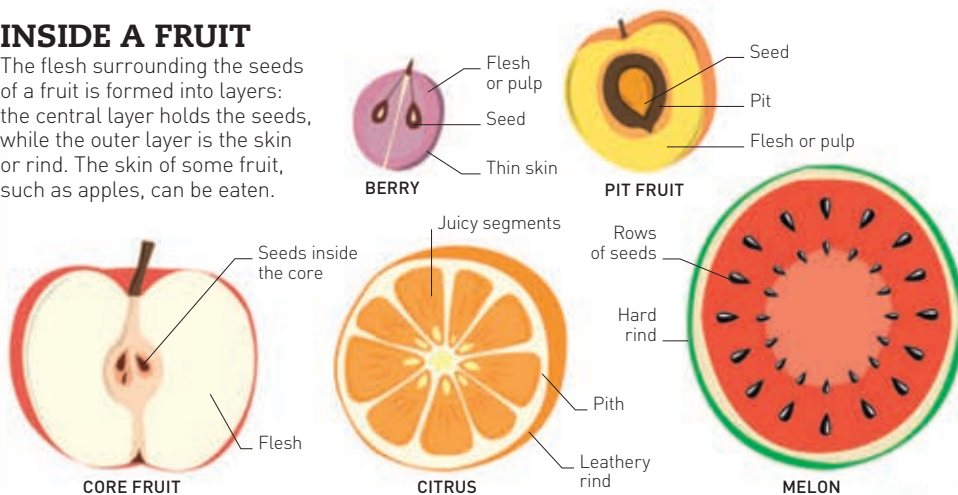


# Fruit

A fruit is the edible part of a plant that develops from its flowers. Each fruit contains a seed (or seeds) that is surrounded by flesh and enclosed in a skin or rind. Fruit is full of natural sugar and usually tastes sweet.

## 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.



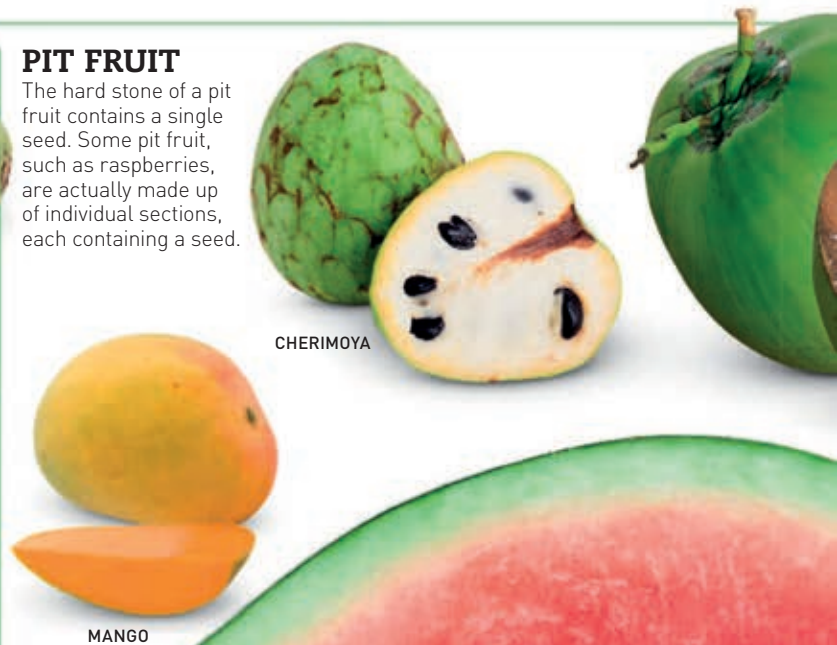
## BERRIES

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.



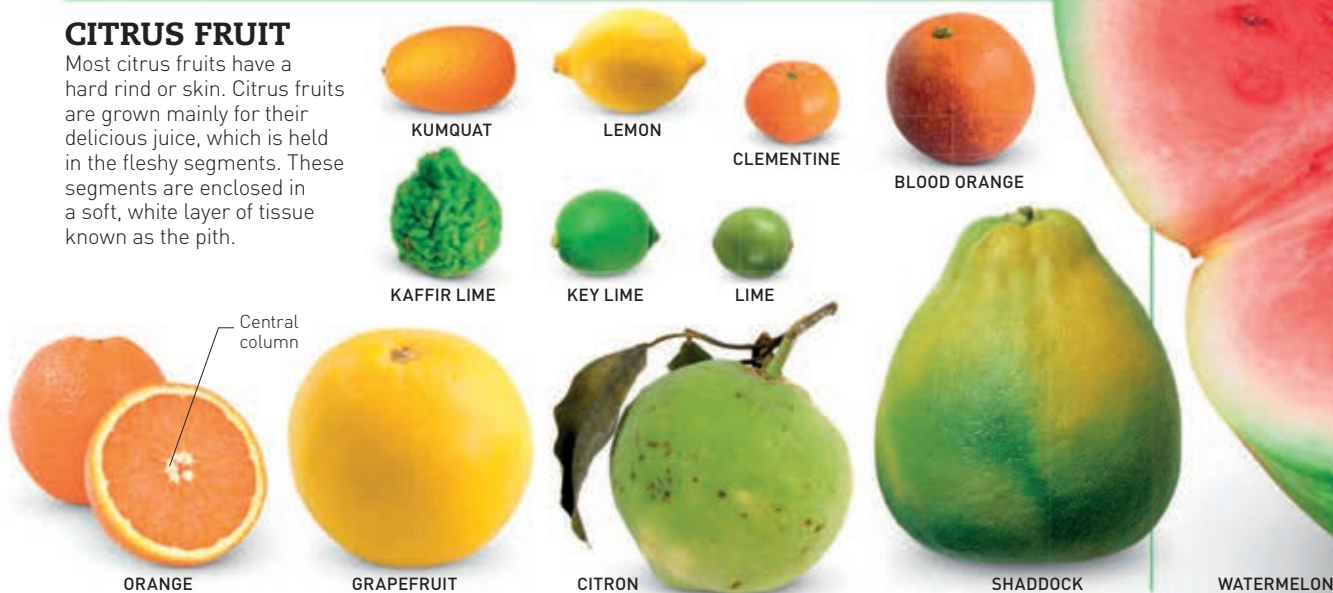
## PIT FRUIT

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.

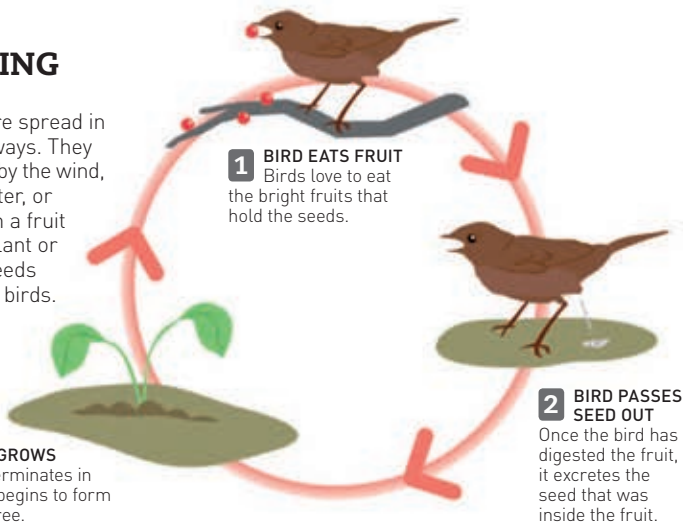




## SPREADING SEEDS

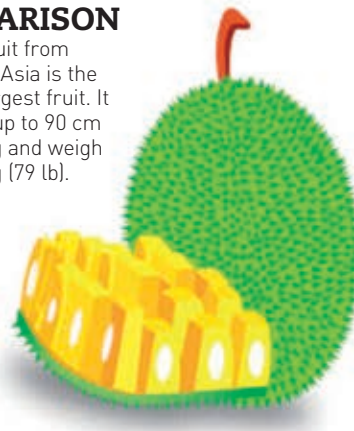
Fruit seeds are spread in a number of ways. They can be blown by the wind, carried by water, or dropped when a fruit falls from a plant or tree. Often, seeds are spread by birds.

**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 90 cm (35 in) long and weigh up to 36 kg (79 lb).



JACKFRUIT

## STINKIEST FRUIT

Many people consider the world's stinkiest fruit to be the durian. It can smell like rotten onions, but has a sweet, custard-like flesh.



DURIAN



COCONUT



NECTARINE



LYCHEE



RAMBUTAN



PEACH



BLACKBERRY



RASPBERRY



DAMSON



PLUM



APRICOT

## ACCESSORY FRUIT

Some kinds of fruit grow differently from others. They are known as accessory fruit. The core fruit piece is sometimes included within this category.



STRAWBERRY

**STRAWBERRIES ARE PART OF THE ROSE FAMILY OF FLOWERING PLANTS**



PINEAPPLE



BREADFRUIT



FIG

## CORE FRUIT

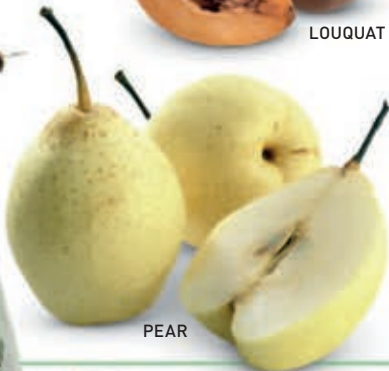
These fleshy fruits have thin, often edible, skins. Their seeds are contained in the core at the centre of the fruit.



LOQUAT



APPLE



PEAR



QUINCE

**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 centre, 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 VEGETABLES

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 savoury cooking, are commonly called vegetables.



FRUIT



POD VEGETABLES



LEAFY VEGETABLES



FLOWERS AND BUDS



ROOT VEGETABLES



BULBS AND STEMS

## COLOURS

You can often tell the health benefits of a vegetable from its colour. The colours 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.

## FRUIT

These vegetables are all the fruit of a plant, and they 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 savoury, not sweet.



PEPPER



RED CHILLI



SQUASH



GOURD



BUTTERNUT SQUASH



MARROW



AUBERGINE



COURGETTE



PUMPKIN

## 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



BROAD 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



SALAD ROCKET



BOK CHOY



CHICKWEED

## 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 fibre, which is good for the digestive system.



CAULIFLOWER



ARTICHOKE



BROCCOLI



DI SICILIA VIOLETTA CAULIFLOWER



ROMANESCO CAULIFLOWER



WATER CHESTNUT



HAMBURG PARSLEY



PARSNIP



RADISH

**“BROCCOLI” IS AN ITALIAN WORD THAT MEANS “LITTLE SPROUTS” OR “LITTLE SHOOTS”**





PURPLE FRENCH BEANS

LIMA BEANS

RUNNER BEANS

PEAS

LABLAB BEANS



CHARD

DANDELION

LAMB'S LETTUCE

BEET GREENS

KALE

CURLY ENDIVE

KOMATSUNA

CAVOLO NERO

LETTUCE

SPINACH

BROAD-LEAVED ENDIVE

LOOSELEAF CHICORY

### 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.



SWEET POTATO

POTATO

TARO

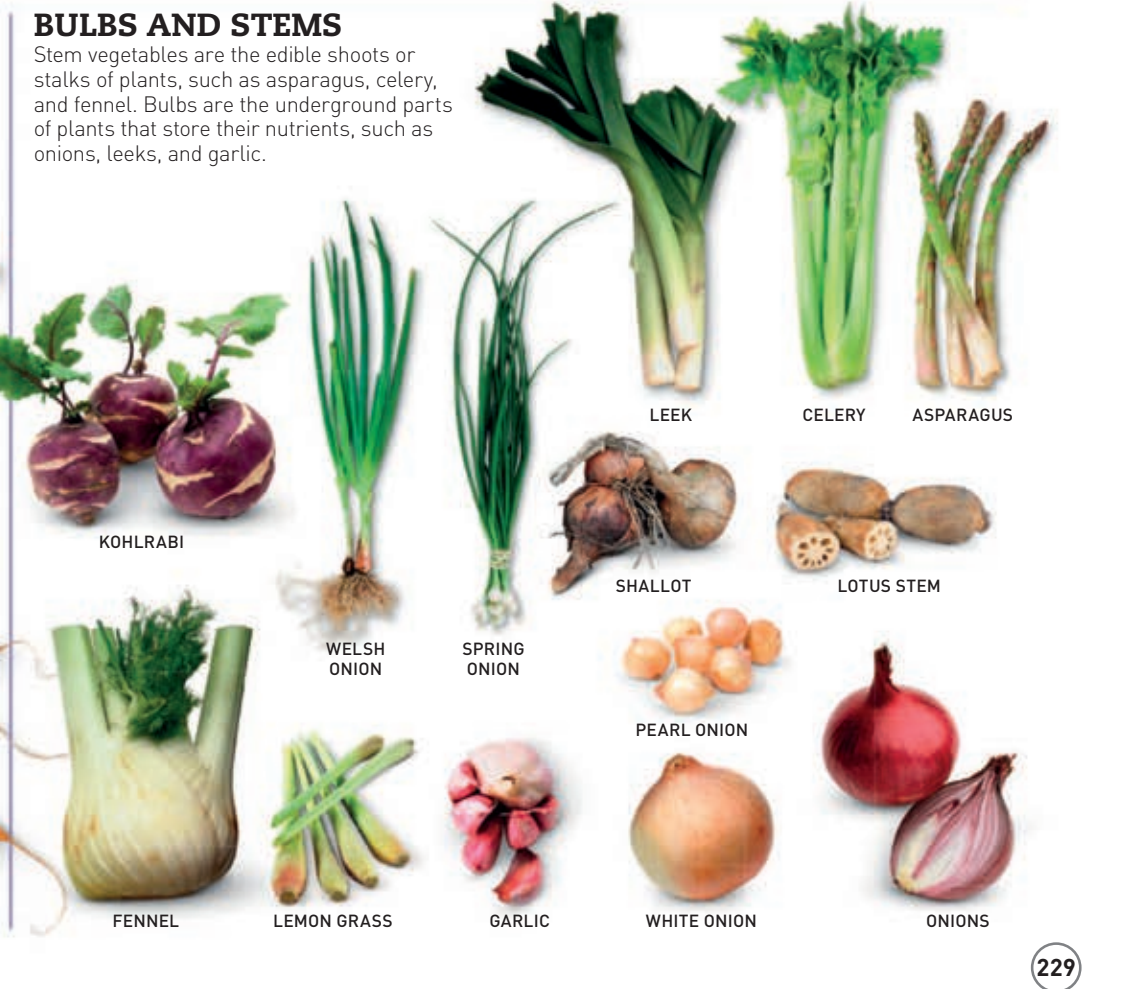
TURNIP

CARROT

BEETROOT

### 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.



KOHLRABI

WELSH ONION

SPRING ONION

LEEK

CELERY

ASPARAGUS

SHALLOT

LOTUS STEM

PEARL ONION

WHITE ONION

ONIONS

FENNEL

LEMON GRASS

GARLIC



## CHEESE-MAKING

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 cheeses, the curds are put into moulds, then left to ripen.

## ADDED FLAVOURS

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.



ROSEMARY



CRANBERRIES



PAPRIKA



CHIVES



THYME



GARLIC



ASH

## TOP CHEESE EATERS

The eight countries listed here are where to find the people who eat the most cheese per person per year (in kg/lb).

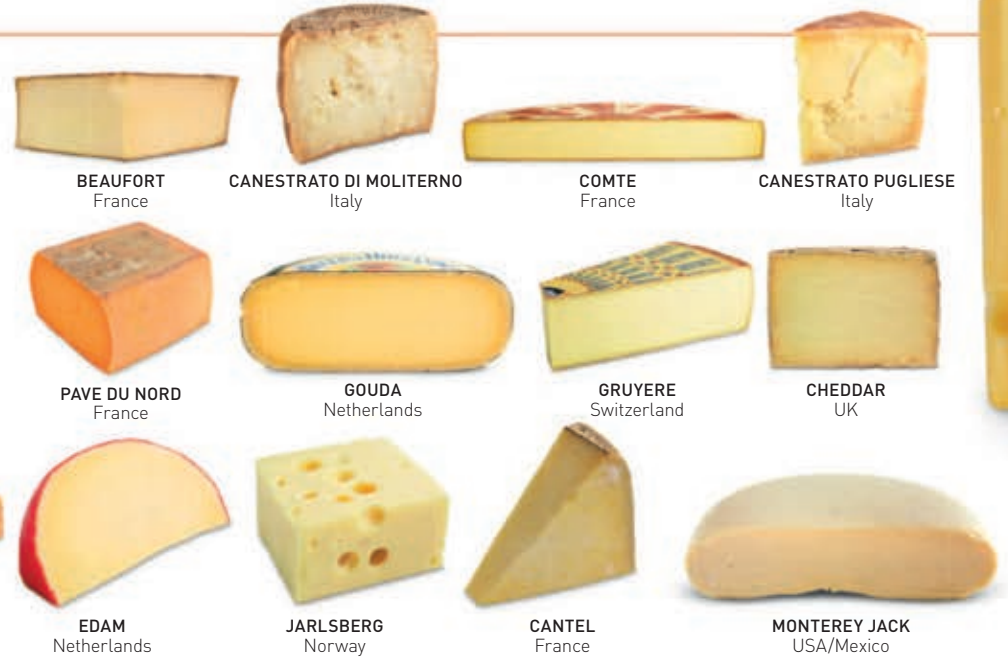
- 1 FRANCE**  
26.3 kg (58 lb) Favourites: Camembert and brie, both soft and creamy cheeses.
- 2 ICELAND**  
24.1 kg (53 lb) Favourite: Skyr, soft cheese with a yogurt-like texture.
- 3 GREECE**  
23.4kg (52 lb) Favourite: feta, tangy, white, and crumbly.
- 4 GERMANY**  
22.9 kg (50 lb) Favourites: Gouda, semi-hard and rich-tasting; and Bruder Basil, a semi-soft smoked cheese.
- 5 FINLAND**  
22.5 kg (49 lb) Favourites: Oltermanni, semi-soft and buttery; and Aura, blue and creamy.
- 6 ITALY**  
21.8 kg (48 lb) Favourites: Parmesan, nutty and grainy; mozzarella, made with buffalo milk; and Gorgonzola, blue-veined and crumbly.
- 7 SWITZERLAND**  
20.8 kg (46 lb) Favourites: Emmental, classic "holey" cheese; and Gruyère, firm and nutty.
- 8 AUSTRIA**  
19.9 kg (44 lb) Favourites: Bergkäse and Tilsiter, both with a strong taste and smell.

# Cheese

Filling a sandwich, used in a sauce, or just nibbled, cheese is one of the world's favourite 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. Semi-hard cheese has a higher moisture content.



## SOFT CHEESE

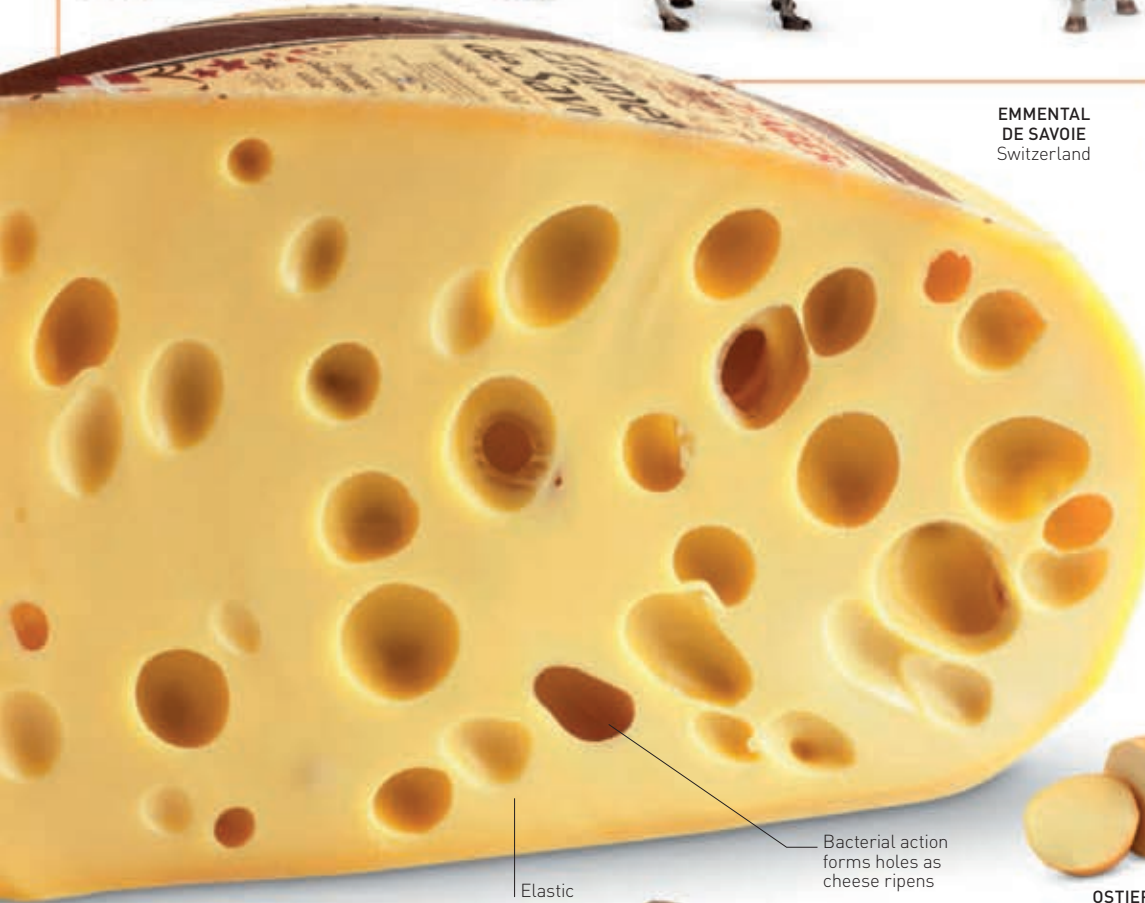
The curds of soft cheeses are not cooked or pressed, but shaped and left to drain. Some types are eaten soon after making. Others are ripened until a wrinkly rind forms. Depending on the type of cheese, the centre may have a creamy or chalky texture.





## 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

Elastic texture

Bacterial action forms holes as cheese ripens

## BLUE CHEESE

The mouldy-looking streaks running through blue cheeses really are mould – but a type that is safe to eat. To produce blue cheese, the makers add mould spores to the curdled milk. After shaping the cheese, they pierce, or “needle”, it to let in air and kickstart the mould's growth. Blue cheese, which can be hard or soft, usually has a strong flavour.



GORGONZOLA  
Italy

STILTON  
UK

ROQUEFORT  
France



BAVARIA BLU  
Germany



BLEU BENEDICTIN  
Canada



BLEU DE CHEVRE  
France



GAMONEDO  
Spain



VALDEON  
Spain



BARKHAM BLUE  
UK



POSTEL  
Belgium



CRESCENT DAIRY FARMHOUSE  
New Zealand



KASHKAVAL  
Hungary



OSTIEPOK  
Slovakia



SARDO  
Argentina



ALLGAUER BERGKASE  
Germany



VASTERBOTTENSOST  
Sweden



GRAVIERA  
Greece



TIROLER GRAUKASE  
Austria



PECORINO SARDO  
Italy



BITTO  
Italy



MANCHEGO  
Spain



PECORINO ROMANO  
Italy



GAMALOST  
Norway

## CHEESE HISTORY

Cheese-making 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.

4000 BCE  
Evidence of dairy farming in the Sahara grasslands.

2000 BCE  
Egyptian tomb paintings show cheese being made.

50 CE  
The Romans invent the cheese press.

1791  
French farmer Marie Harel invents Camembert cheese.

1348  
First reference to cheese from Parma, later known as Parmesan.

1860S  
Mass-produced rennet makes cheese-making more consistent.

## 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.

1170  
First reference to Cheddar, from Somerset in England.



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 939 kg (2,070 lb) goats cheese takes the world title for the biggest cheese ever.

## 2000



# Bread

First eaten around 30,000 years ago, bread is a favourite 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 plaited and fluffy.

## MAKING BREAD

Making bread is not difficult, although you need some strength to knead the dough and patience while it proves (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.



WHOLEMEAL ROLL  
UK



PICOS ROLLS  
Spain



SKILLET BREAD  
USA



PIRAGI  
Latvia

## WHO EATS THE MOST BREAD?

These ten countries eat more bread per person per year than anywhere else in the world.

### 1 TURKEY

104.6 kg (230.5 lb) per person per year. Favourites: bazlama, gözleme, and pide.



### 2 CHILE

96 kg (211.5 lb) per person per year. Favourites: marraqueta, hallulla, and coliza.



### 3 ARGENTINA

76 kg (167.5 lb) per person per year. Favourites: pan de campo, pan de chapa, and chipas.



### 4 DENMARK

70 kg (154 lb) per person per year. Favourites: rye and pumpernickel.



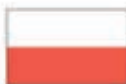
### 4 GREECE

70 kg (154 lb) per person per year. Favourites: daktyla, lagana, and pitta.



### 4 POLAND

70 kg (154 lb) per person per year. Favourites: rye, wholegrain, flavoured breads, and bagels.



### 5 IRELAND

68 kg (150 lb) per person per year. Favourites: potato, soda, and barmbrack.



### 6 HUNGARY

60 kg (132 lb) per person per year. Favourites: lángos, pogácsa, and pretzels.



### 6 THE NETHERLANDS

60 kg (132 lb) per person per year. Favourites: wholegrain, rye, and suikerbrood.



### 7 GERMANY

57 kg (125.5 lb) per person per year. Favourites: rye, wholegrain, and wheat-rye.



## 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  
USA



WHOLEMEAL COTTAGE LOAF  
UK



ZOPF  
Switzerland



CIABATTA  
Italy



BAGUETTE  
France



WHITE LOAF  
UK



SOURDOUGH LOAF  
Middle East



PANE DI PATATE  
Italy



PARTYBROT  
Germany

## RAISING 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 BREAD  
Italy



PIZZA  
Italy

## FLATBREADS

Most flatbreads do not contain yeast, although some, such as pitta bread and naan bread, are slightly leavened. Pitta bread opens up to form a pocket that can be filled with different ingredients. Other flat breads can be used like a plate and then eaten.



PITTA BREAD  
Middle East



PIDE  
Turkey



NAAN  
India



FLATBREAD  
Italy



CRISPBREAD  
Sweden



TORTILLA  
Spain

## FLAVOURS FOR BREAD

Bread can be mixed with lots of different ingredients to make it taste savoury or sweet. Savoury breads can be flavoured with strong tastes, like onion and cheese. Sweet-flavoured breads often have fruit, nuts, and spices added to them.

GERMANY HAS MORE THAN 1,300 VARIETIES OF BREAD, ROLLS, AND PASTRIES





**4** Put the dough into a clean bowl, cover with clingfilm and let it prove (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 tin and cover with clingfilm and let it rise for 90 minutes.



**8** Bake the bread for about 30 minutes in a pre-heated oven at 180°C/350°F/ Gas Mark 4 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 tin so that it stays fresh.



**PARKER HOUSE ROLLS**  
USA



**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 BREAD**  
Ireland



**ANADAMA BREAD**  
USA



**GLUTEN-FREE BROWN BREAD**  
USA



**PANE DI PRATO**  
Italy



**SODA BREAD**  
Ireland



**GOZLEME**  
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**



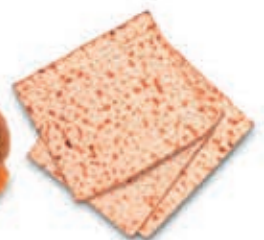
**OLIVES**



**CHEESE**



**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 wholemeal flour.



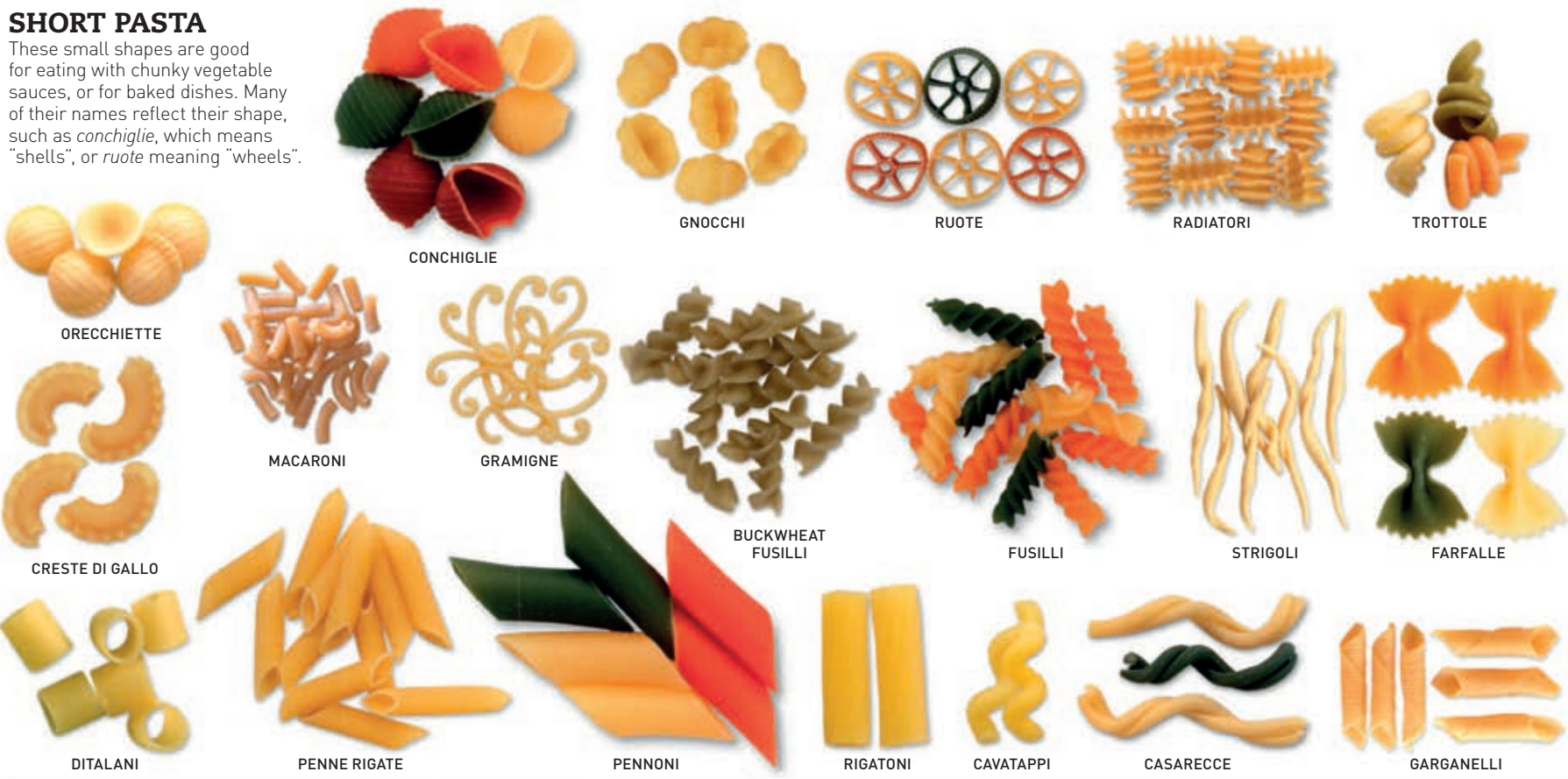
**1 ADD THE EGGS TO THE FLOUR**  
Make a well in the centre of the flour and then add the eggs.



**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 means "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 flavour.



## 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**  
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 cling film and let it rest for 30 minutes. Then 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 PASTA STRANDS**  
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

## COLOURED PASTA

The basic ingredients of pasta don't change, but you can add different foods to pasta that will affect its colour and taste. Added flavours include garlic, herbs, and wine, as well as vegetables such as mushrooms.



CURRY



HERBS



WILD MUSHROOM



TOMATO



RED WINE



SPINACH












ONION



EGG

## WHO EATS THE MOST PASTA?

Nearly 13.5 million tonnes of pasta is produced worldwide each year. Here are the nine countries that eat the most pasta per person.

- 1 ITALY**  
26 kg (57 lb) per person per year. Italians eat 1,524,006 tonnes of pasta each year. 
- 2 VENEZUELA**  
12.3 kg (27 lb) per person per year. Venezuela's total consumption is 350,213 tonnes each year. 
- 3 TUNISIA**  
11.9 kg (26 lb) per person per year. Tunisia's total annual consumption is nearly 130,000 tonnes. 
- 4 GREECE**  
10.5 kg (23 lb) per person per year. The Greeks consume around 120,000 tonnes of pasta annually. 
- 5 SWITZERLAND**  
9.3 kg (21 lb) per person per year. Switzerland's total annual consumption is 73,130 tonnes. 
- 6 SWEDEN**  
9 kg (20 lb) per person per year. Sweden's total consumption is just over 86,000 tonnes. 
- 7 USA**  
8.8 kg (19 lb) per person per year. The USA is the world's largest consumer overall with a total of 2,700,000 tonnes of pasta each year. 
- 8 CHILE**  
8.4 kg (19 lb) per person per year. Chile's total consumption is 144,000 tonnes each year. 
- 9 PERU**  
8.2 kg (18 lb) per person per year. The Peruvians consume 250,000 tonnes annually. 

THERE ARE MORE THAN 600 DIFFERENT SHAPES OF PASTA PRODUCED THROUGHOUT THE WORLD



# 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?

These ten countries eat more fish per person per year than anywhere else in the world.

- 1 **MALDIVES**  
154 kg (339.5 lb) Favourites: skipjack tuna, yellowfin tuna, and mahi-mahi.
- 2 **ICELAND**  
94 kg (207.2 lb) Favourites: haddock, halibut, herring, and plaice.
- 3 **KIRIBATI**  
76.3 kg (168 lb) Favourites: lobster, yellowfin tuna, and skipjack tuna.
- 4 **GUYANA**  
73 kg (161 lb) Favourites: crab, tilapia, and catfish.
- 5 **JAPAN**  
71.9 kg (158.5 lb) Favourites: bluefin tuna, salmon, prawns, and eel.
- 6 **FRENCH POLYNESIA**  
67.5 kg (149 lb) Favourites: tuna, mahi-mahi, octopus, sea urchin, and prawns.
- 7 **SEYCHELLES**  
62.3 kg (137 lb) Favourites: octopus, tuna, squid, red snapper, and grouper.
- 8 **NORWAY**  
61.9 kg (136.4 lb) Favourites: smoked salmon, prawns, trout, crab, cod, and herring.
- 9 **PORTUGAL**  
58.7 kg (129.4 lb) Favourites: cod, sardines, octopus, squid, crab, lobster, clams, mussels, and oysters.
- 10 **MALAYSIA**  
54.2 kg (119.4 lb) Favourites: prawns, crab, squid, cuttlefish, octopus, and sea cucumbers.

## 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.

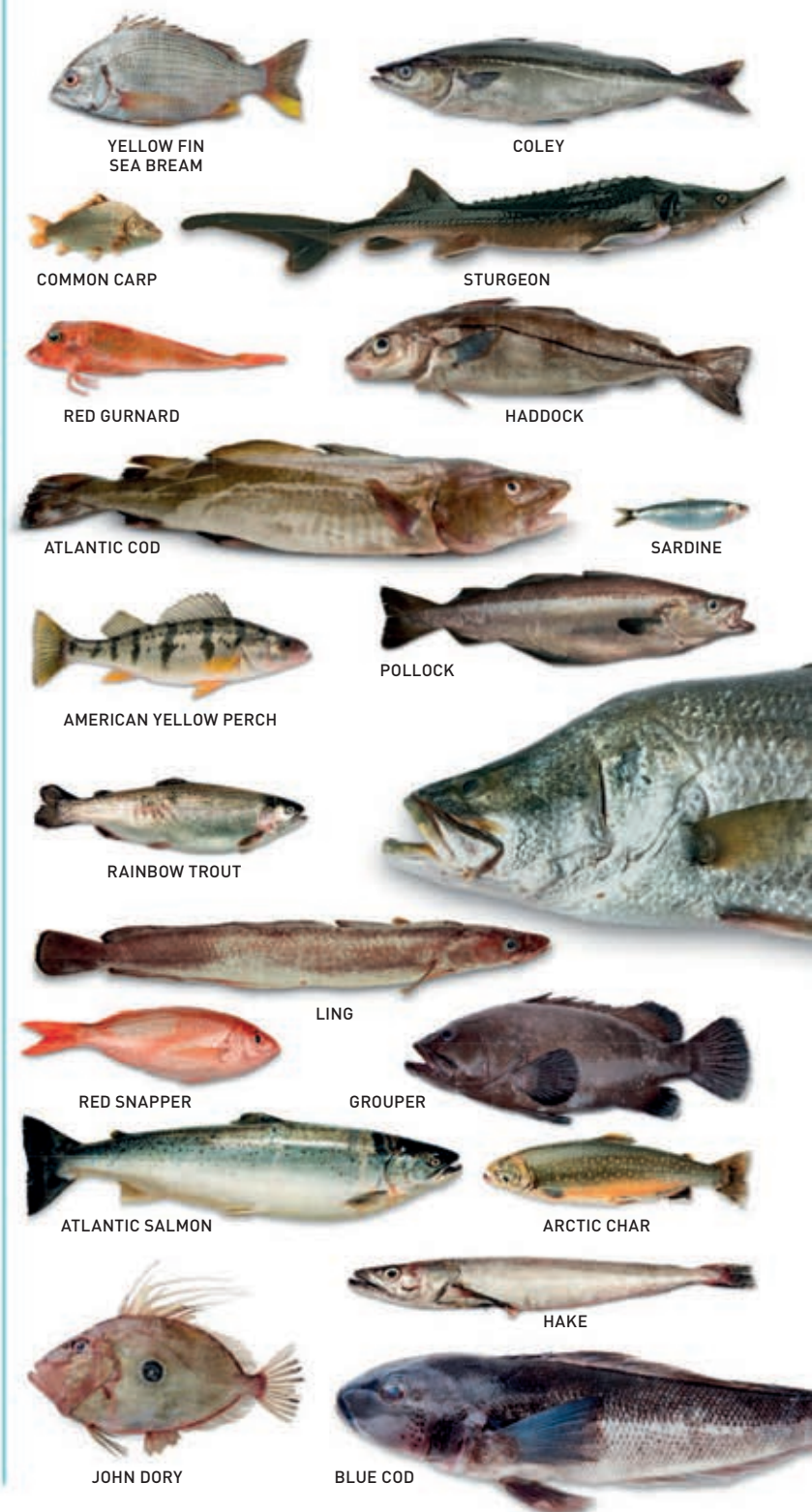


CUTS OF SALMON

Tail

Tail fillet

Steak



YELLOW FIN SEA BREAM

COLEY

COMMON CARP

STURGEON

RED GURNARD

HADDOCK

ATLANTIC COD

SARDINE

AMERICAN YELLOW PERCH

POLLOCK

RAINBOW TROUT

LING

RED SNAPPER

GROUPE

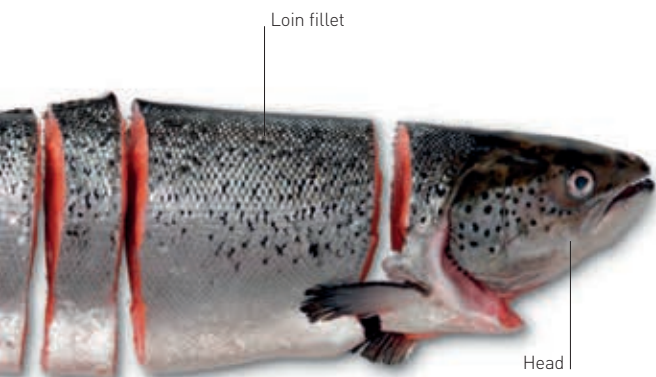
ATLANTIC SALMON

ARCTIC CHAR

JOHN DORY

BLUE COD





TILAPIA



CATFISH



SAND WHITING



RED TILAPIA



ATLANTIC WHITING



ATLANTIC MACKEREL



ATLANTIC HERRING



YELLOWFIN TUNA



BARRAMUNDI



PIKE



SEA BASS



RED MULLET



MONKFISH



ANCHOVIES



MORAY EEL



BREAM



LAKE TROUT

## FLAT FISH

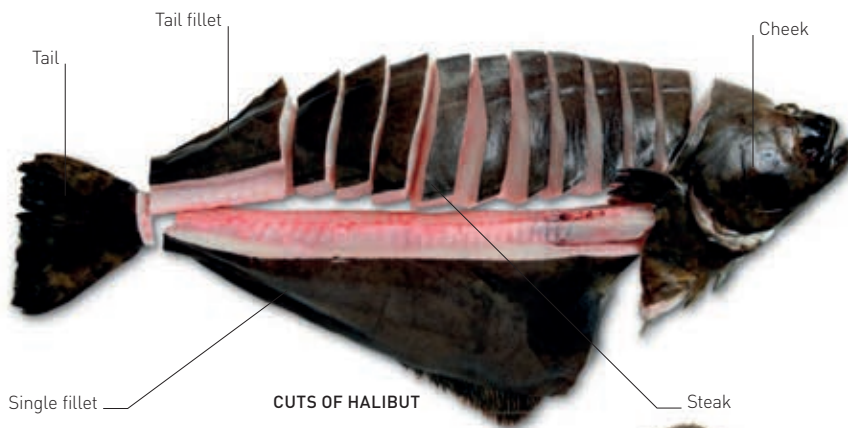
Flat fish start life as small round fish, but turn on to their side as they grow. Flat fish are usually cut into long slices along their backbone. If they are large and thick enough, it is possible to cut steaks from them.



BRILL



SOLE



CUTS OF HALIBUT



TURBOT



DAB



PLAICE



HALIBUT

## 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



ABALONE



CUTTLEFISH



SQUID



WHELKS



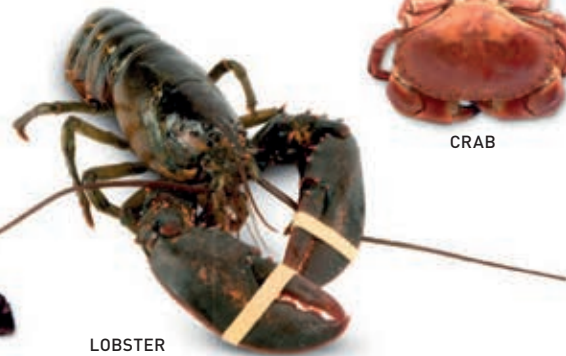
COCKLES



CLAMS



WINKLES



LOBSTER



CRAB



PRAWNS



MUSSELS



OYSTERS



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?

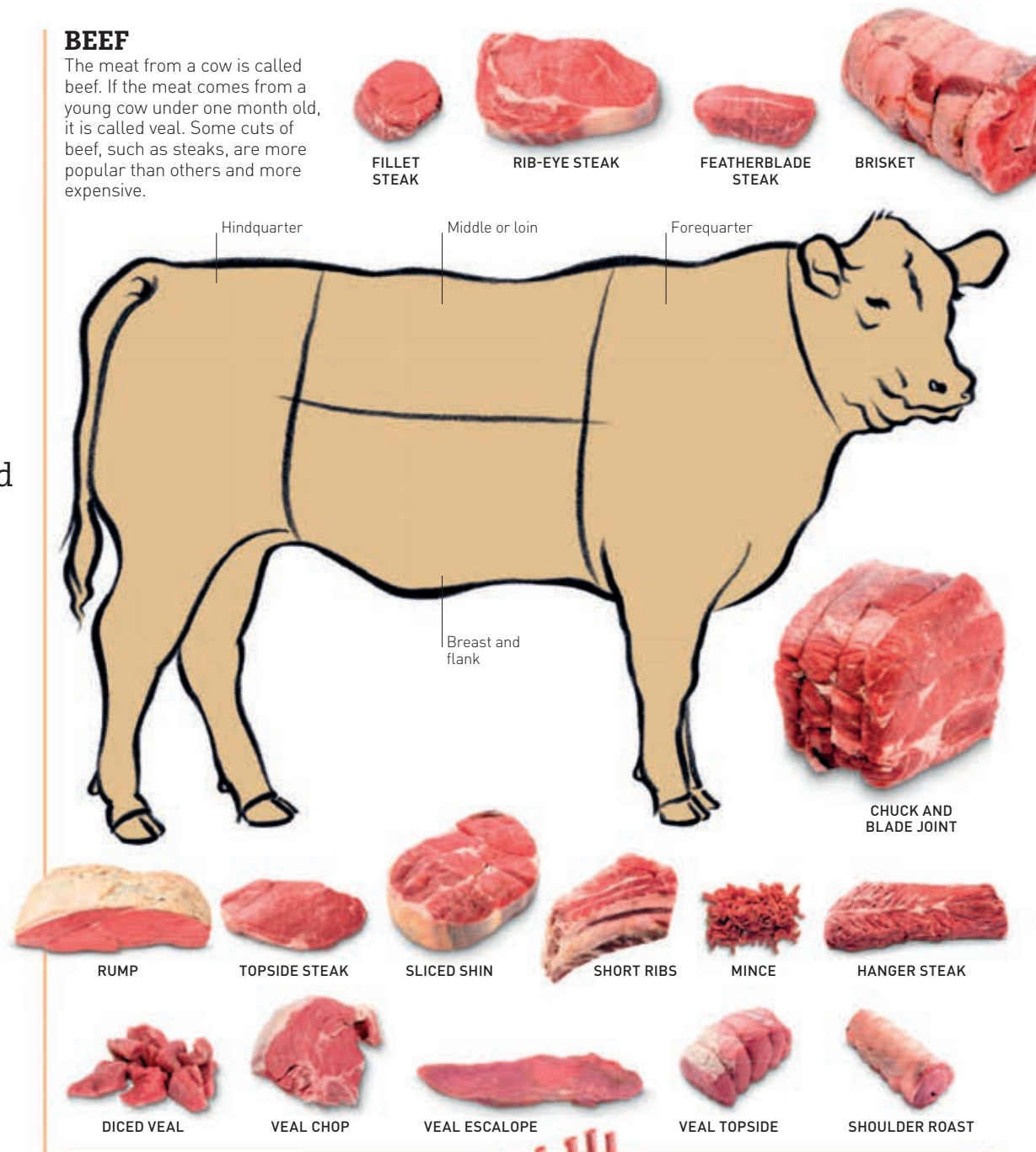
These ten countries eat more meat per person per year than anywhere else in the world.

- URUGUAY**  
126.5 kg (279 lb) Favourites: beef, veal, and pork.
- USA**  
124 kg (274 lb) Favourites: beef (especially steak), chicken, and pork (especially bacon).
- CYPRUS**  
117.6 kg (259 lb) Favourites: chicken and pork (especially tenderloin and preserved forms).
- SPAIN**  
113.1 kg (249 lb) Favourites: beef, pork (especially cured hams), and lamb.
- DENMARK**  
112.4 kg (248 lb) Favourites: pork (minced and especially preserved forms) and beef.
- NEW ZEALAND**  
109.9 kg (242 lb) Favourites: lamb and chicken.
- AUSTRALIA**  
108.9 kg (240 lb) Favourites: lamb and beef.
- CANADA**  
101.1 kg (223 lb) Favourites: beef, venison, pork (especially preserved forms), chicken, duck, and goose.
- FRANCE**  
99.9 kg (220 lb) Favourites: beef, lamb, pork, chicken, and duck.
- IRELAND**  
99.4 kg (219 lb) Favourites: beef, pork, and lamb.



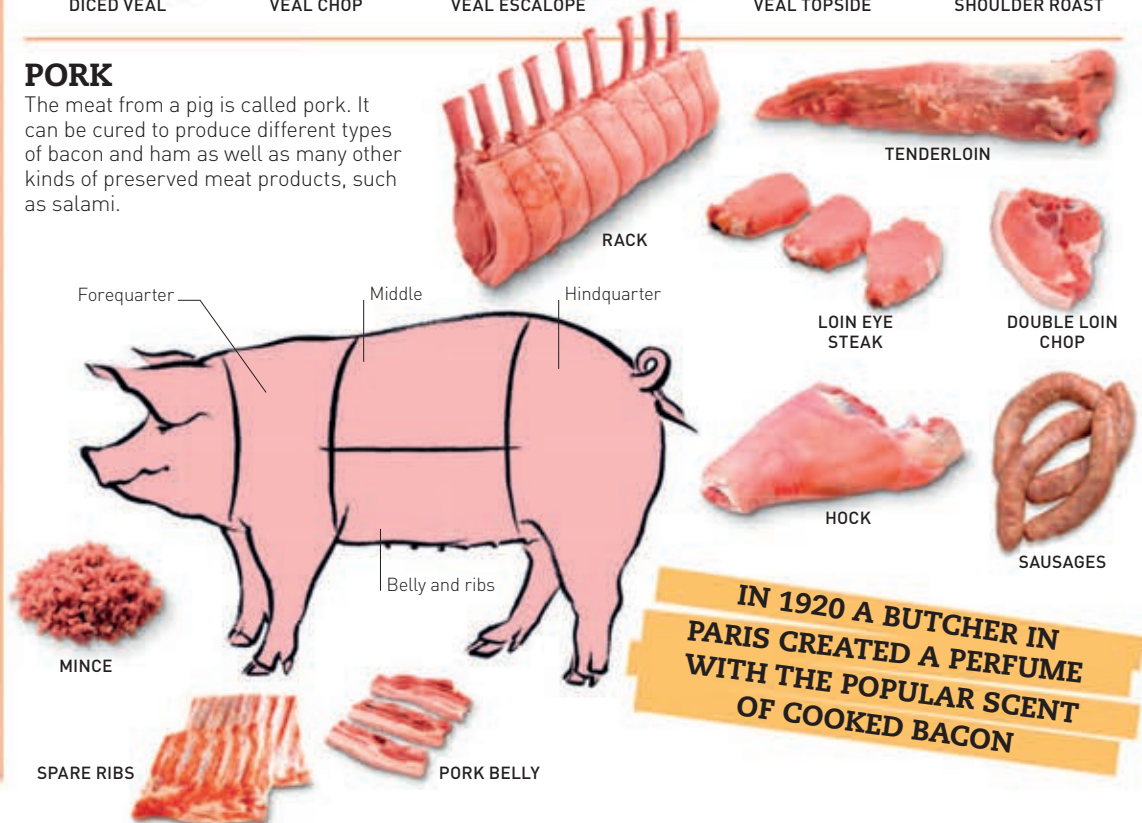
## BEEF

The meat from a cow is called beef. If the meat comes from a young cow under one 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.

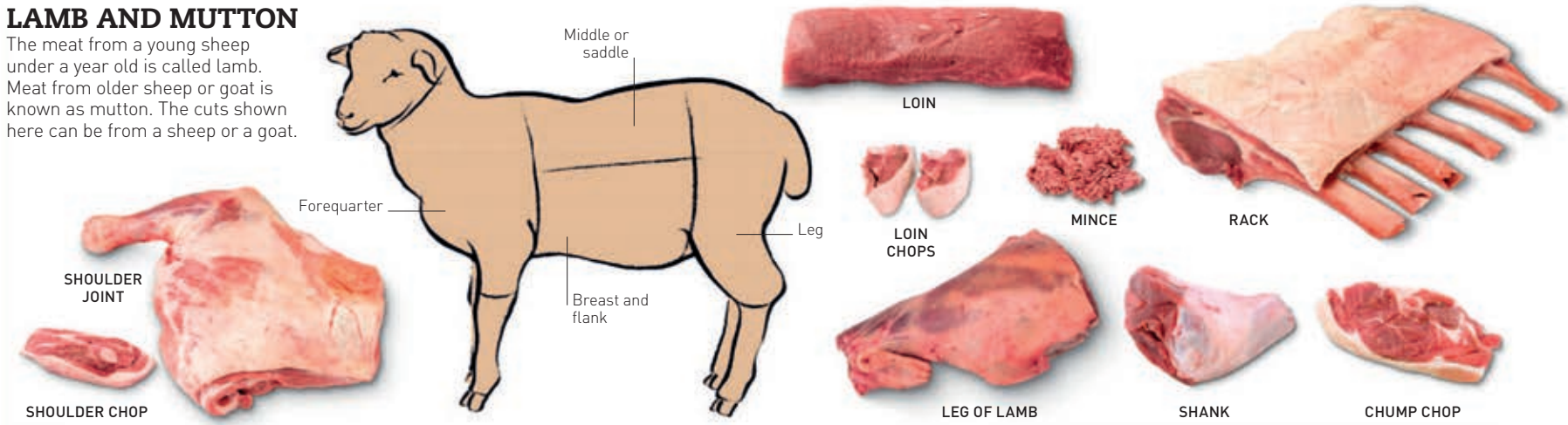


**IN 1920 A BUTCHER IN PARIS CREATED A PERFUME WITH THE POPULAR SCENT OF COOKED BACON**



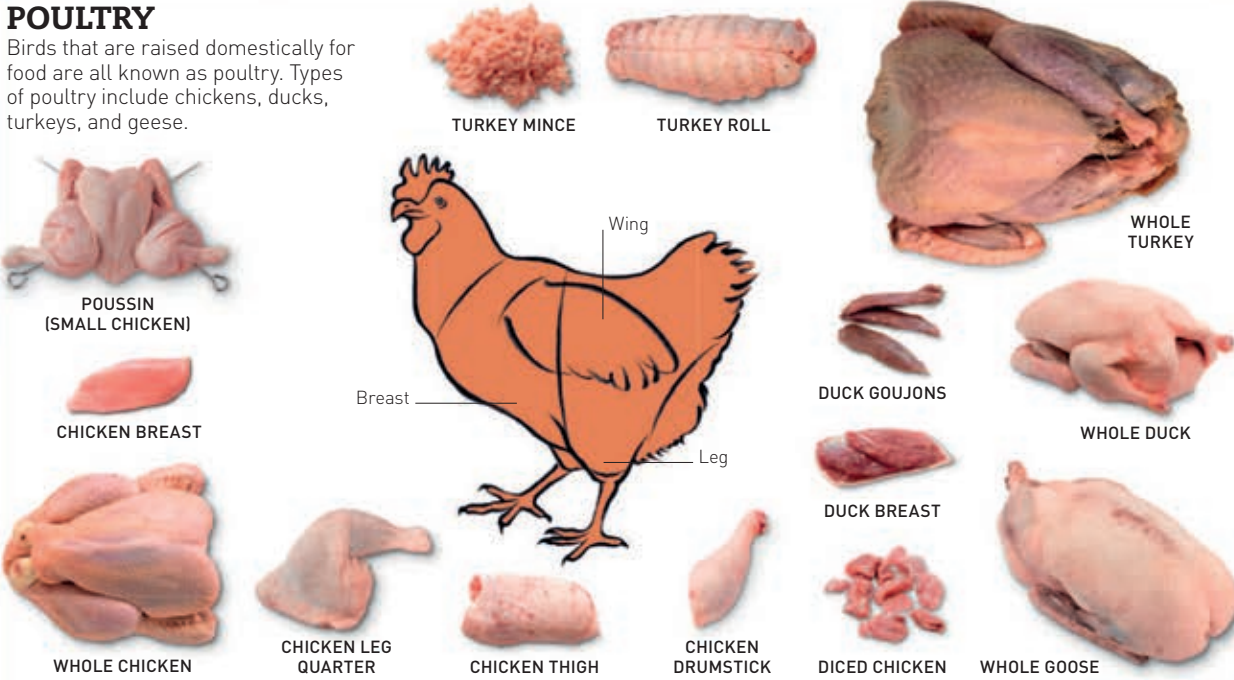
## LAMB AND MUTTON

The meat from a young sheep under a year old is called lamb. Meat from 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 chickens, ducks, turkeys, and geese.



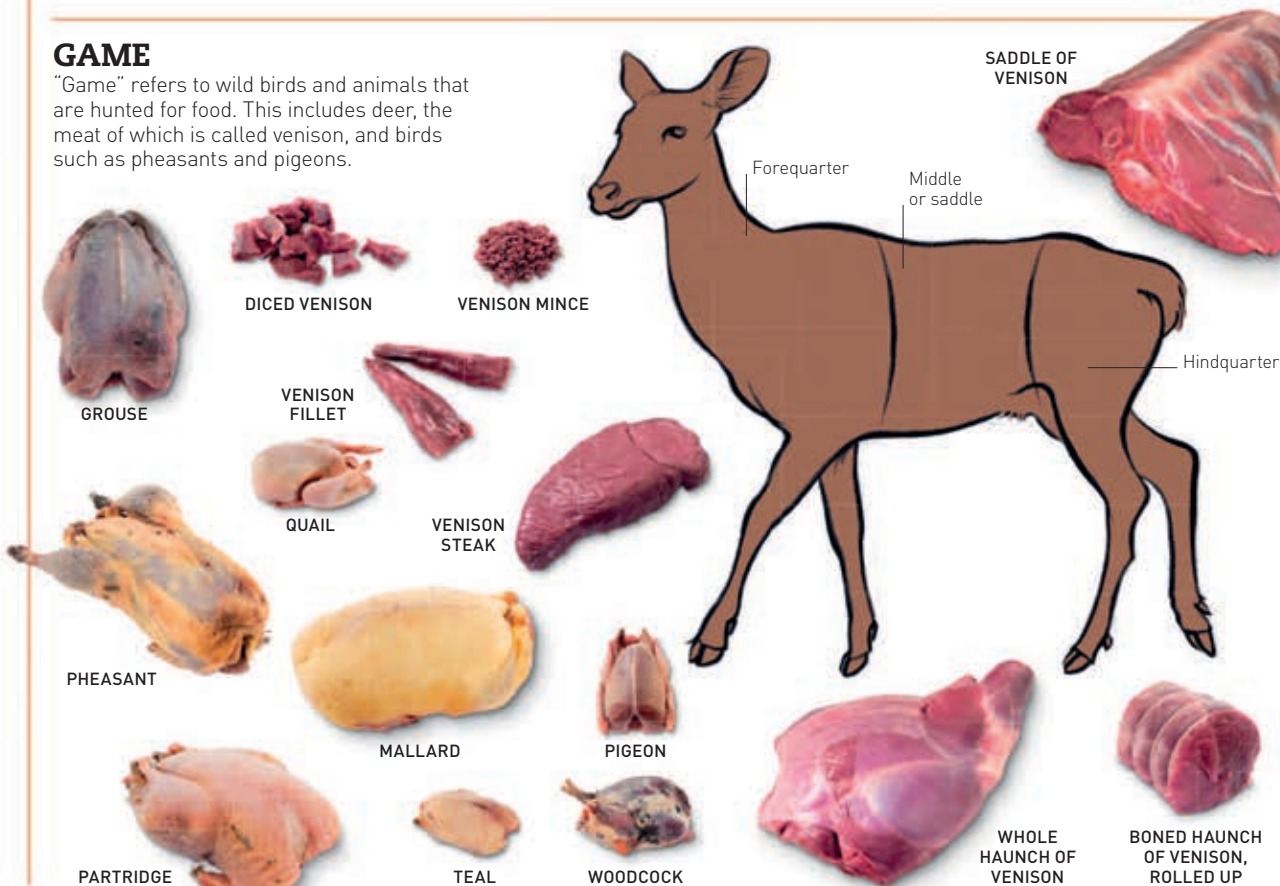
## PRESERVED MEATS

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 – they wore tunics called togas, and sandals.



ROMAN TOGA

BROOCH TO HOLD ROBE IN PLACE



STUDDED SANDALS

## 5TH CENTURY CE

### MEDIEVAL

Rich young men could become knights. They wore metal armour 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 colours, too, such as scarlet-red, as exotic dyes were imported from around the world.

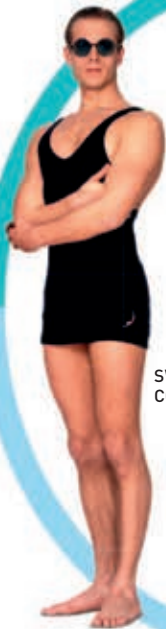


PLUS FOURS AND KNITTED VEST

## 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 sport to get in shape.



SWIMMING COSTUME



FEDORA HAT



PLUS FOURS AND POLO SHIRT



BAGGY SUIT

## 1920s

### THE ROARING TWENTIES

Sport was the new trend, so many men dressed in a more casual style, ready for cycling, golf, tennis, athletics, and dancing. Short trousers called plus fours were a popular new fashion.



KNICKERBOCKERS WITH ARGYLE SOCKS



OPEN SUMMER SHOES



BROGUES



STRIPED ENAMEL CUFFLINKS



STRAW BOATER



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.



CASUAL ATTIRE



BAGGY TROUSER 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 trousers or jeans with tight-fitting shirts or sweaters. Pop music was a big influence on fashion and hairstyles.



LEATHER COAT, SLIM TROUSERS



BEATLES-STYLE SUNGLASSES



POINTED SHOES





FURS WITH FEATHERED HAT

SHORT TUNIC WITH COLOURED STOCKINGS

▶ **LATE 1500s**

**ELIZABETHAN**

Men's clothes became even fancier. Gentleman with money wore fitted velvet jackets with wide, frilly lace collars, and knee-length trousers called breeches with long silk or wool socks.



SUIT WITH RUFF



BREECHES WITH PADDED JACKET

▶ **1700s**

**ROCOGO**

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

◀ **1900-10s**

**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 colours 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 TROUSERS



SWIMMING COSTUME

WAISTCOAT AND POCKET WATCH

◀ **1800s**

**THE DANDY**

Wealthy men of the 19th century wore top hats and curled their hair and moustaches. 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**

**FLARES AND PLATFORMS**

Men experimented with fashion and enjoyed dressing up for fun in colourful patterned clothes. Extra-long flared trousers were worn with high platform shoes, and hairstyles were long and shaggy.



BIG SUNGLASSES



PLATFORM SHOES



FANCY PLATFORMS



CHECKED JACKET AND FLARES

▶ **1980s and 1990s**

**INDIVIDUAL STYLE**

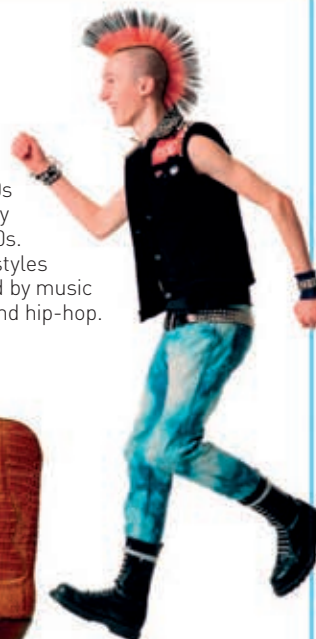
There were many looks to choose from in the 1980s and 90s. Suits had padded shoulders in the 1980s and became very slim in the 1990s. Many clothing styles were influenced by music such as punk and hip-hop.



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 trainers are the most popular look. Other casual styles include chinos or khaki trousers, worn with polo shirts, graphic T-shirts, or sweatshirts.



SUNGLASSES



CLASSIC TRAINERS



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

Women wore the same type of clothing for centuries, 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 colourful accessories to add personality to plain outfits.



WAR ADVERT  
To encourage women to make clothes last longer.



HAIR TIED UP, KNEE-LENGTH DRESS



EMERALD-GREEN HEELS



HAT WITH FLOWERS



LITTLE EVENING HAT



MATCHING HAT, GLOVES, AND SHOES



LONG SUIT DRESS



DAY HANDBAG



PEEP-TOE HEELS

## ◀ 1930s

### GLAMOROUS GOWNS

In this decade, fashion was inspired by Hollywood film stars. Long, slinky 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



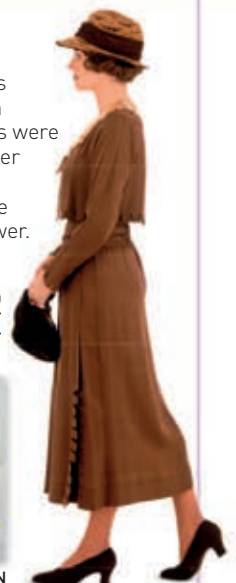
WIDE-BRIMMED STRAW HAT



ELEGANT LEATHER GLOVES



DRESS PATTERN



FITTED JACKET AND SKIRT

## ▶ 1950s

### THE "NEW LOOK"

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

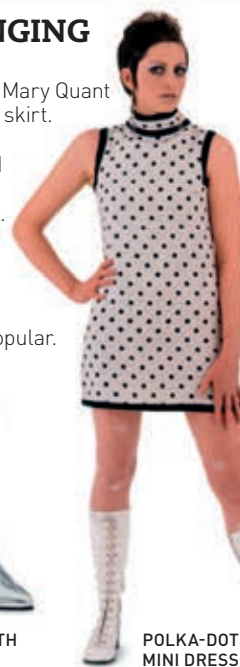
## ▶ 1960s

### 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



▶ 1700s

**THE FLAMBOYANT 1700s**

French Queen Marie Antoinette became one of the first fashion celebrities. She loved clothing and often changed her outfits. Bright colours 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 sport, went to parties, and lived on their own. They wore loose, knee-length dresses, or trousers, 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

◀ 1900–20s

**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

**HIPPY STYLE**

Bright colours, big patterns, big hair, and even bigger shoes were in fashion in the 1970s. Long skirts and dresses and wide flared trousers 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.



PUNK TARTAN MINI AND PINK LEGWARMERS



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 trainers 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 SACHEL



BLUE BOWLING BAG



HIGH-TOP TRAINERS



CHUNKY-HEELED SANDALS



JEANS WITH CASUAL TOPS









# 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 pitch to play on.



**MARBLE**  
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 different surfaces. Players hit a felt-covered bouncy ball to each other across a net using tightly strung graphite or fibreglass rackets.



**BOULES**  
Played outside, two teams throw large, very heavy, metal balls, "boules", towards 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 pitch. 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 between two areas, known as the wickets, while the other team tries to get them "out".



**HOCKEY**  
Played on a large outdoor grass pitch 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 ten 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 team-mate. 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 the 22 balls into the pockets, using wooden cues (sticks).

**POOL**

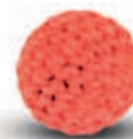
Similar to snooker, but played on a smaller table with only eight balls. Two players use cues to knock the coloured balls into the pockets.

**RACQUETBALL**

A fast game, played on an enclosed indoor 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 11 players. 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 football pitch. 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 of ten players try to shoot a rubber ball into each other's goals using long sticks with nets at the top.

**BASEBALL**

Two teams of nine take turns to bat and field. Batters hit a ball thrown by the "pitcher" and then run 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**

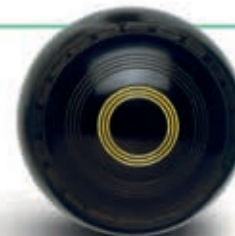
An outdoor game, players use a small mallet to hit balls through metal hoops placed in the ground. Players take turns and must play the hoops in order; the first to finish wins.

**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 furthest wins.

**SOFTBALL**

Softball is a variant of baseball, played using a larger ball on a smaller pitch. It can be played inside or outside by teams of nine or ten. 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 green.

**FOOTBALL**

Two teams of 11 players each try to score goals by kicking a football from one to another and then into netted goals at either end of a large grass pitch. Variants of the game can be played indoors or on the beach.

**GAELIC FOOTBALL**

In Gaelic football, 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 "ten-pin bowling" because players try to knock down ten long, bottle-shaped objects, known as pins. Players score points for the number of pins knocked down in each set, after having two attempts.

**AMERICAN FOOTBALL**

Played by two teams of 11 players on a large pitch, 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 forwards 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 pitch 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 pitch. The aim is to get the ball to the opponent's end of the pitch 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.



# Football

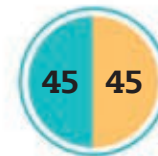
Football is one of the most popular sports in the world. Its appeal is its simplicity: all you need to play is a ball, and then you can play virtually anywhere – on grass, indoors, in the street, or even on the beach.

## THE GAME

During a football 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



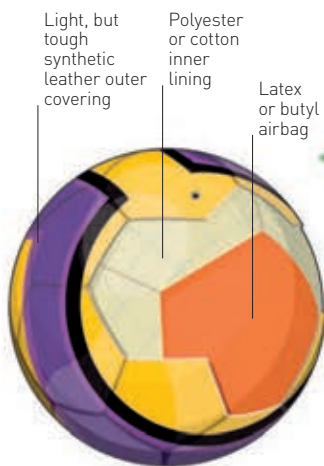
TWO HALVES OF  
45 MINUTES



HAS TWO TEAMS  
OF 11 PLAYERS

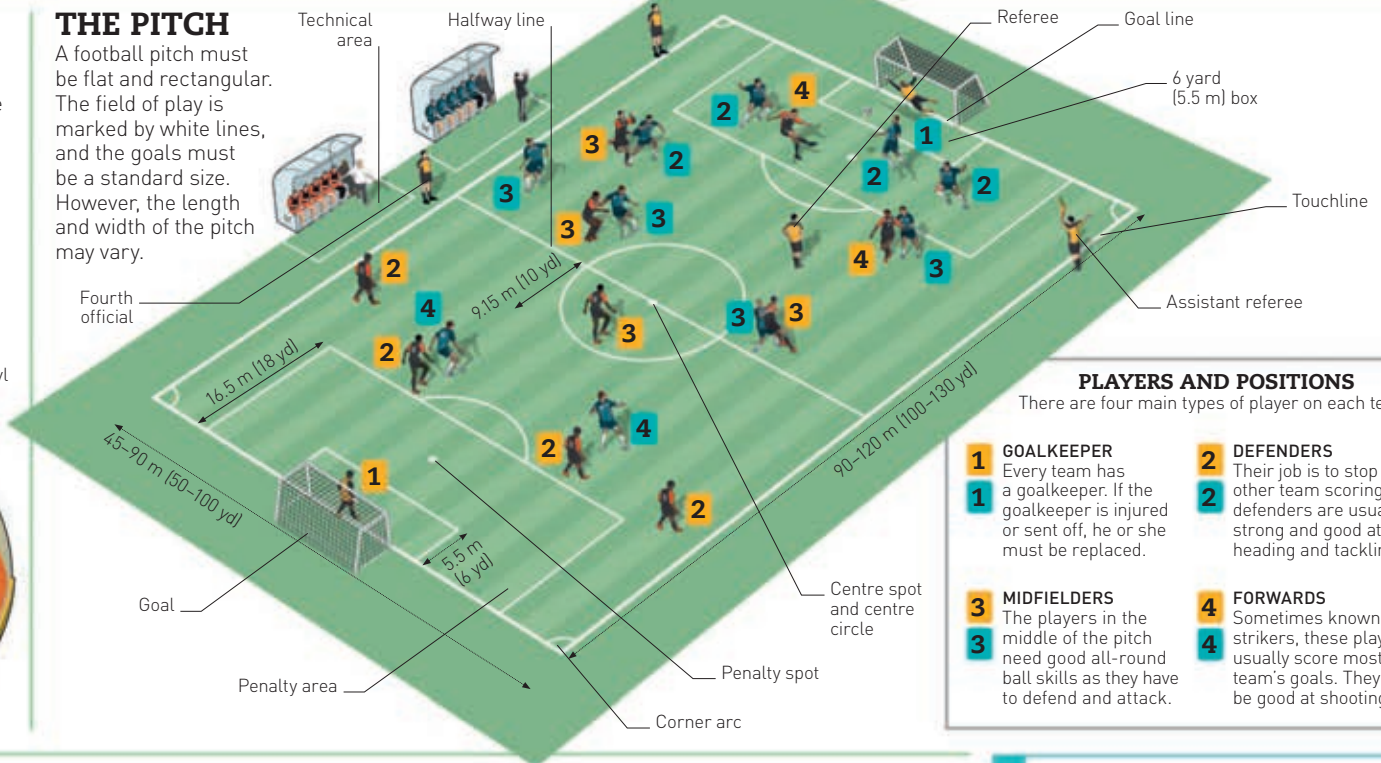
## THE BALL

The first footballs were made of inflated pigs' bladders covered with leather. They were heavy and not very bouncy, especially if they got wet. Modern footballs are made of high-tech materials and are much lighter and bouncier.



## THE PITCH

A football pitch 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 pitch may vary.



## PLAYERS AND POSITIONS

There are four main types of player on each team.

- |  |   |
|--|---|
| <b>1</b> <b>GOALKEEPER</b><br>Every team has a goalkeeper. If the goalkeeper is injured or sent off, he or she must be replaced.         | <b>2</b> <b>DEFENDERS</b><br>Their job is to stop the other team scoring, so defenders are usually strong and good at heading and tackling.   |
| <b>3</b> <b>MIDFIELDERS</b><br>The players in the middle of the pitch need good all-round ball skills as they have to defend and attack. | <b>4</b> <b>FORWARDS</b><br>Sometimes known as strikers, these players usually score most of the team's goals. They must be good at shooting. |

## FORMATIONS

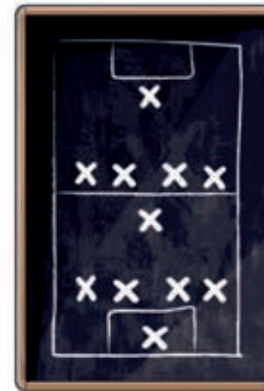
Before a match, the manager organizes the players in a way that he or she thinks will help them to win. This is known as the formation. The formation is usually a set of three or four numbers, which show how many defenders, midfielders, and forwards there are. Often teams will start a match in one formation 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 defence 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 FOOTBALL

During a match, a referee, assisted by officials on each touchline, makes sure the game is played fairly. Football 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 offence, he or she will be shown a red card and "sent off" from the pitch. 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 football around the world. Since 1932 FIFA has organized an international competition to find the best football 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 208 members, but each continent, apart from Antarctica, also has its own football federation. These govern the game in the region and organize international competitions at club and country level.

**UEFA (EUROPE) AND CAF (AFRICA) ARE THE LARGEST FEDERATIONS, EACH WITH 52 MEMBERS**



## ATTACKING SKILLS

The attacking team is the one in possession of the ball and which moves towards 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 pitch to the centre 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 practise this kick on soft ground to prevent injury.



#### 1 LIFT OFF

Raise your non-kicking leg in the air and push off with the other foot.

#### 2 SCISSOR MOTION

As you start to fall backwards, 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 defence. 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

Corners, throw-ins, free kicks, and penalties are all dead-ball situations known as "set-pieces". Teams will spend a lot of time practising 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

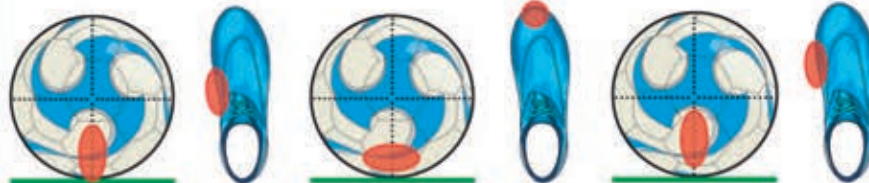
Here are the best places to aim for if you want to score a penalty, and the different ways you could strike the ball. Even if the goalkeeper guesses where you will shoot, he or she is unlikely to be able to save it – unless the shot is weak.

### 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.



# American football

Also known as gridiron in some countries, American 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.

## 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).



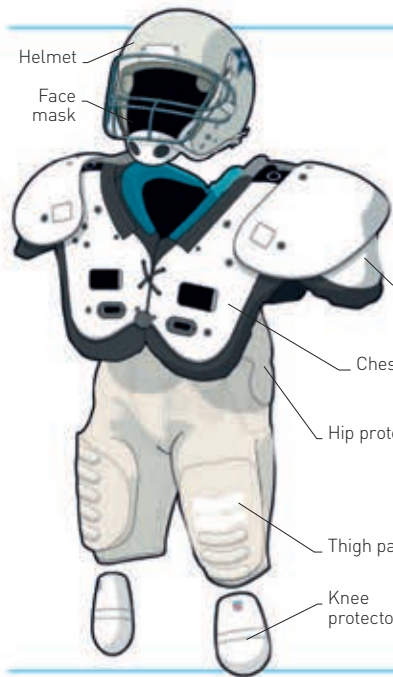
LASTS  
60 MINUTES



4 QUARTERS OF  
15 MINUTES



HAS 2 TEAMS OF  
11 PLAYERS



## EQUIPMENT

American 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 kit, as head clashes in a game are common. Players also wear body armour worn over soft shock-pads, which absorb any hard blows; this gives them a top-heavy appearance.



### 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 28 cm (11 in) long, has a circumference of 71 cm (28 in) at its widest point, and weighs 425 g (15 oz).

## SCORING POINTS

The objective in American 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.

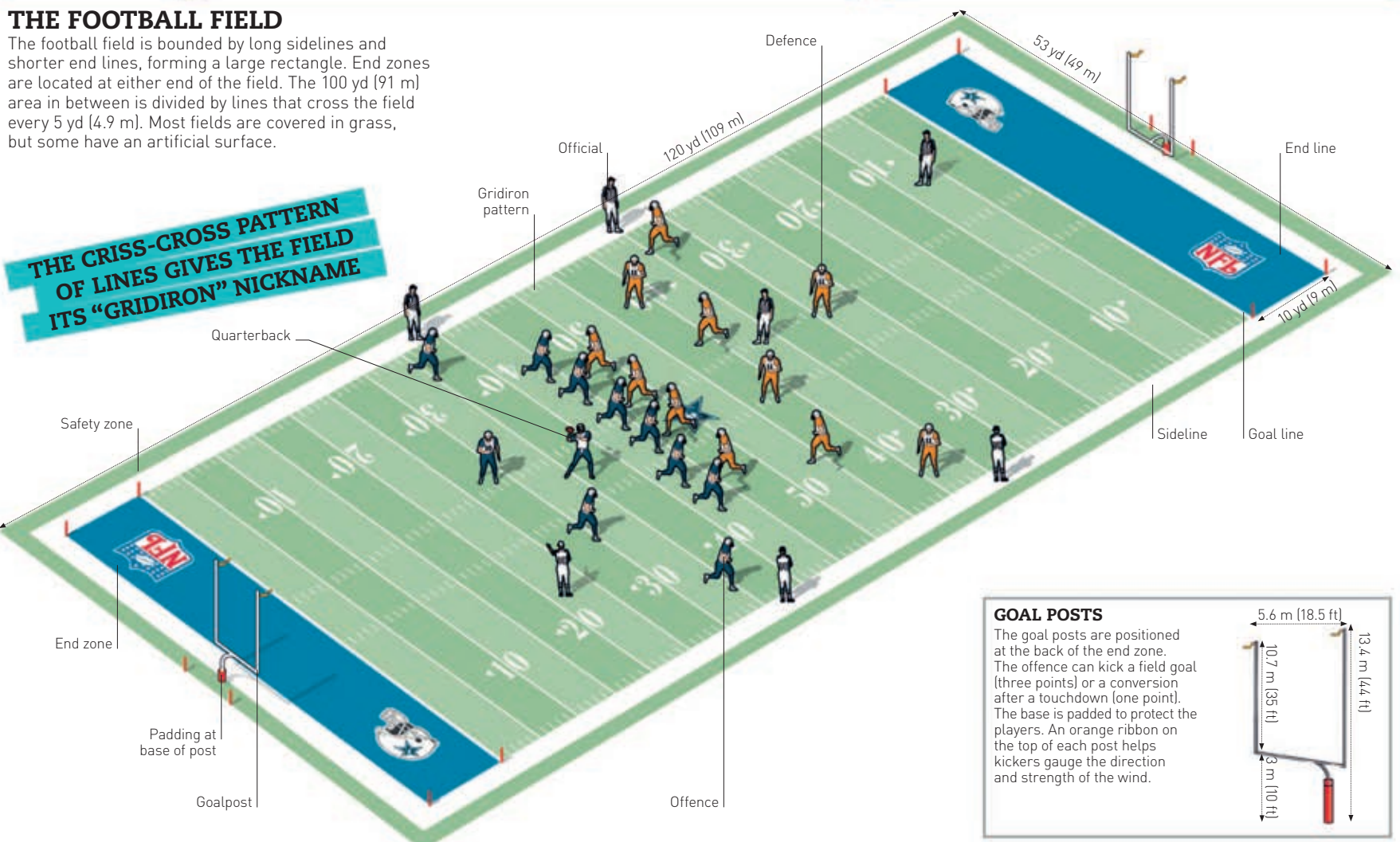
### SAFETY

A safety, worth two points, is awarded if an opponent is tackled or spills the ball in his own end zone and it goes out of play.

## THE FOOTBALL FIELD

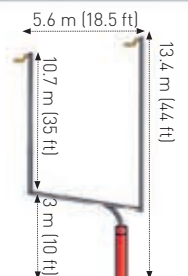
The football field is bounded by long sidelines and shorter end lines, forming a large rectangle. End zones are located at either end of the field. The 100 yd (91 m) area in between is divided by lines that cross the field every 5 yd (4.9 m). Most fields are covered in grass, but some have an artificial 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 offence 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 American football. The team in possession of the ball is called the offence. It has four chances, called "downs", to advance the ball 10 yd (9 m) towards 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 DEFENCE

The aim of the defence is to stop the offence from gaining the 10 yd (9 m) they require to gain four new downs. Many teams use a formation called the 4-3 defence, 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 defence:

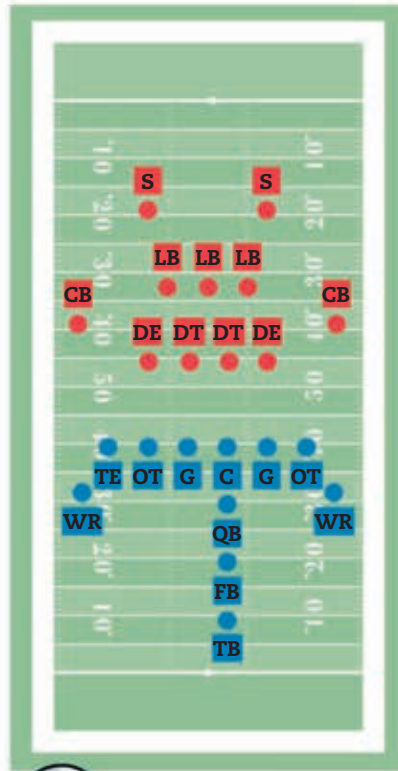
- DE** Defensive end
- DT** Defensive tackle
- LB** Linebacker
- CB** Cornerback
- S** Safety

### BASIC OFFENCE

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 tailback, or running back. A tight end lines up on one side, with a wide receiver at each end.

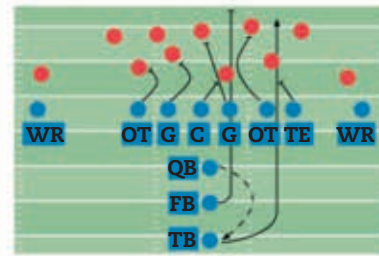
There are eight positions in offence:

- WR** Wide receiver
- TE** Tight end
- OT** Offensive tackle
- G** Guard
- C** Centre
- QB** Quarterback
- FB** Fullback
- TB** Tailback, or running back



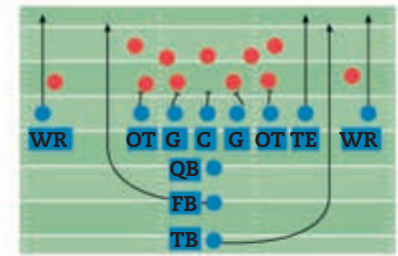
## PLAYS

American football is punctuated by a series of plays, or downs. Offensive plays aim to advance the ball towards the opponents' end zone. Defensive plays aim to stop the offence moving forwards. Some of the most well-known plays are described below.



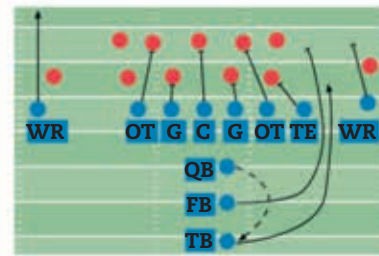
### TAILBACK OFF-TACKLE

The tailback off-tackle is the most common running play in offence. The quarterback hands the ball to the tailback, who runs through a hole created by the offensive tackle and the tight end.



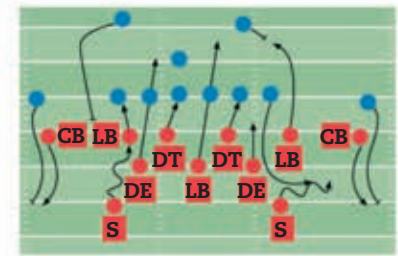
### HAIL MARY

The Hail Mary is a passing play in which the quarterback throws a long ball towards one of a number of receivers. The play is often used as a last resort by a trailing team towards the end of the game.



### SWEEP

The sweep is an organized offensive running play in which a tailback receives the ball from the quarterback and then runs parallel to the line of scrimmage. This gives the fullback and offensive linemen time to create a gap for the tailback.



### THE BLITZ

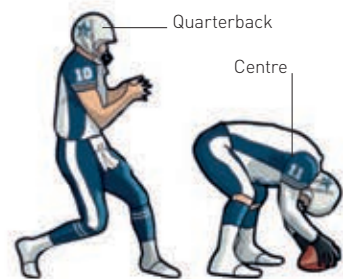
The blitz is a defensive tactic used to combat passing plays. The aim is to put the opposition quarterback under pressure by swamping the offence with defenders.

## 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

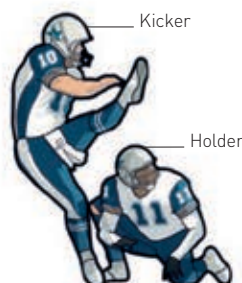
The centre snaps the ball through his legs to the quarterback.

#### 2 THE PASS

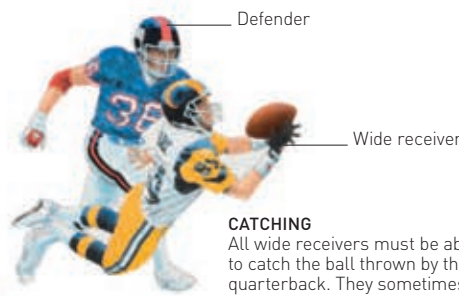
After collecting the ball, the quarterback grips the ball by the laces and passes it point first. The ball is spun as it is thrown, making it fly straight.

### KICKING

All American 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 centre, who snaps the ball to him. The holder catches the ball and sets it up for the kicker. The kicker steps forwards and swings his foot through the ball, aiming to send it between the goal posts.



**ON AVERAGE, THE NFL HAS MORE SPECTATORS PER GAME THAN ANY OTHER SPORTING LEAGUE IN THE WORLD - 68,331 IN 2014**



### CATCHING

All wide receivers must be able to catch the ball thrown by the quarterback. They sometimes do this running at full speed, and often while having to fight off a defender.



### DEFENCE

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 offence 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 offence 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 mostly closely associated with the USA, where it is one of the most popular sports.

## THE GAME

Two teams take it in turns to bat and field. 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 160 km/h (100 mph), 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

7.5 cm (3 in)

### CATCHER'S MASK

Face and head protection is essential for catchers. Batters also wear helmets to protect their heads.

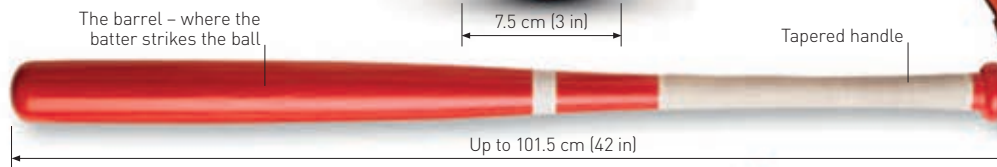


### GLOVES

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 up to 1 kg (2.2 lb).



The barrel – where the batter strikes the ball

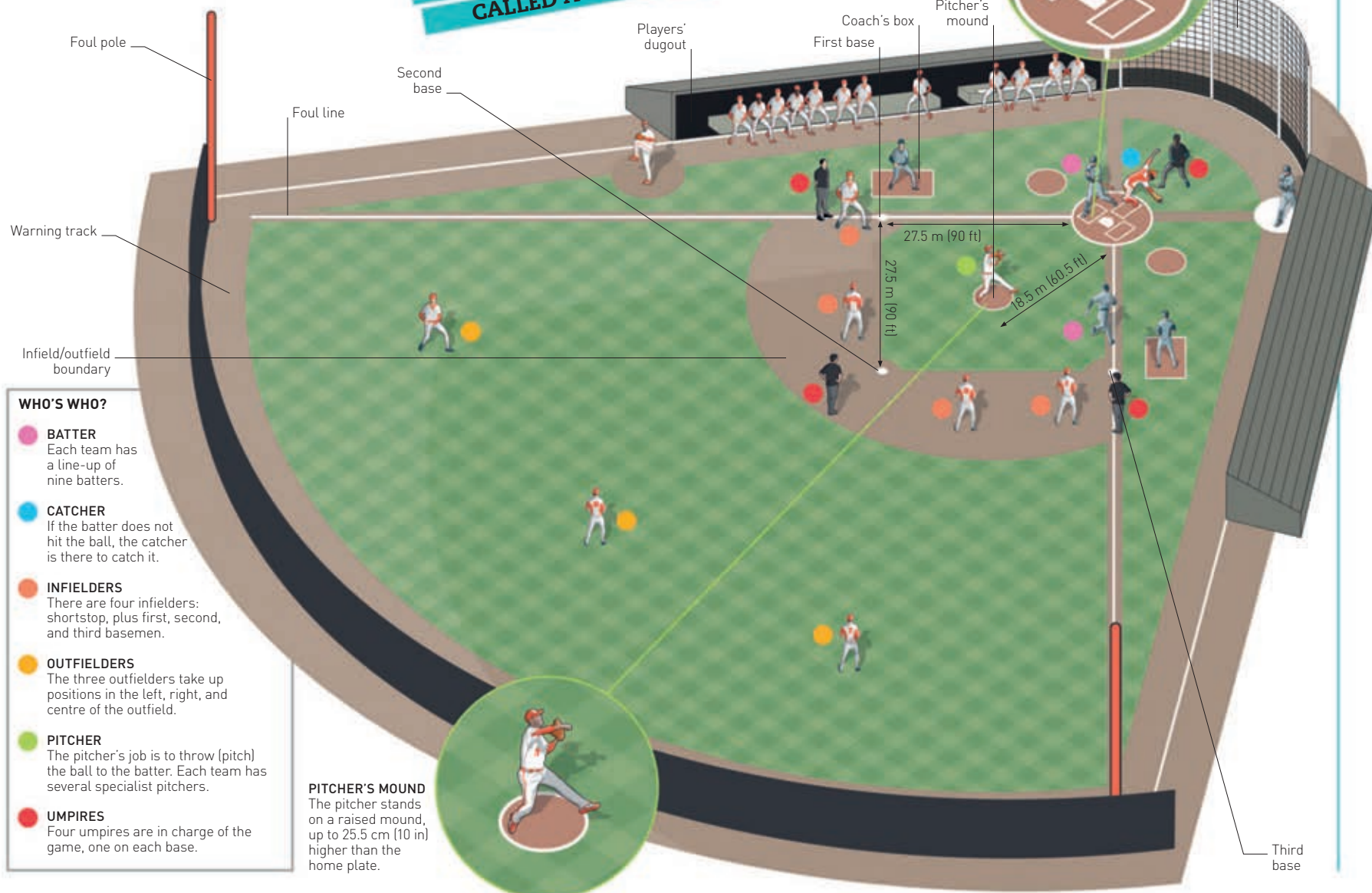
Tapered handle

Up to 101.5 cm (42 in)

## 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.
- INFIELDBERS**  
There are four infielders: shortstop, plus first, second, and third basemen.
- OUTFIELDERS**  
The three outfielders take up positions in the left, right, and centre 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 25.5 cm (10 in) 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 his back foot on the pitching rubber and then raises his front leg to waist height.



### 2 STRIDE

He then plants his front foot firmly on the ground and swings his pitching arm back.



### 3 PITCH

Finally, the pitcher throws his arm forwards, 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 towards the home plate.

### CURVEBALL

A twist of the wrist gives this pitch topspin, which causes it to curve downwards at the last moment.



#### TAKING A TURN

The best curveballs cause the batter to swing at the wrong spot.

### SLIDER

Gripped slightly off-centre, 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!

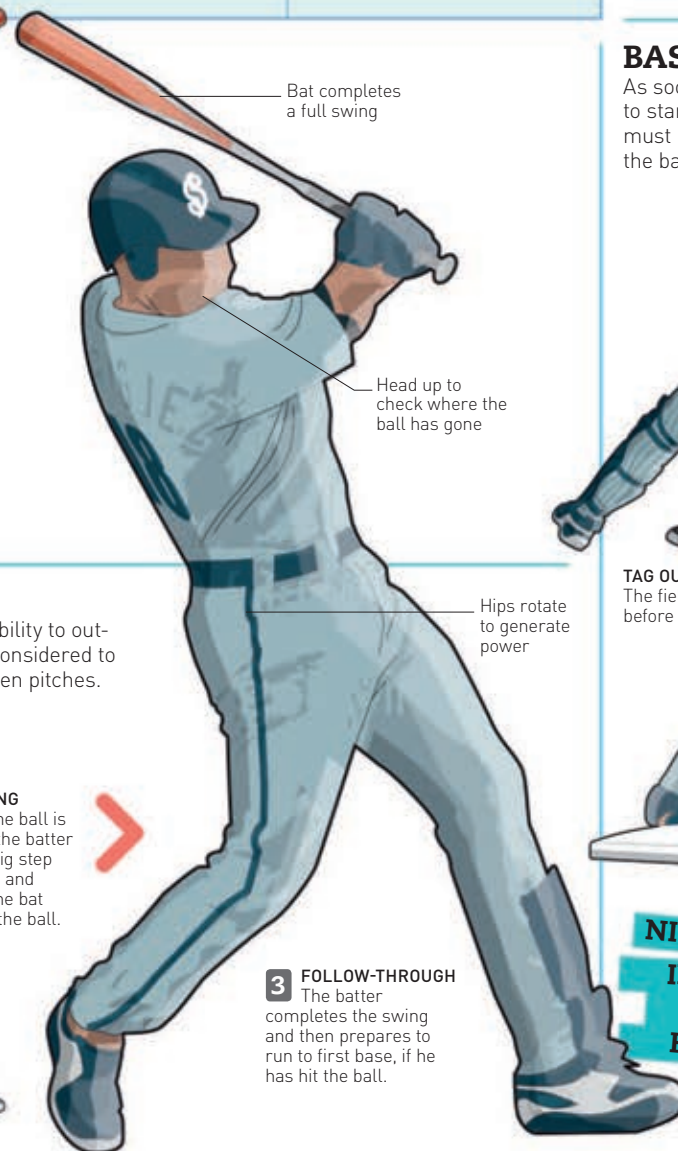
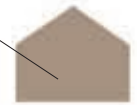
The pitcher must pitch the ball into the area known as the "strike zone". If the batter does not swing at all, misses the ball, or hits it into foul territory, the umpire at the home plate will call "strike". If a batter has three strikes, he or she is out, and it is the next batter's turn.

### STRIKE ZONE

The strike zone is the area above the home plate between the batter's knees and the mid-point of his or her torso.



Home plate

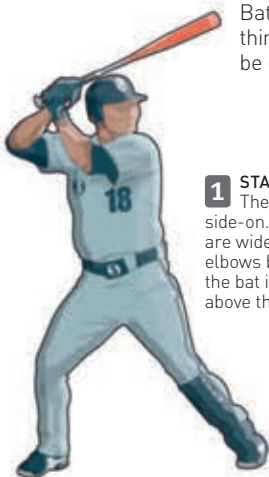


## BATTING

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 ten pitches.

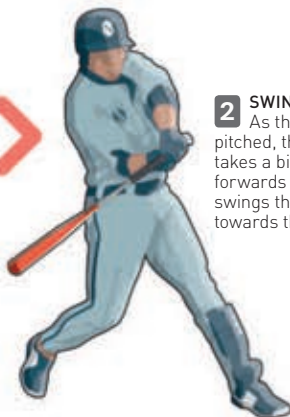
### 1 STANCE

The batter stands side-on. The legs are wide apart, the elbows bent, and the bat is raised above the head.



### 2 SWING

As the ball is pitched, the batter takes a big step forwards and swings the bat towards the ball.



### 3 FOLLOW-THROUGH

The batter completes the swing and then prepares to run to first base, if he has hit the ball.

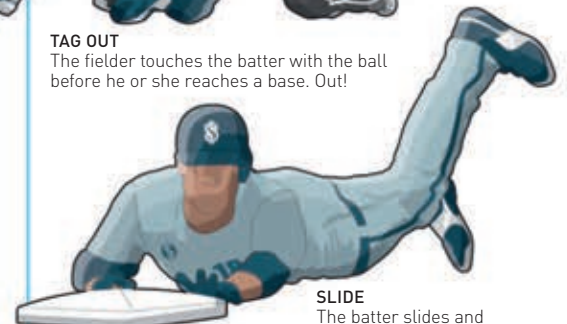
## BASE RUNNING

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 team-mate 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, LONGBALL, MOON SHOT, BOMB, OR GOPHER BALL**



# Basketball

Basketball is a fast-paced ball sport, invented in Massachusetts, USA, in 1891 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.



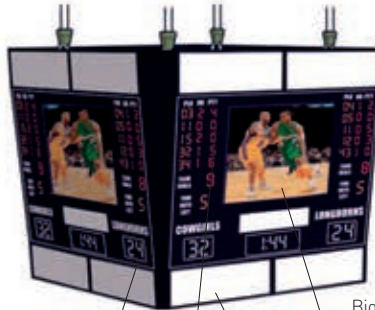
**BALL**  
A modern ball is made of rubber or a synthetic composite covered in leather. It is 75–78 cm (30–32 in) in circumference and weighs 600–650 g (21–23 oz).



**BASKET AND BACKBOARD**  
The basket is a 45 cm (18 in) hoop with netting hanging from it, 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  
Team and player stats  
Big screen  
Space for advertising

## THE GAME

Two teams of five players each try to score points by shooting a ball through a hoop, which is 3.05 m (10 ft) above the ground. The winning team is the one that has scored 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 USA. The NBA sets out only 12 basic 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 offences 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

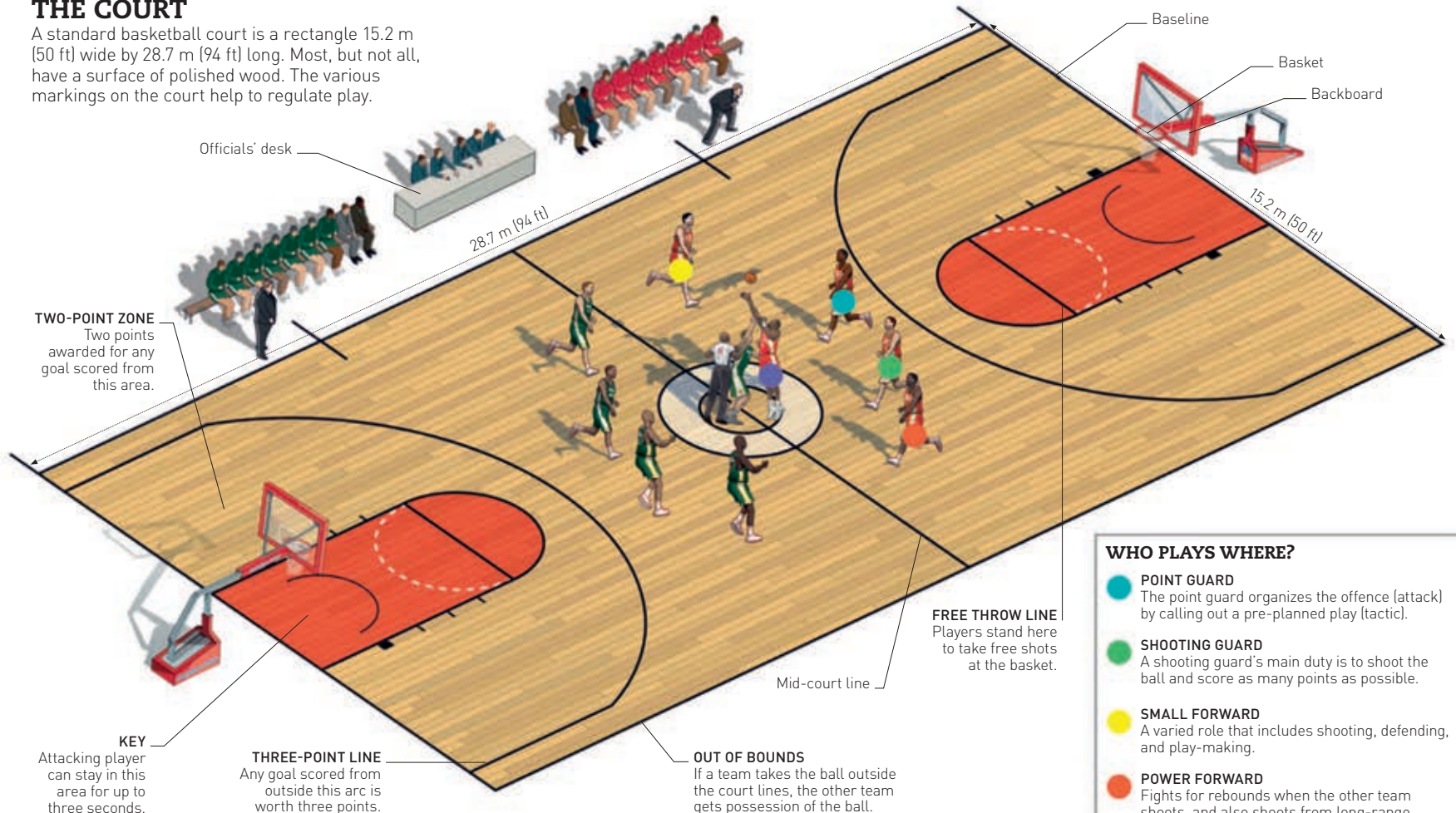
When a player breaks the rules, they commit a foul. For instance, players must dribble (bounce the ball in front of them) as they run. If they do not, they commit a foul known as "travelling".

### 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 15.2 m (50 ft) wide by 28.7 m (94 ft) long. Most, but not all, have a surface of polished wood. The various markings on the court help to regulate play.



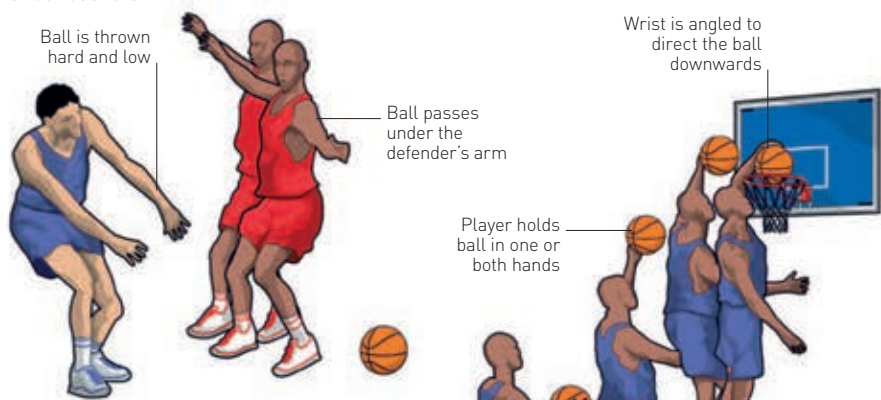
### WHO PLAYS WHERE?

- **POINT GUARD**  
The point guard organizes the offence (attack) by calling out a pre-planned 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 when the other team shoots, and also shoots from long-range.
- **CENTRE**  
The centre is usually the tallest player and is the team's main shot-blocker.

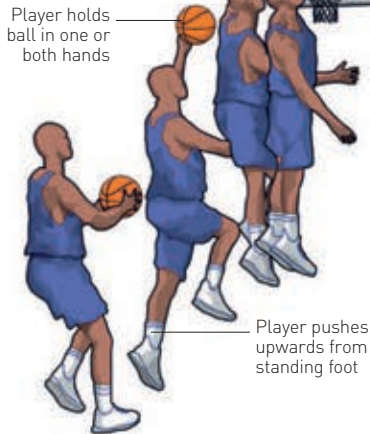


## SKILLS AND TECHNIQUES

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 his chest, a player can bounce the ball to a team-mate. 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 downwards 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.

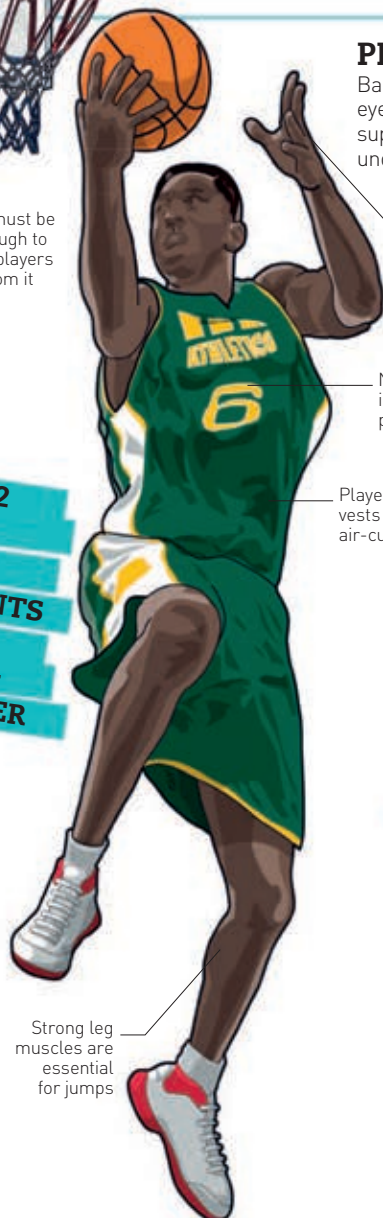


The backboard is made of a shatterproof material called Plexiglas

The hoop must be strong enough to withstand players hanging from it

## 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 1.8 m (6 ft) and are often as tall as 2.1 m (7 ft).



Large hands enable a player to grip the ball one-handed

Number identifies player

Players wear loose vests and shorts, and air-cushioned trainers

Strong leg muscles are essential for jumps

**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 team-mate.



## 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 travelling.



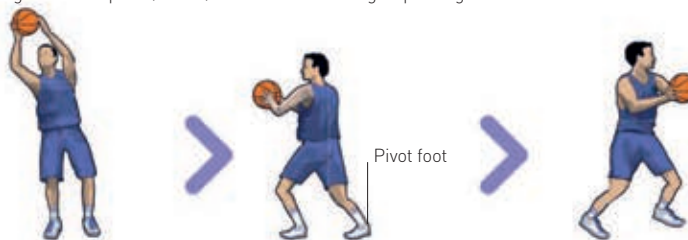
**1** Using the hand furthest from your opponent, bounce the ball hard towards the ground.

**2** Running forwards, control the ball with the fingertips as it rises back up towards you.

**3** Keep your hand directly over the ball – if you touch the underside of the ball, you will be penalized.

## 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.



**1** The player stops dribbling or catches the ball. One of his feet must become the pivot foot.

**2** The player swivels round on his pivot foot, looking for opportunities to shoot or pass the ball.

**3** If a player drags his pivot foot or lifts it off the ground, he will be penalized for travelling.

## 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.



**CHARGING**  
One arm out to the side indicates that an attacking player has run into a defender.



**JUMP BALL**  
Both arms up mean that two players have a grip of the ball, so the referee is calling a jump ball.



**TRAVELLING**  
Arms rotating indicate that a player has moved with the ball without dribbling it.



**BLOCKING**  
Clenched fists against the waist signal that one player has blocked the way of another.



**TWO-POINT SCORE**  
Left arm raised with two fingers showing indicates a two-point basket to the scorekeeper.



**THREE-POINT SCORE**  
Both arms up, with three fingers up on each hand, signals a basket worth three points.

**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 1961-62 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

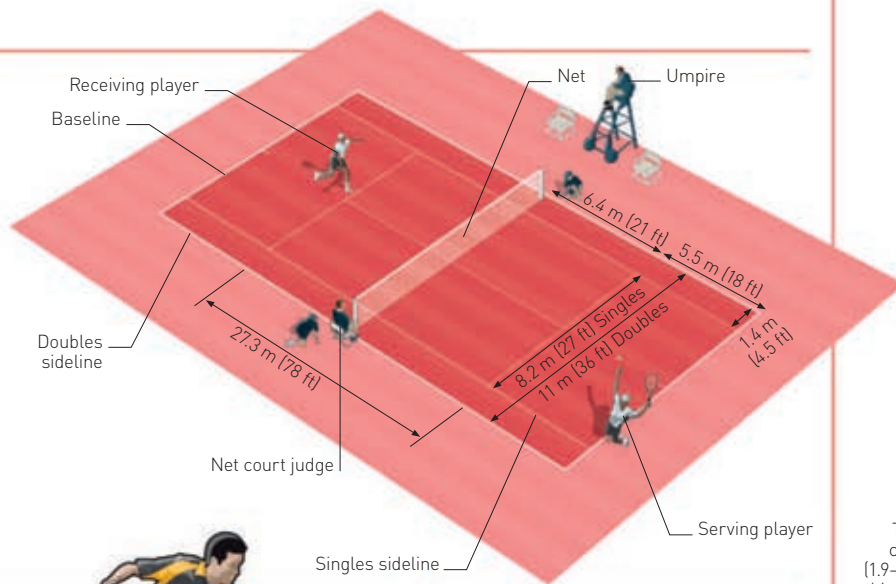
Players take it in turns to serve and can score points whenever their opponent fails to return a ball over the net or hits the ball out of play. Tennis (also known as lawn tennis) matches are made up of games and sets, with players needing to win six games to win a set. Matches can last for hours as a player must always win the final set by two games.



BEST OF THREE OR FIVE SETS



SINGLES OR DOUBLES



## TABLE TENNIS

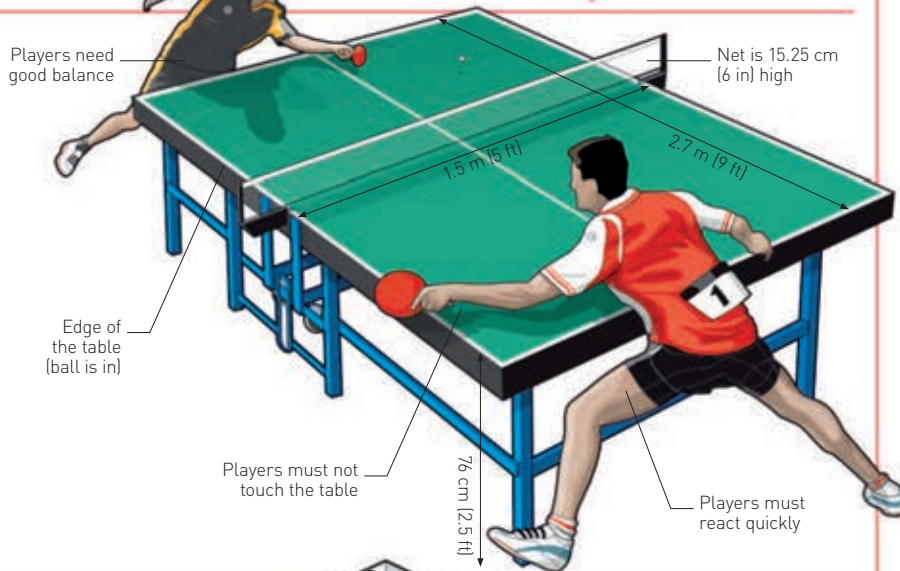
A player wins a point if his or her opponent cannot return the ball or if the return does not land on the table. The first player to score 11 points wins the game. However, if both players score 10 points, the first player to gain a two-point advantage wins the game. Table tennis is also known as ping pong.



BEST OF FIVE OR SEVEN GAMES



SINGLES OR DOUBLES



## SQUASH

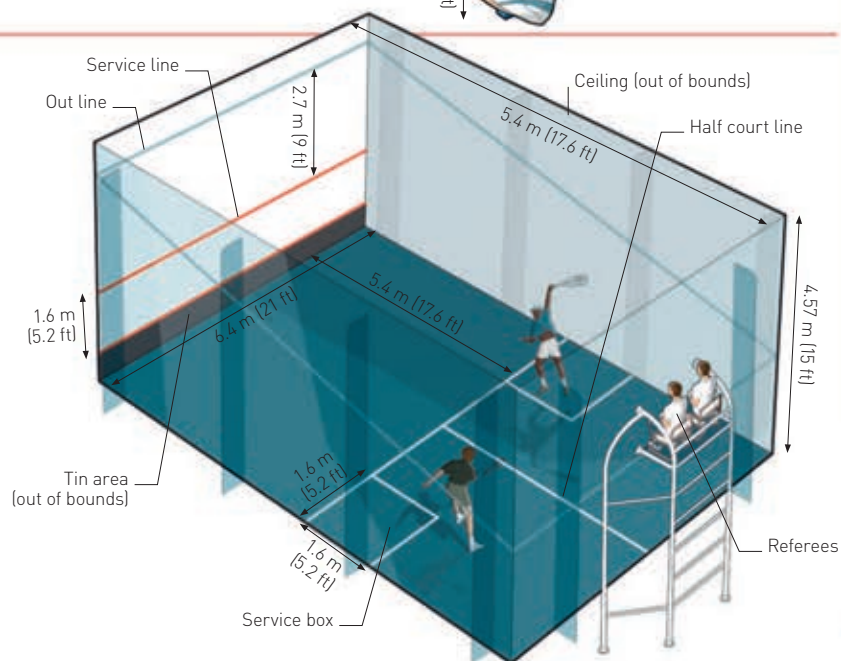
Squash is played on a four-walled court and players take it in turns to serve. They can win points if their opponent fails to hit the ball after it has bounced once, or if they hit the ball out of bounds. A player needs 11 points to win the game, but if the score is tied at 10-10, a player needs to win by two points.



THE BEST OF 3 OR 5 GAMES



SINGLES (DOUBLES CAN BE PLAYED ON A BIGGER COURT)



## EQUIPMENT

Most rackets have a metal or wooden frame containing a network of strings. The tightness and density of the strings affects the way in which the racket controls the ball. What a ball is made of, its size, and weight can also affect the speed and style of the game.



TENNIS RACKET

TENNIS BALL

Tennis balls are made of rubber, covered in felt and weigh 56–59 g (1.9–2 oz). During a match, balls may be hit so hard that they lose their bounce and need to be replaced.

TABLE TENNIS BAT



TABLE TENNIS BALL

Made of celluloid and filled with gas, a table tennis ball weighs a mere 2.7 g (0.1 oz).



SQUASH RACKET

SQUASH BALL

Squash balls are made of hollow rubber. A coloured dot shows how fast or bouncy the ball is – orange is the slowest and blue the fastest.



## 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

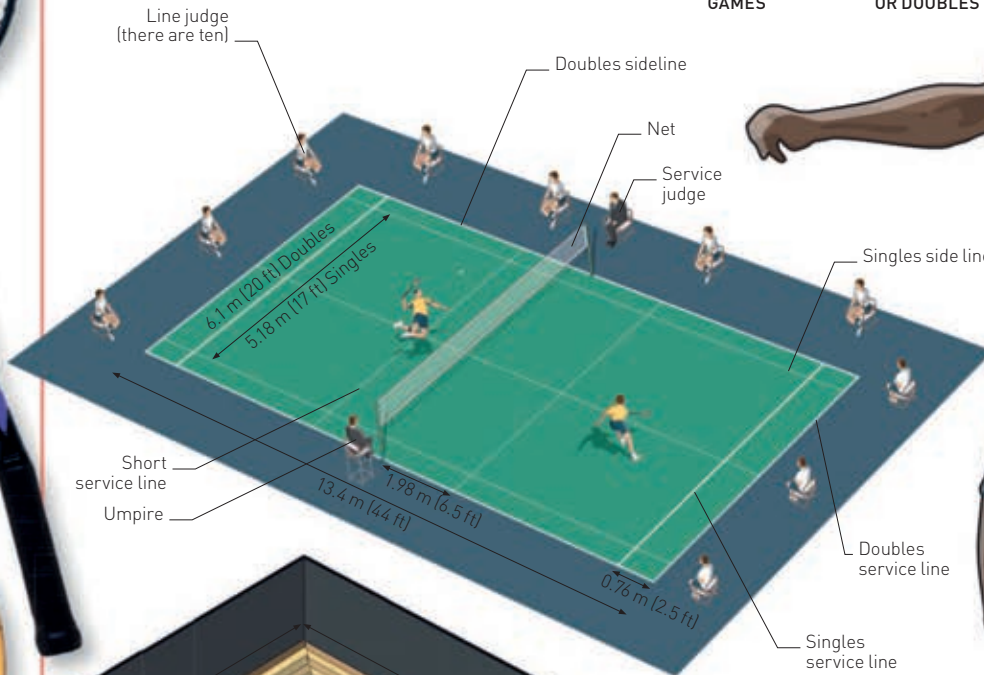


SINGLES OR DOUBLES



BADMINTON RACKET

**SHUTTLECOCK**  
The rounded base is made of cork covered in leather. The top has 16 feathers, which are often plastic.

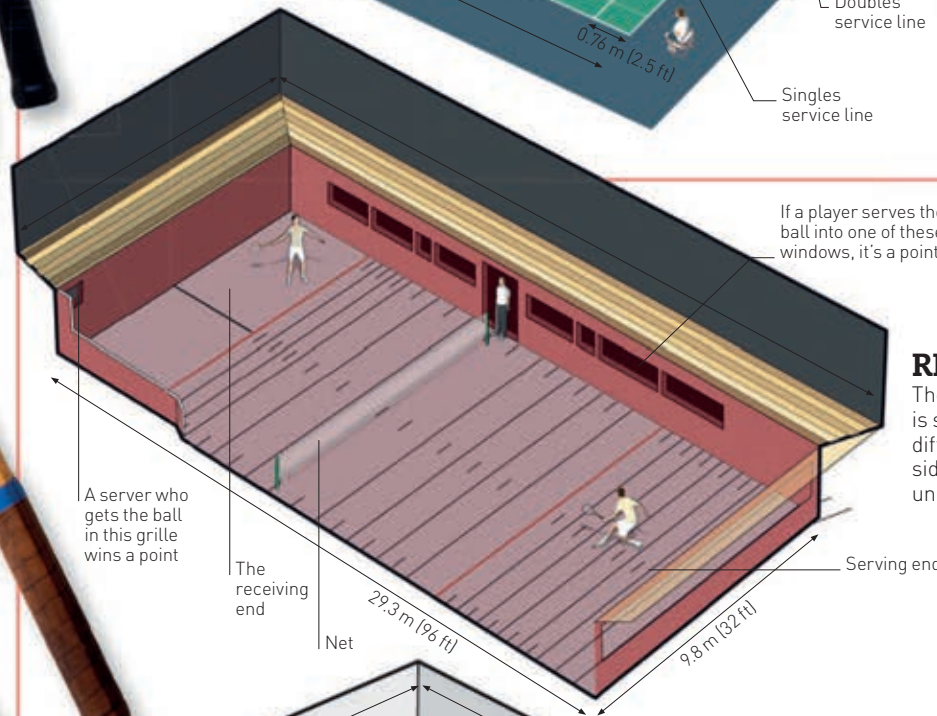


**PRECISION AND POWER**  
Badminton shots can be softer than other racket sports due to the shape and weight of the shuttle. However, powerful smash shots are also effective.



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. They are usually handmade.



**THERE ARE ONLY 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

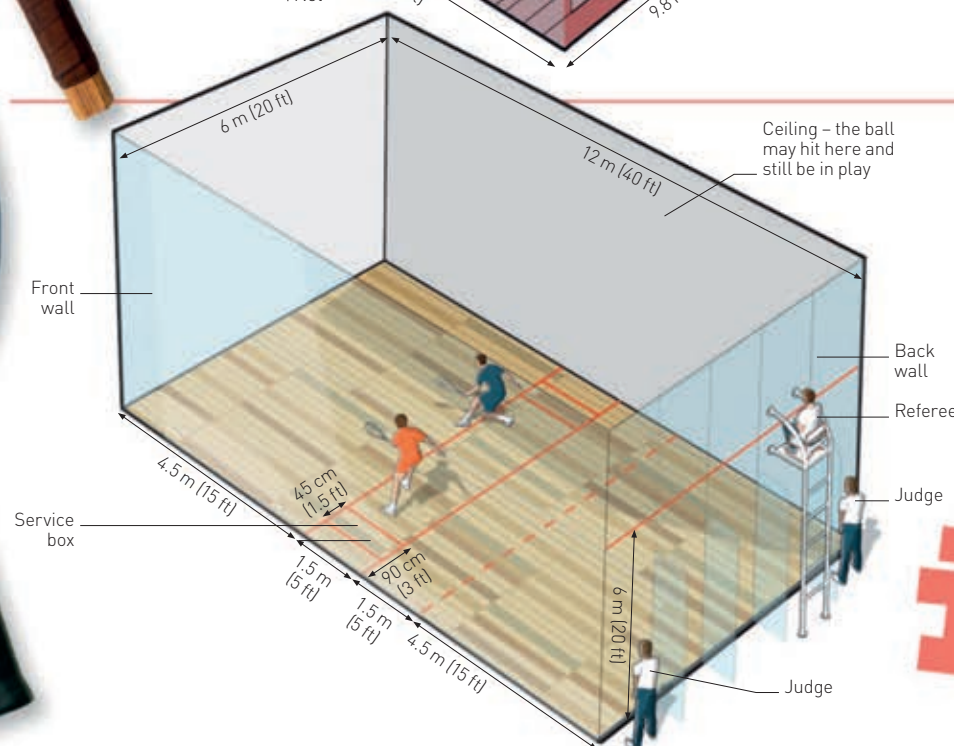


SINGLES OR DOUBLES



RACQUETBALL RACKET

**RACQUETBALL**  
Balls are made of rubber to make them bounce. They weigh about 40 g (1½ oz).



## RACQUETBALL

Played on a similar court to squash, the objective of racquetball is to hit the ball so 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 to gain some sporting 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



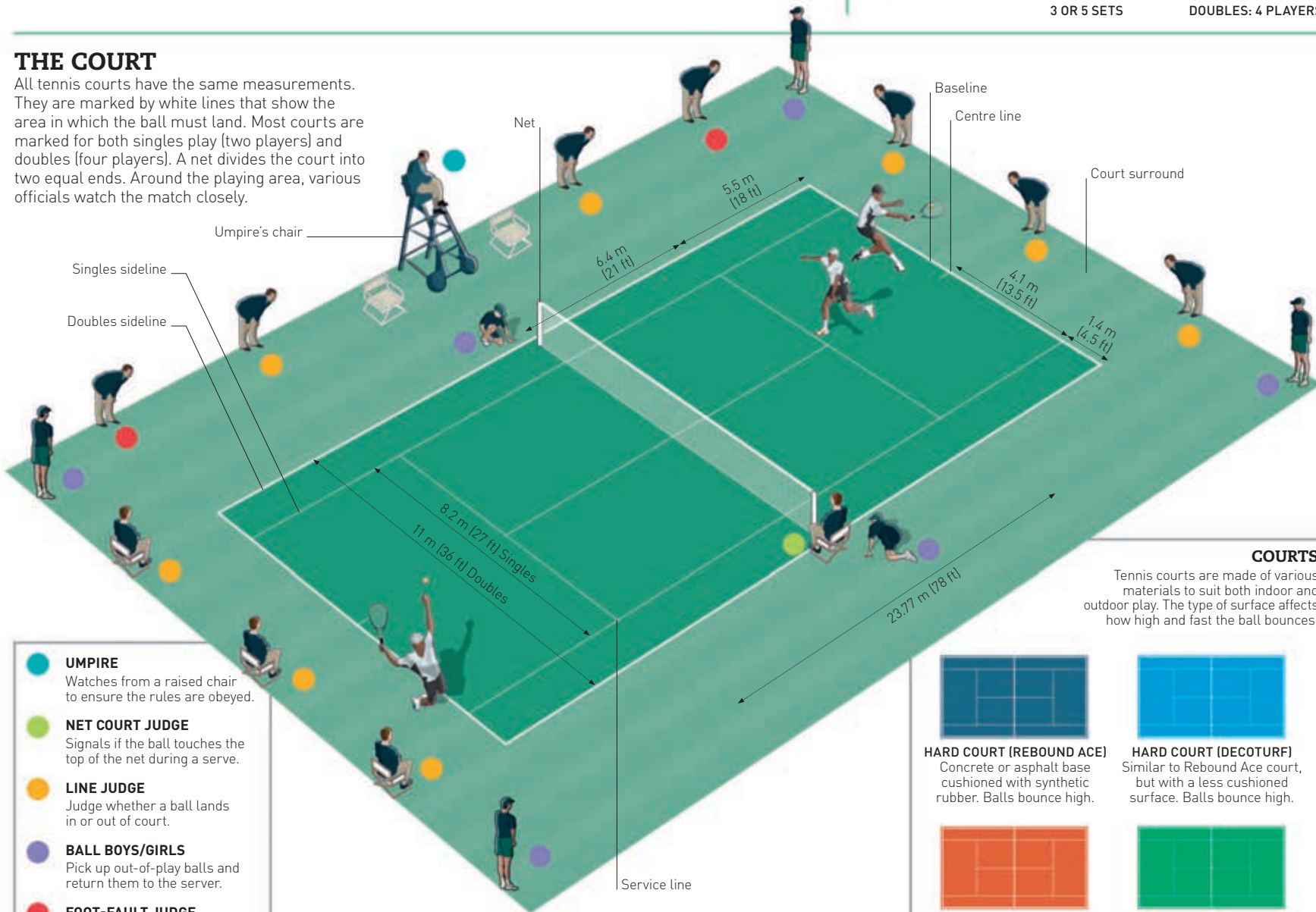
A MATCH CAN BE 3 OR 5 SETS



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.



## 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.

- 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 JUDGE**  
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 JUDGE**  
Checks that a server does not step across the baseline before hitting the ball.

## 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 you are already two points ahead of your opponent.

Set markers	Sets won	Score for game in progress
1 2 3 4		
6 7 8	R. FEDERER (1)	2 5 30
0 6 7	VS.	
	R. NADAL (2)	1 5 40

Completed sets | Two sets were decided by tie-breaks | Players' names | Score for set in progress

**THE "LOVE" SCORE IN TENNIS MAY COME FROM "L'OEUF", FRENCH FOR "EGG" - WHICH IS ZERO-SHAPED**

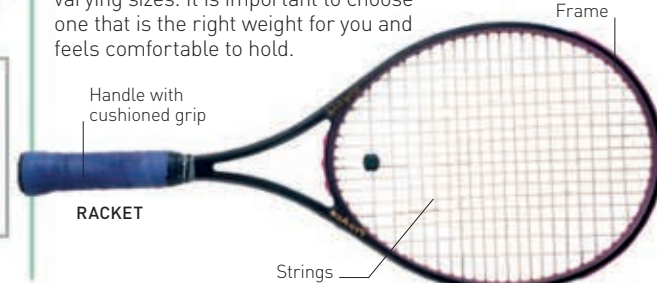
**TIE-BREAK**  
If the score is six games all, a tie-break is played. This game has special rules. A tie-break, and the set, is won when a player wins seven points and is at least two points ahead. There is no tie-break in the final set.

## 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 for you and feels comfortable to hold.



BALLS



RACKET

Strings



## 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**  
Stand behind the baseline, just to the right of centre.



**2 PREPARE**  
Turning sideways, hold the racket and ball in front of you.



**3 TOSS**  
Toss the ball up and bend your racket arm back, ready to hit.



**4 THROW**  
Throw the racket over your head and hit the ball. Follow through the stroke.

## 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.

- 1 STEFFI GRAF** Germany – 22 wins
- 2 SERENA WILLIAMS** USA – 21 wins
- 3 CHRIS EVERT** USA – 18 wins
- 3 MARTINA NAVRATILOVA** Czechoslovakia/USA – 18 wins
- 4 ROGER FEDERER** Switzerland – 17 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 you hit it.



**1 RACKET BACK**  
Take the racket back and up, turn your shoulders to the side, and step forwards.



**2 MEET THE BALL**  
Swing the racket forwards to meet the ball in front of your body. Hit the ball and follow through the stroke with the racket.

## 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**  
Stretch out your racket arm and step forwards. Watch the ball all the time.



**2 SHORT FOLLOW-THROUGH**  
After making contact with the ball, finish 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. You may have to spring up to reach the ball. Fully stretch your racket arm and reach up with the other arm. Drop the racket head behind your back and then accelerate it forwards to hit the ball.



Reach up with your opposite arm

Turn your body sideways and position yourself under the ball

## BACKHAND DRIVE

You play this stroke when your opponent hits the ball towards the side opposite your racket arm.

**1 SWING BACK**  
As the ball comes, turn your shoulders to the side and swing your racket back.



**2 STEP**  
With a firm grip on the racket, step forwards to meet the ball. Stretch out your racket arm to hit the ball in front of your body.



**3 FOLLOW THROUGH**  
Keeping the swing going, follow through the shot with your racket. Do not take your eyes off the ball until it is safely over the net.

Turn your shoulders to the side as you take the racket back

**DOUBLE-HANDED BACKHAND**  
Two hands can give extra strength and power a backhand drive.

## BACKHAND SLICE

Once you have mastered the basic backhand, you can try the more challenging backhand slice. A ball hit with this stroke spins and lands low, so it can take your opponent by surprise.



**1 BACK**  
Take the racket back as you would for the backhand drive, with the head angled slightly up.



**2 SLICE**  
Step into the shot and slip the head of the racket under the ball. Hit the ball when it is just in front of your body.



**3 FOLLOW-THROUGH**  
Keep your arm straight and follow through with a short chopping movement. This part of the stroke is important, as it drives the ball forwards.



# 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-round 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



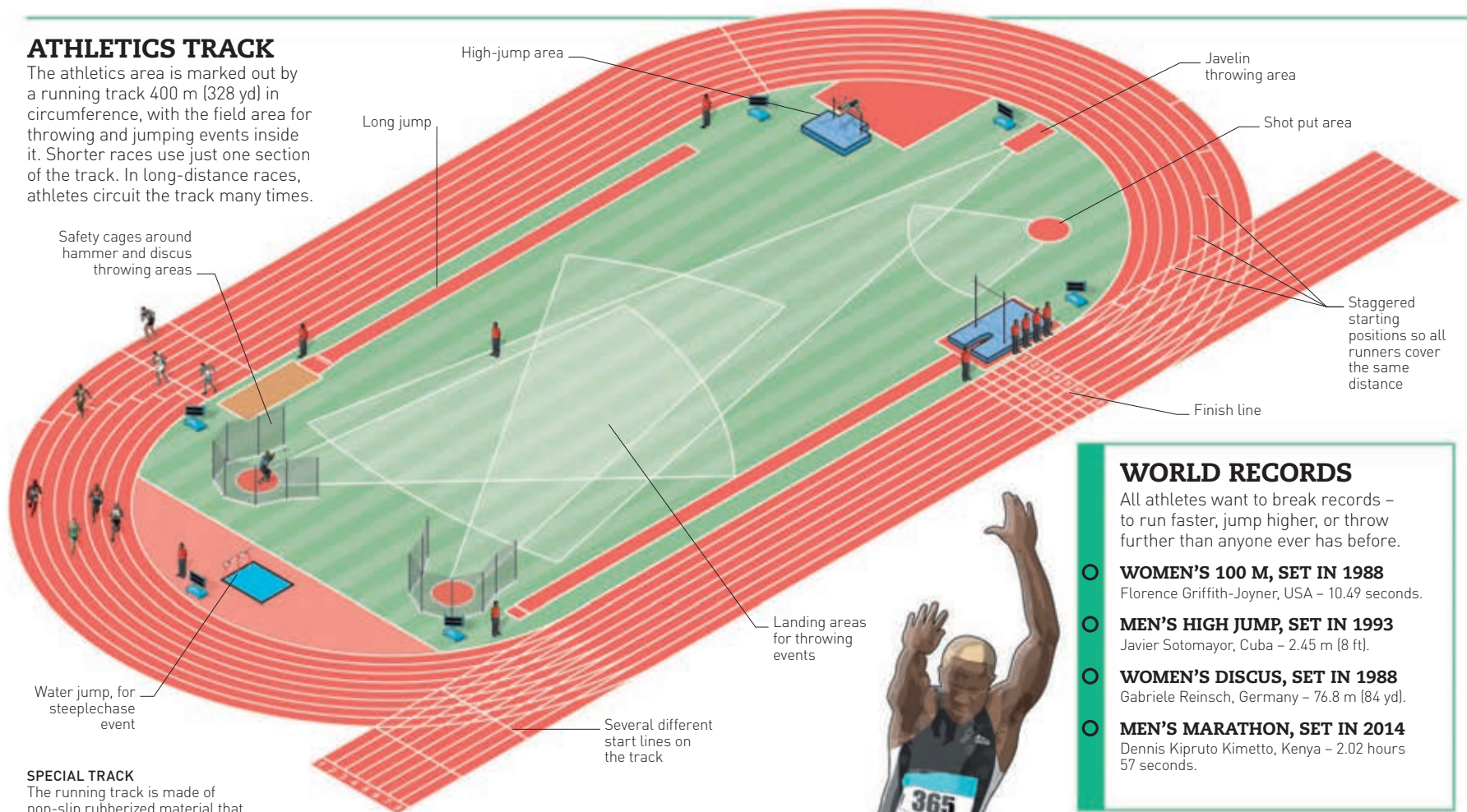
THROWING



JUMPING

## ATHLETICS TRACK

The athletics area is marked out by a running track 400 m (328 yd) 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

All athletes want to break records – to run faster, jump higher, or throw further than anyone ever has before.

- **WOMEN'S 100 M, SET IN 1988**  
Florence Griffith-Joyner, USA – 10.49 seconds.
- **MEN'S HIGH JUMP, SET IN 1993**  
Javier Sotomayor, Cuba – 2.45 m (8 ft).
- **WOMEN'S DISCUS, SET IN 1988**  
Gabriele Reinsch, Germany – 76.8 m (84 yd).
- **MEN'S MARATHON, SET IN 2014**  
Dennis Kipruto Kimetto, Kenya – 2:02 hours 57 seconds.

## SPECIAL TRACK

The running track is made of non-slip 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 forwards, 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

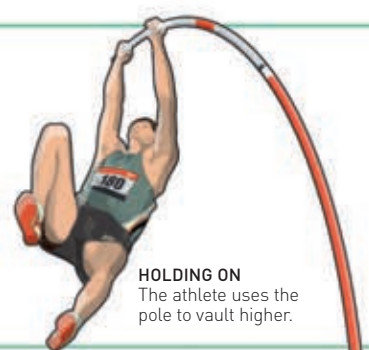
Athletes competing in this event try to leap the furthest through the air from a running jump. They concentrate on five stages: their run-up, last two steps, takeoff, travel through the air, and their landing.



**CAREFUL JUMP**  
Athletes must take off before the line.

## POLE VAULT

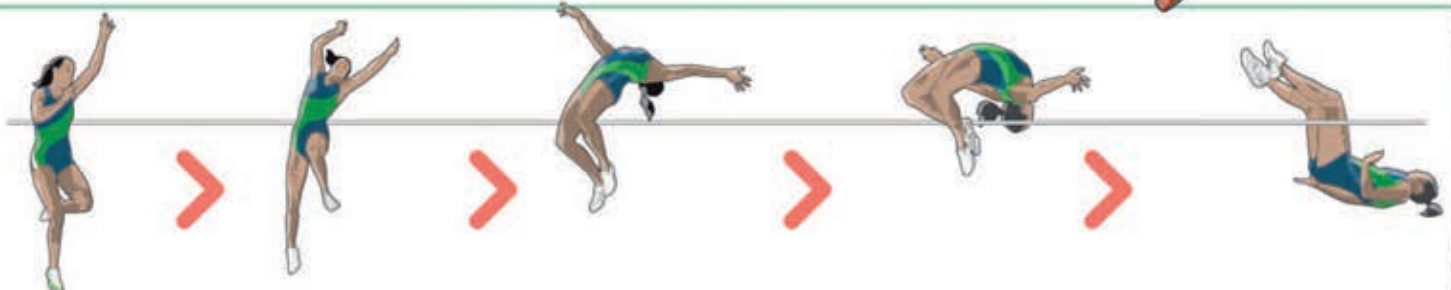
In this event, competitors use a bendy pole to clear a bar that is set higher and higher. The vaulter runs down the track with the pole, pushes the end into a box, and uses the pole as a lever to swing up and over the bar.



**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**  
She starts to twist her body so that her back faces the bar.

**3 ARCHING BACK**  
Her body arches backwards.

**4 HIGH POINT**  
She kicks her legs up to clear the bar.

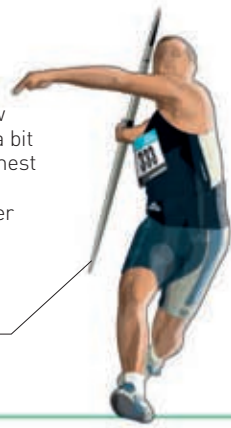
**5 LANDING**  
She positions her arms in preparation for landing.



## JAVELIN

Athletes compete to see who can throw the javelin (which is a bit like a spear) the furthest down the field. Men throw a slightly longer javelin than women.

Javelin

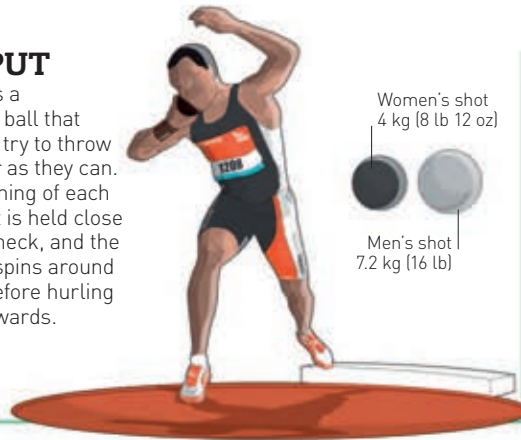


## SHOT PUT

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 forwards.

Women's shot  
4 kg (8 lb 12 oz)

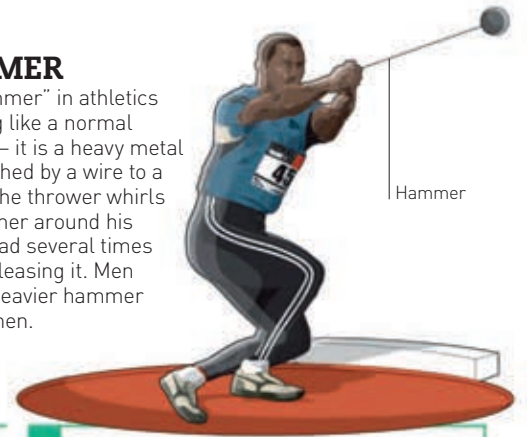
Men's shot  
7.2 kg (16 lb)



## 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 disc that spins through the air when it is thrown hard. The women's discus weighs 1 kg (2.2 lb) while the men's weighs 2 kg (4.4 lb). The winner is the person who throws it furthest.



**1 PRELIMINARY SWING**  
Holding the discus in one hand, the athlete starts to swing it back and forwards.

**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.

## MULTI-PART EVENTS

In these track and field events, competitors need to be all-round athletes with a combination of skills.

- HEPTATHLON**  
This two-day competition for women includes seven events: 200 m, 100 m hurdles, high jump, shot put, long jump, javelin, and 800 m.
- DECATHLON**  
Men compete in ten events in this two-day competition: 100 m, long jump, shot put, high jump, 400 m, 100 m hurdles, discus, pole vault, javelin, and 1,500 m.

## 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 (3,280 yd) 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 42.2 km (26.2 miles) 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 <i>(men only)</i>
200 m	400 m hurdles
400 m	4 x 100 m relay
100 m hurdles <i>(women only)</i>	4 x 400 m relay

## SPRINTING

These fast races are run over distances from 100–400 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.

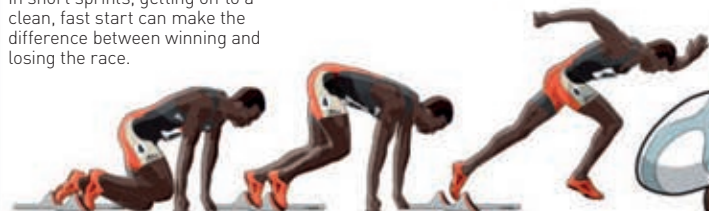
**HURDLES**  
Competitors have to jump hurdles while running.



**WHEN USAIN BOLT BROKE THE 100 M WORLD RECORD IN 2009, HE COVERED AN ASTONISHING 12.2 M (40 FT) 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 multi-sport 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

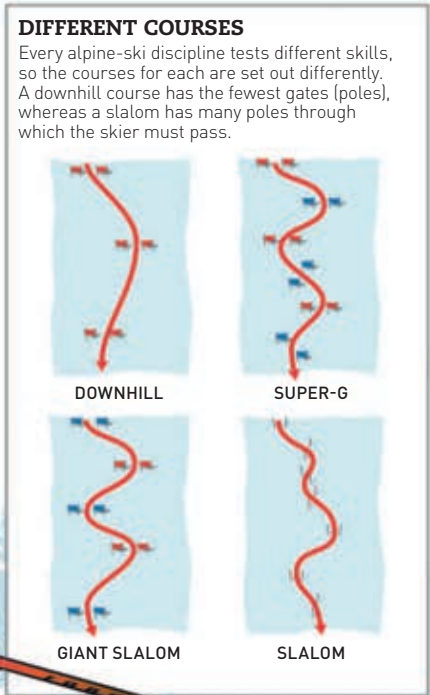
- KJETIL ANDRE AAMODT (NORWAY)**  
 The only alpine skier to win eight Olympic medals, four of them gold – in Super-G (1992, 2002, 2006) and combined (2002).
- JANICA KOSTELIC (CROATIA)**  
 The only woman in history to win four Winter Olympic golds – three in 2002 and one in 2006.
- ALBERTO TOMBA (ITALY)**  
 The dominant technical skier of the late 1980s and early 1990s.



**THE WORD "SLALOM" COMES FROM THE NORWEGIAN WORD "SLALAM", MEANING "GENTLE SLOPE"**



**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.



## ALTERNATIVE SKIING METHODS

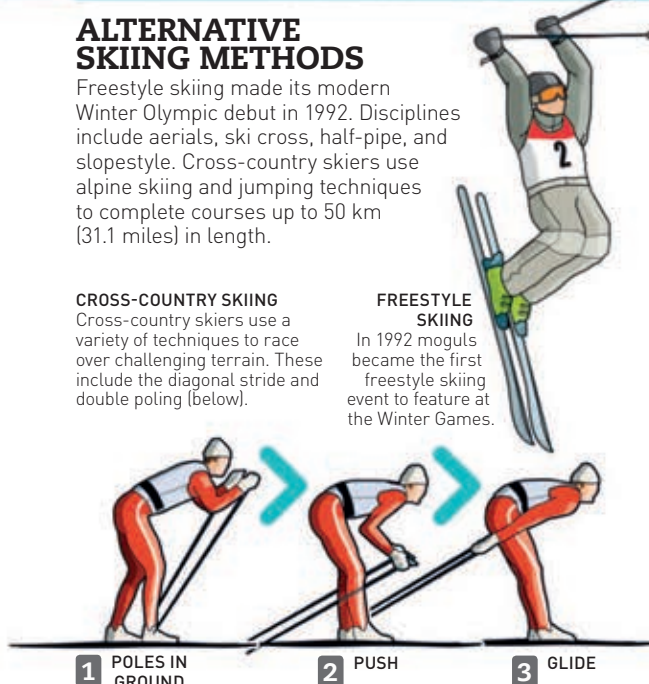
Freestyle skiing made its modern Winter Olympic debut in 1992. Disciplines include aerials, ski cross, half-pipe, and slopestyle. Cross-country skiers use alpine skiing and jumping techniques to complete courses up to 50 km (31.1 miles) in length.

### 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 USA 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 ski-like 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.



**HALF-PIPE**  
 Half-pipe events take place in a specially constructed U-shaped arena. Competitors perform tricks, such as the alley-oop (above), as they descend.

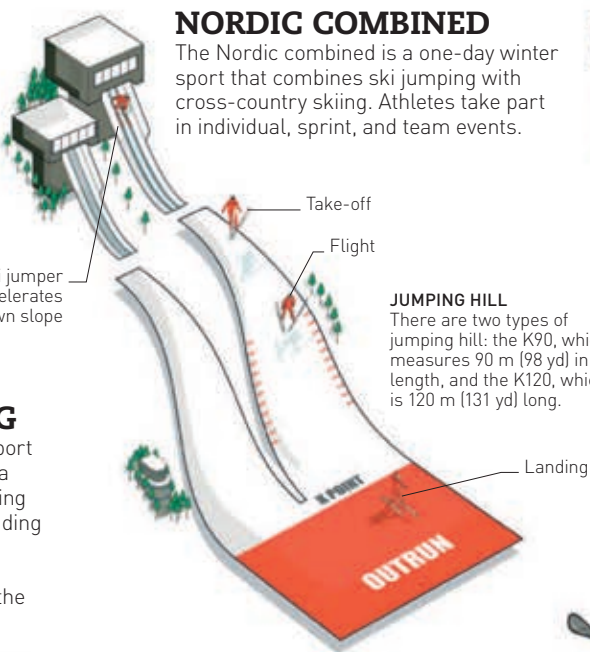
**SLOPESTYLE**  
 Slopestyle sees participants navigate a downhill course littered with obstacles, such as jumps and rails (right). Scores are awarded for staying upright for the duration of the course and for the tricks performed.





## 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 furthest 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 90 m (98 yd) in length, and the K120, which is 120 m (131 yd) 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 bobsleigh, 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.

### BOBSLEIGH

Bobsleigh 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

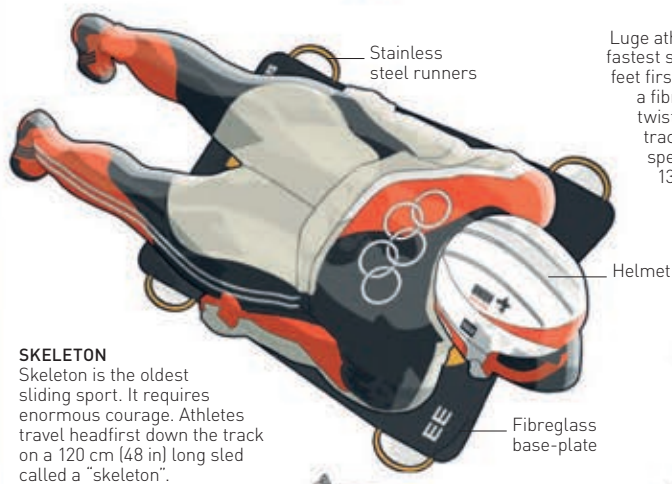
All members of the team must jump into the sled within 50 m (55 yd) of the start line.

### 3 FULL STEAM 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.

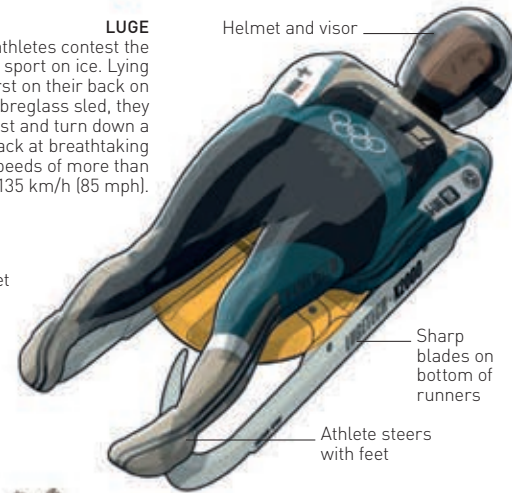


### SKELETON

Skeleton is the oldest sliding sport. It requires enormous courage. Athletes travel headfirst down the track on a 120 cm (48 in) long sled called a "skeleton".

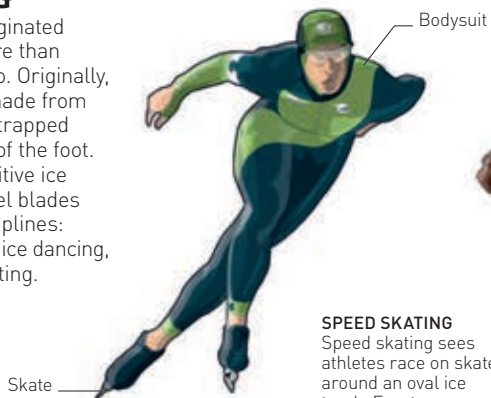
### LUGE

Luge athletes contest the fastest sport on ice. Lying feet first on their back on a fibreglass sled, they twist and turn down a track at breathtaking speeds of more than 135 km/h (85 mph).



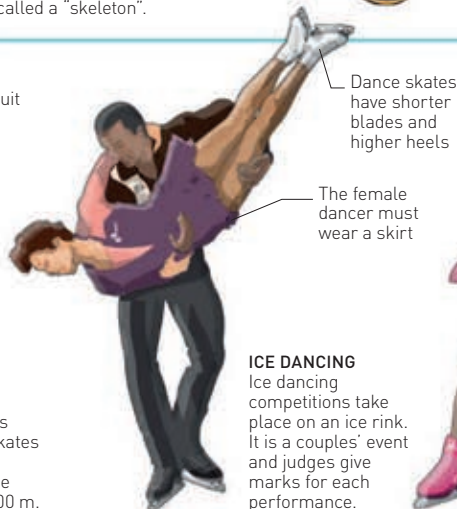
## SKATING

Ice skating originated in Finland more than 3000 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.



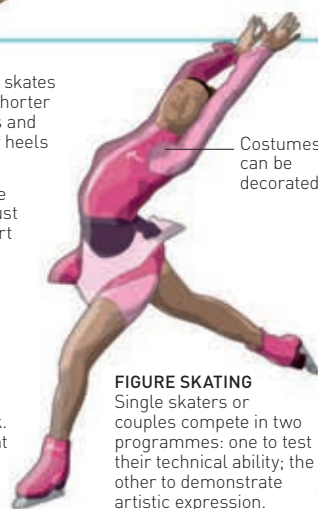
### SPEED SKATING

Speed skating sees athletes race on skates around an oval ice track. Events range from 500 m to 5,000 m.



### 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 programmes: one to test their technical ability; the other to demonstrate artistic expression.

## TOP FIGURE SKATERS

- GILLIS GRAFSTROM (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.



## MOUNTAIN BIKING

Mountain biking (MTB) is one of the newest cycling sports, started by cyclists riding off-road trails in California, USA, 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 pedalling 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 his feet up under his body at the same time.



## EVENTS

MTB is still quite a 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 towards the rider's finishing time.

### MOUNTAIN BIKE

A mountain bike must be sturdy, to cope with bumpy trails, but still light enough to be manoeuvrable.



### RIDER PROFILE

BMX riders need to be flexible and fit. Freestylers have style and creative flair.

Gloves stop hands from slipping

Full-length trousers with padded knees



## 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.

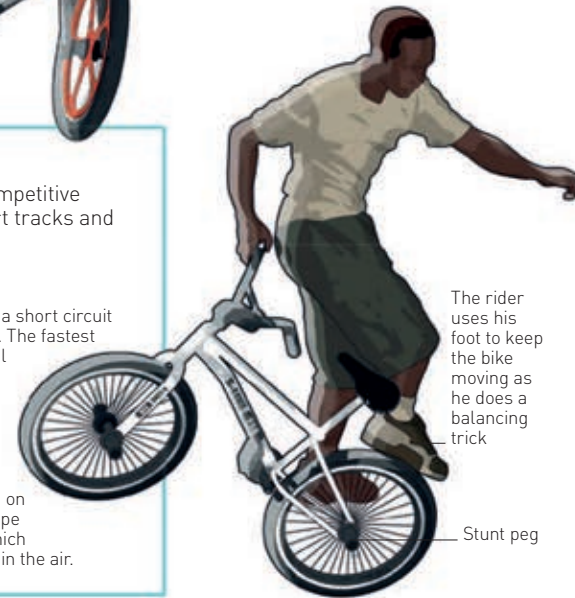
### FLATLAND RIDING

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.

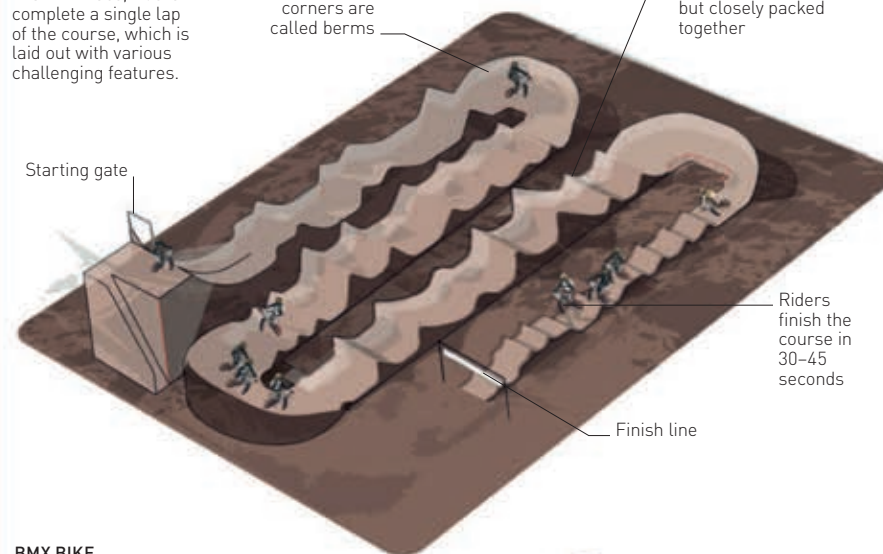


### DIRT TRACK

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

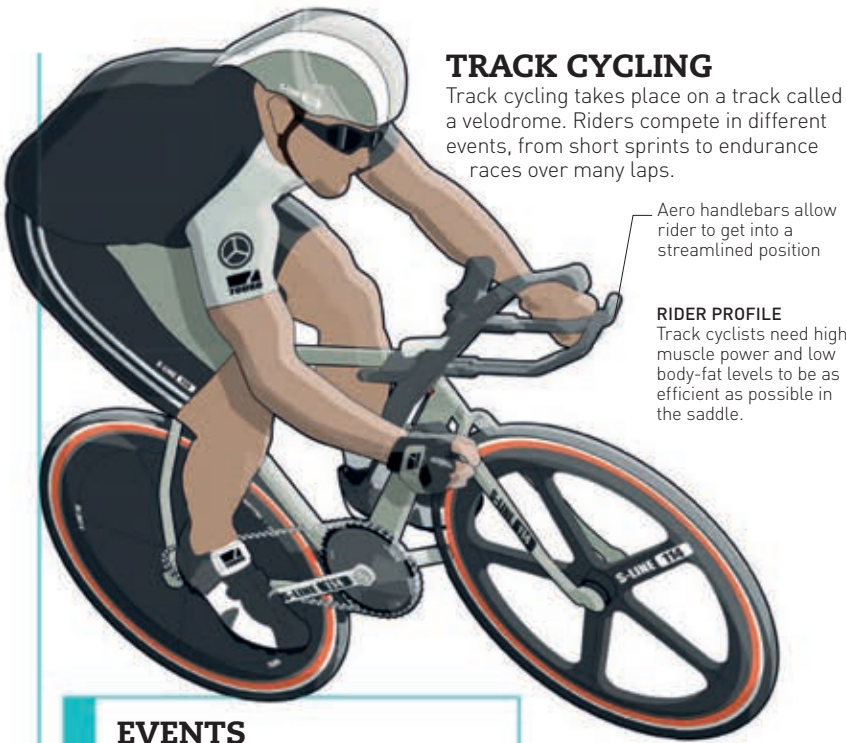


### BMX BIKE

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.







## 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

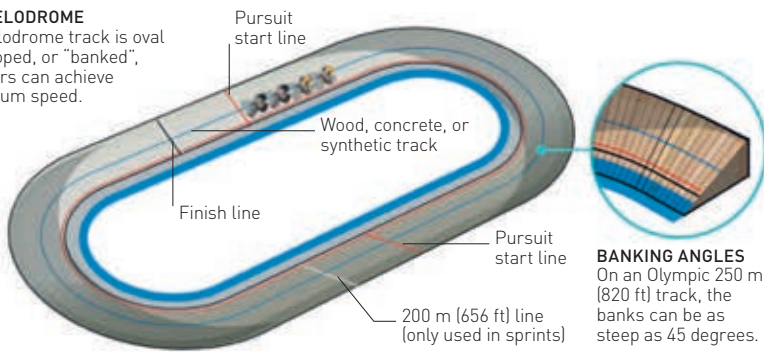
There are ten Olympic track cycling events, with men and women competing in each of the five events listed.

- **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 4 km (2.5 miles). 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.

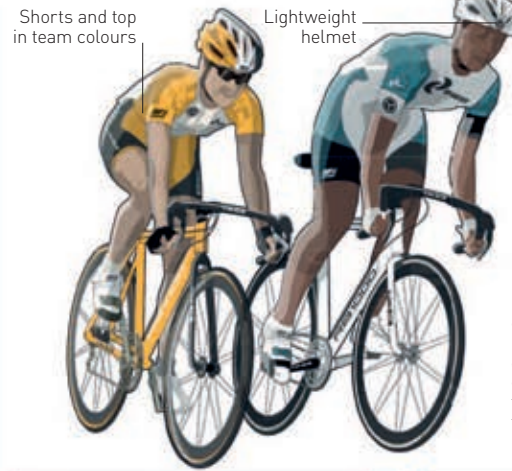


**MADISON**  
The Madison is a relay event for teams of two. When the riders change over, one uses his hand to propel the other into the race.

**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.



## ROAD RACING

Road racing is one of the most physically demanding of all sports. Multi-stage races can cover thousands of kilometres in a few weeks and include all-day mountain climbs and 80 km/h (50 mph) 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 3,500 km (2,175 miles) 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.

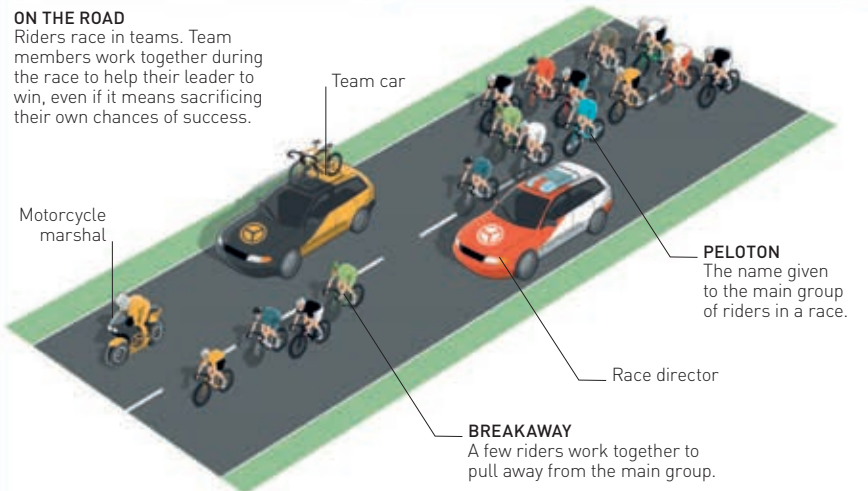
## RACE FORMATS

Road race formats range from one-day races to multi-stage 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 270 km (168 miles), 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-centre circuit of less than 5 km (3 miles), 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 to 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.



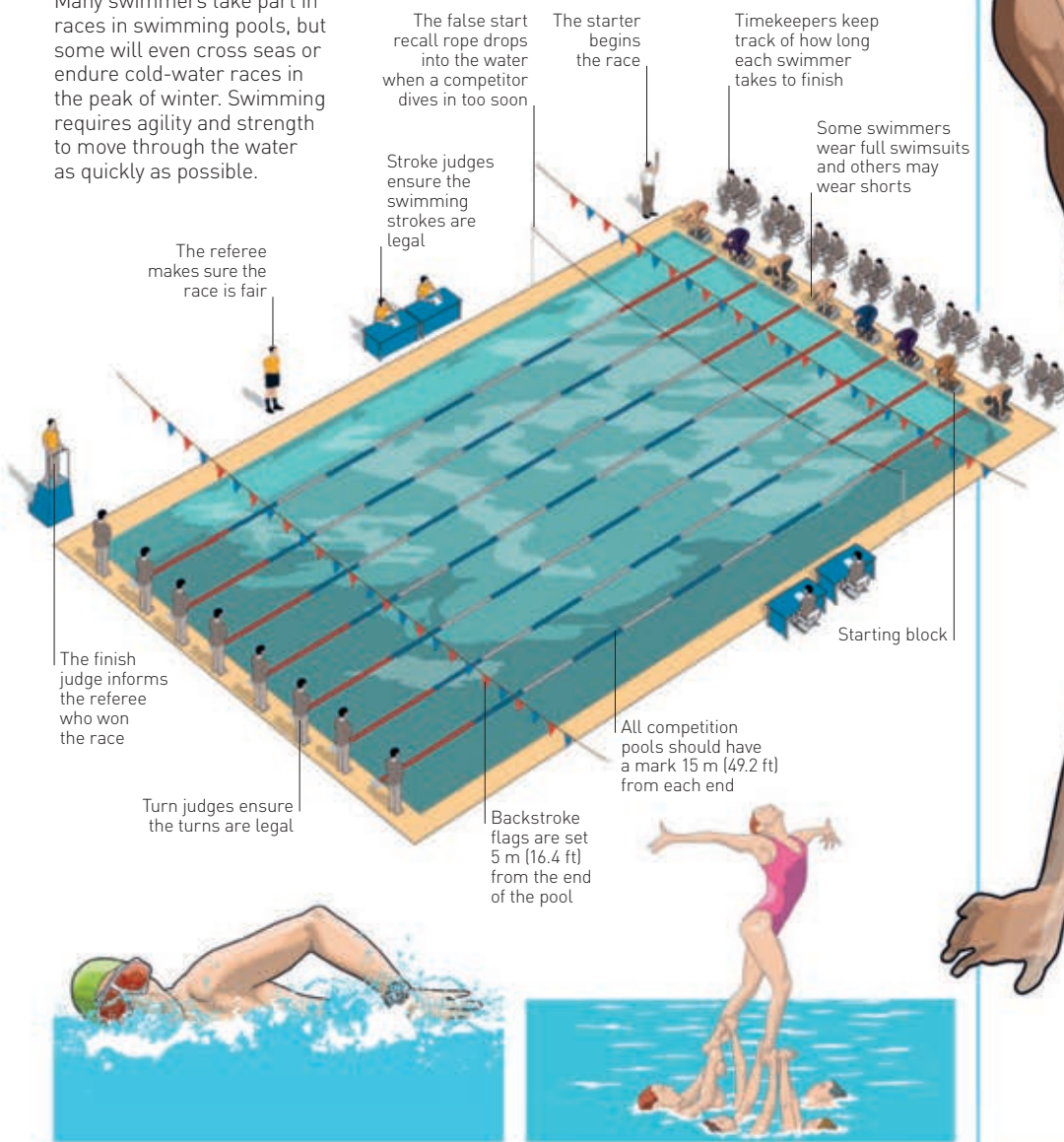


# Water sports

Water provides the perfect environment to show off sporting 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

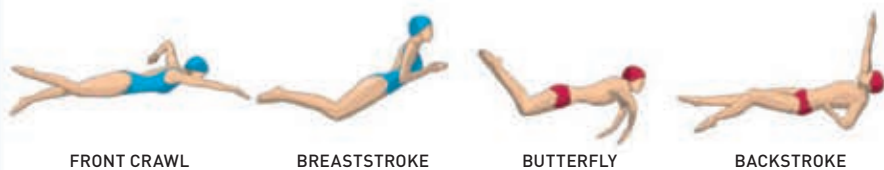
To glide through the water at great speed, swimmers must perfect their arm strokes and leg kicking so each movement propels them forwards.

### 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.

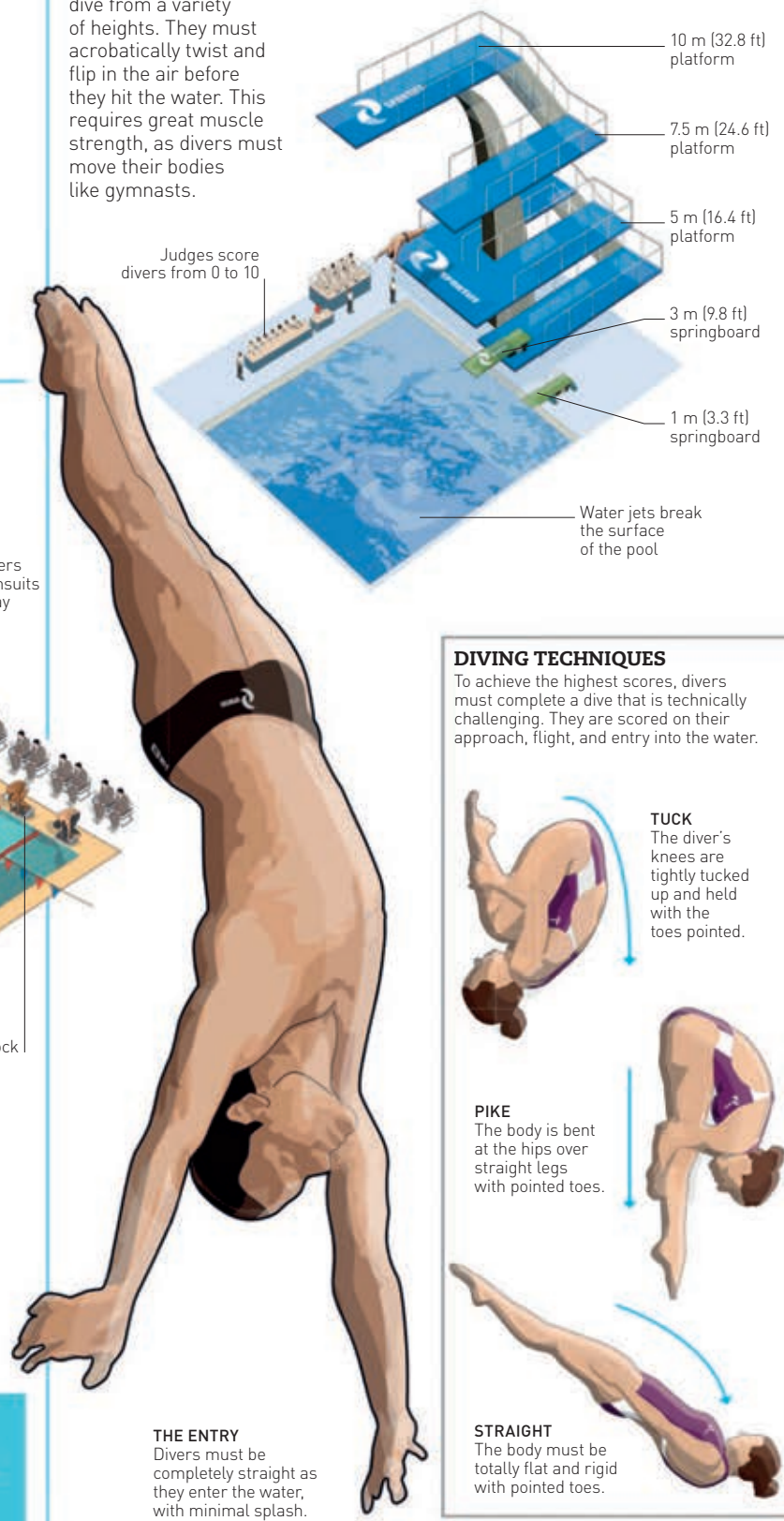
## SWIMMING STROKES

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.



## 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.

## 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.





## 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 forwards.



### 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 towards 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 backwards 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 use 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.

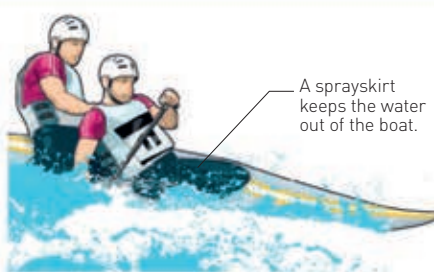
## WHITE WATER SPORTS

White water is made when rivers pass through rocky areas and create rapids. Adrenaline-seekers try to manoeuvre crafts such as kayaks, canoes, and rafts as they travel down the turbulent rivers in races, 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, which 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.



**WIND DISPLAY**  
Shows the direction of the wind.



**DEPTH DISPLAY**  
Helps sailors avoid water that is too shallow.



**COMPASS**  
Helps sailors keep track of the boat's direction.



**COURSE PLOTTER**  
The plotter shows which compass points to follow when it is placed over a map.



Dividers measure distance on chart

**NAUTICAL CHARTS**  
Charts are detailed maps of a sailing area, with hazards and reference points shown.

## 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 to 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 4.2 m (14 ft) dinghy for solo sailing.



### 470 CLASS

A 4.7 m (15.4 ft) dinghy for a crew of two.



### 49ER CLASS

A 4.9 m (16 ft) dinghy with CCA spinnaker for speed.



### TORNADO CLASS

A 6.1 m (20 ft) catamaran with two body sections that increase the boat's speed.



### OCEAN RACER (VOLVO 70) CLASS

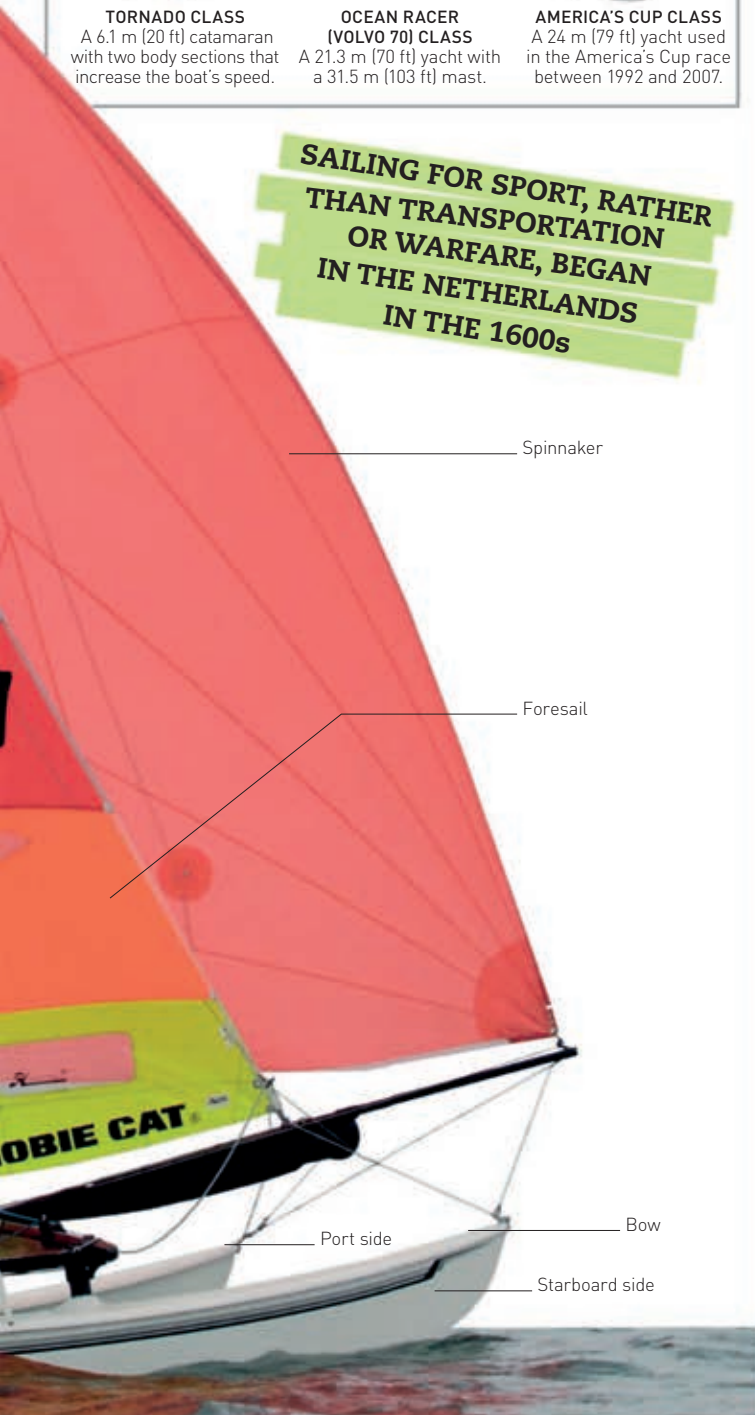
A 21.3 m (70 ft) yacht with a 31.5 m (103 ft) mast.



### AMERICA'S CUP CLASS

A 24 m (79 ft) 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**

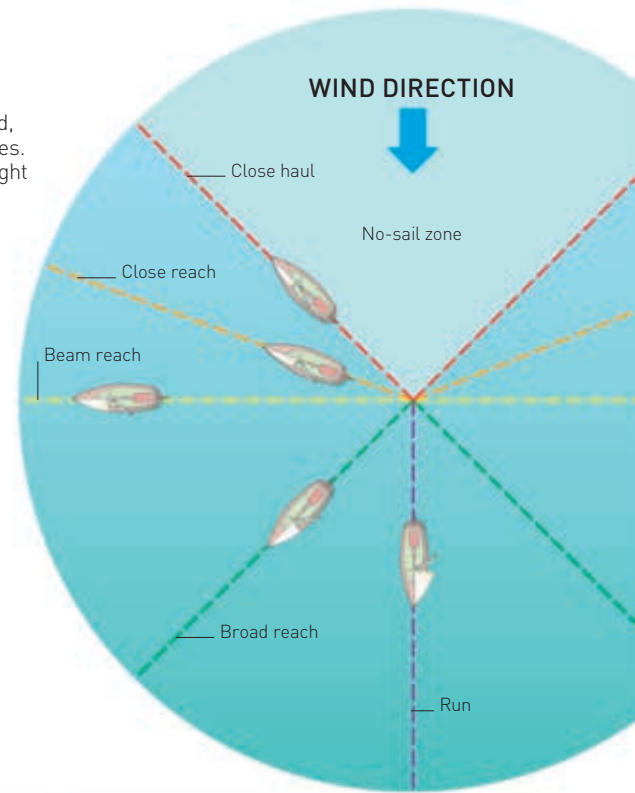


## USING THE WIND

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 forwards in the direction it faces. A sailing boat 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 centreline.
- **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 GYBING

There are two ways of turning a boat: tacking and gybing. Tacking is a safer, slower way of turning as it allows more control of the sails. Gybing is faster and is especially good for racing.



### TACKING

Turn the boat to face upwind.



### GYBING

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), 1895–98**  
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.
- **FRANCIS JOYON (FRANCE), 2008**  
Broke Ellen MacArthur's record to become the fastest person to sail solo around the world without stopping, in 57 days, 13 hours, 34 minutes, and 6 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

- Route du Rhum
- Volvo Ocean Race
- Velux 5 Oceans
- South Atlantic Race



### VELUX 5 OCEANS

This ambitious solo round-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. 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 salt water.



**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.



**SALT WATER**  
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 fibreglass or carbon fibre. 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



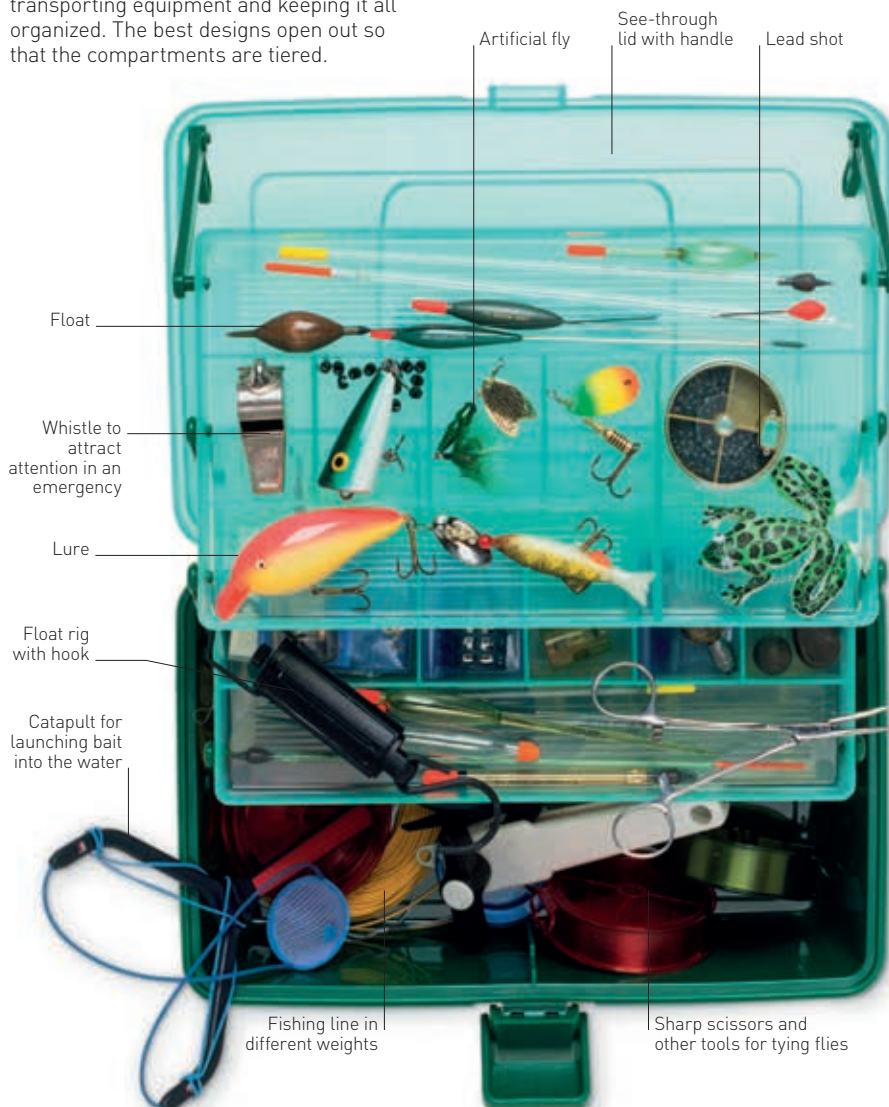
FISHING LINES



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 colours and flavours.



RED BOILIES



YELLOW BOILIES



DOG BISCUITS



SWEETCORN



WORMS



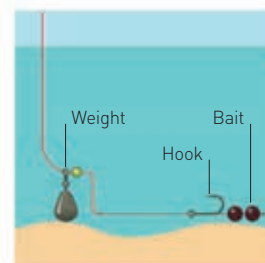
WAX WORMS

## 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.

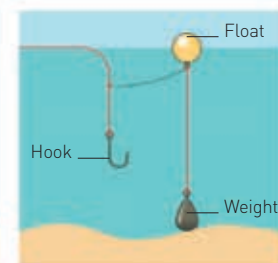


LEAD WEIGHTS



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.



SPLIT SHOT

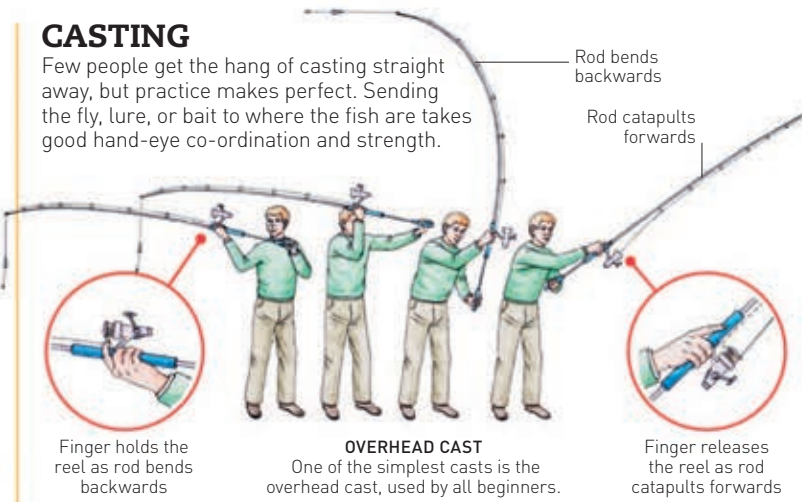


WIRE



## CASTING

Few people get the hang of casting straight away, but practice makes perfect. Sending the fly, lure, or bait to where the fish are takes good hand-eye co-ordination 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 1932 by English fisherman Edward Peel, 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.



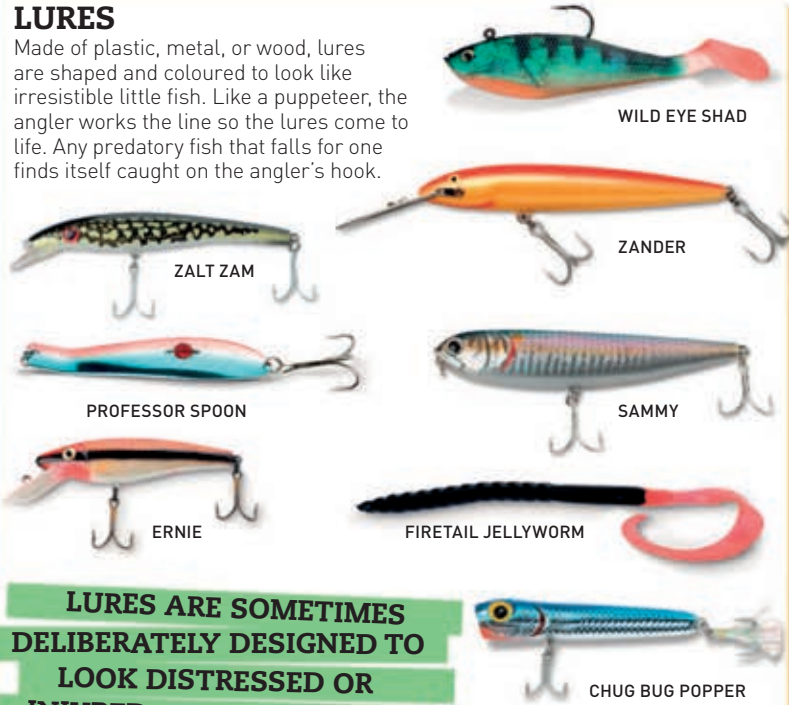
TRADITIONAL SCALES



PORTABLE SCALES

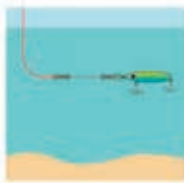
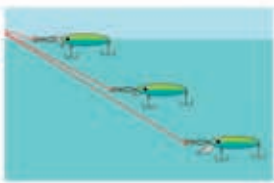
## LURES

Made of plastic, metal, or wood, lures are shaped and coloured 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.



**COLOURFUL FLOATS**  
Bright colours attract fish and also help the angler keep track of where the float is in the water.

## UNUSUAL 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 weird and wonderful 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. This technique means they disturb the fish as little as possible.



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.



PORTUGUESE WATER DOG
- 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 towards 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 colours (attractors).



**WRIST ACTION**  
In streams or rivers, the fly-angler aims to cast the fly upstream. Then it will gently drift downstream in a natural-looking way.

## ATTRACTORS

Attractors are often brightly coloured. The fly-angler usually moves them around a lot to tempt fish to attack.



Legs make ripples on the surface

Rubber legs create movement

Big, buoyant eyes



# 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 *wushu*.

### KUNG FU: SANSHOU

Sanshou is a Chinese martial art similar to kickboxing. It is never practised 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 150 years ago in England.

### THAI BOXING

Unlike Western boxers, Thai boxers attack with feet, elbows, and knees as well as fists.

### CAPOEIRA

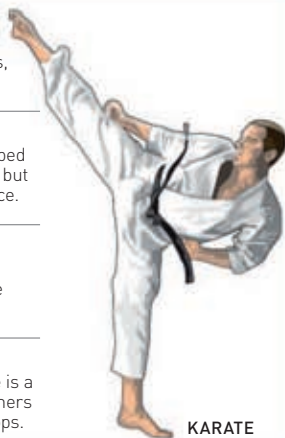
African slaves in Brazil developed capoeira. It looks like a dance, but it is really a form of self-defence.

### 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-defence. 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

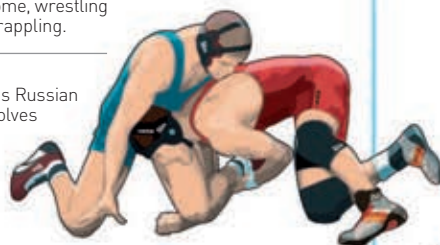
This sport is most associated with Japan, but it originated in China in the 3rd century BCE.

### WRESTLING

As popular today as it was in Ancient Greece and Rome, wrestling involves one-to-one grappling.

### SOMBO

Very 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

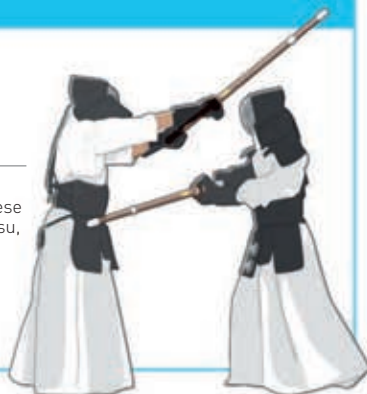
Samurai warriors practised an early form of kyudo, which is similar to archery.

### 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), 210 cm (7 ft)

JIAN (SWORD), 103 cm (3.4 ft)

DAO (CURVED SWORD), 98 cm (3.25 ft)

NANDAOU (BROADSWORD), 97 cm (3.25 ft)



Taijijian sword is 110 cm (3.6 ft) long

Swishing tassels emphasize the moves

Chinese tunic worn over loose trousers

### 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

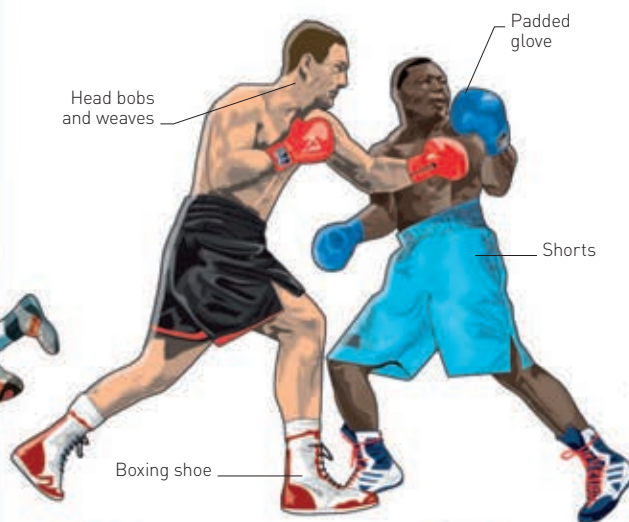
This move, known as *pu bu*, is a very low squat. One arm arches over the head to counterbalance the crouching.

### 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 most points or who knocks out his or her opponent.



Head bobs and weaves

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 his arm.



### HOOK

Hooks are delivered to the side of the head or body. The best hooks are those an opponent does not see coming.



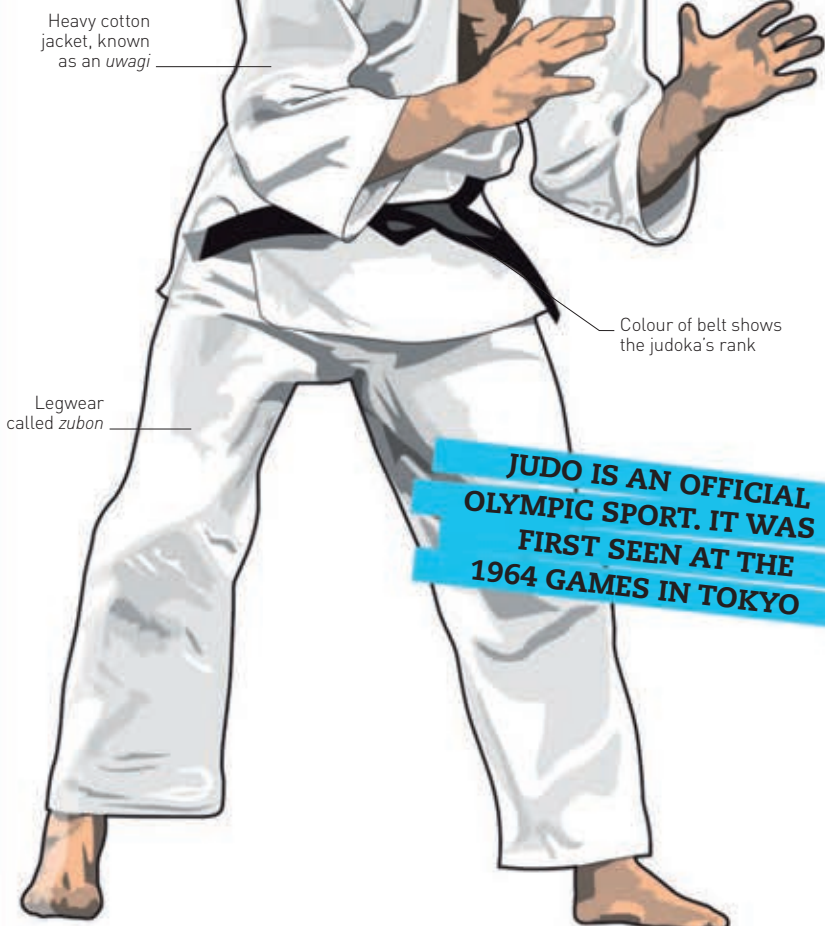
### UPPERCUT

This powerful punch is delivered on to the opponent's chin from below. It often results in a knockout.

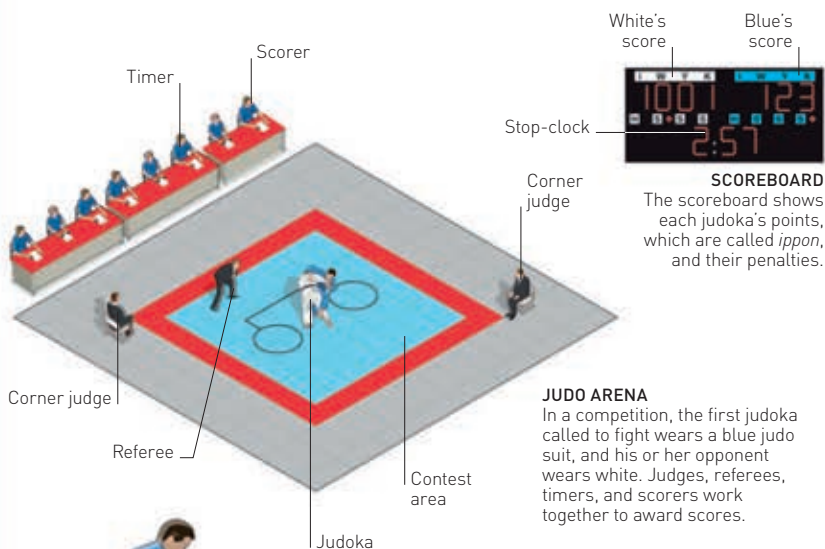


## JUDO

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.



**JUDO IS AN OFFICIAL OLYMPIC SPORT. IT WAS FIRST SEEN AT THE 1964 GAMES IN TOKYO**



### 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.

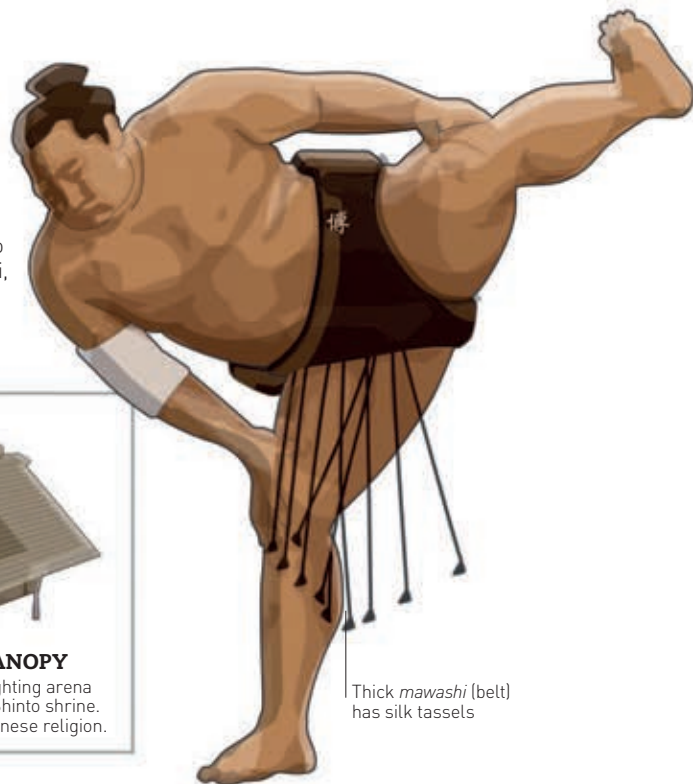


### OKURI-ERI-JIME

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. The heaviest sumo star, Konishiki Yasokichi, weighed 287 kg (633 lb) 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.



### YORIKIRI

This move involves seizing the opponent's *mawashi* and trying to march him out of the ring.



### UWATENAGE

In this attack, the wrestler grips his opponent's *mawashi* and pulls him down, while turning his own upper body.

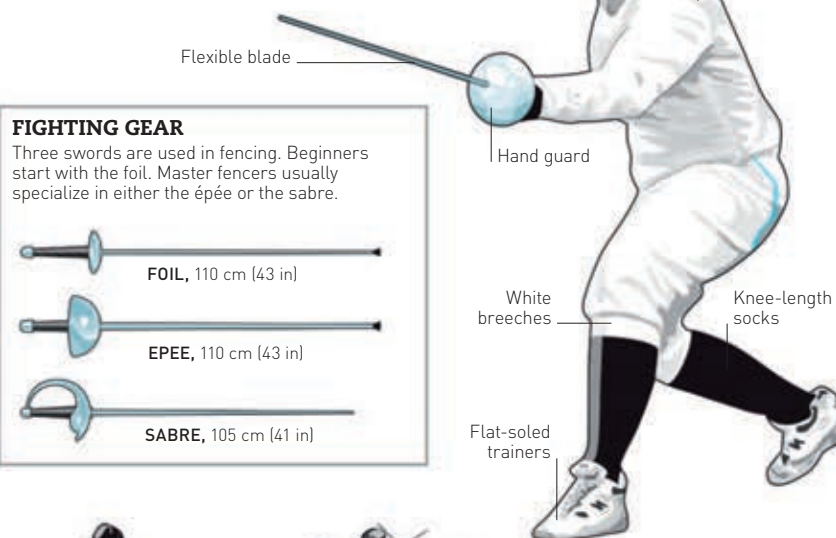


### HATAKIKOMI

As one wrestler charges, the other steps to the side and then slaps the opponent's back or arm so he falls over.

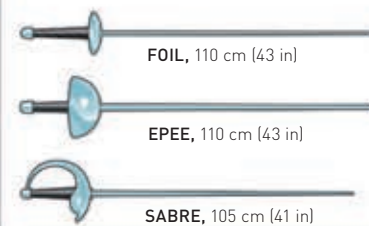
## FENCING

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 *sabre*.



### ATTACK

The fencer extends his or her sword arm towards 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.



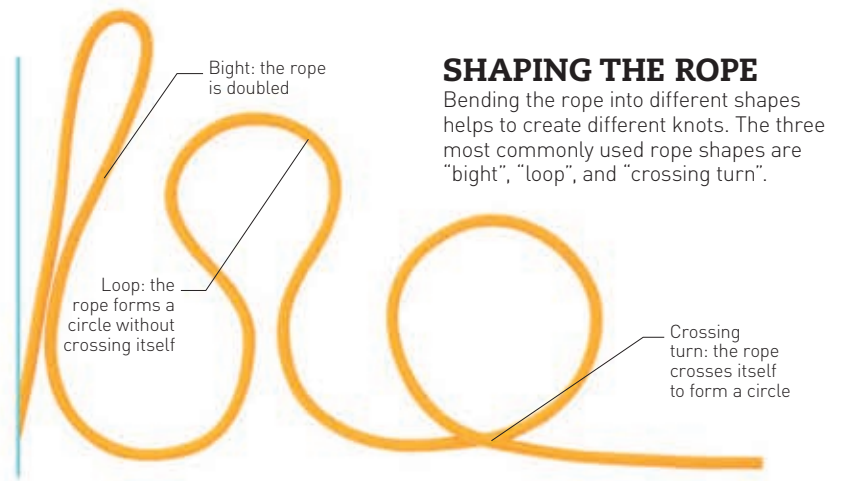
### RIPOSTE

After a parry, the follow-up counterattack is known as a riposte. The name comes from the French word for "reply".



# Knots

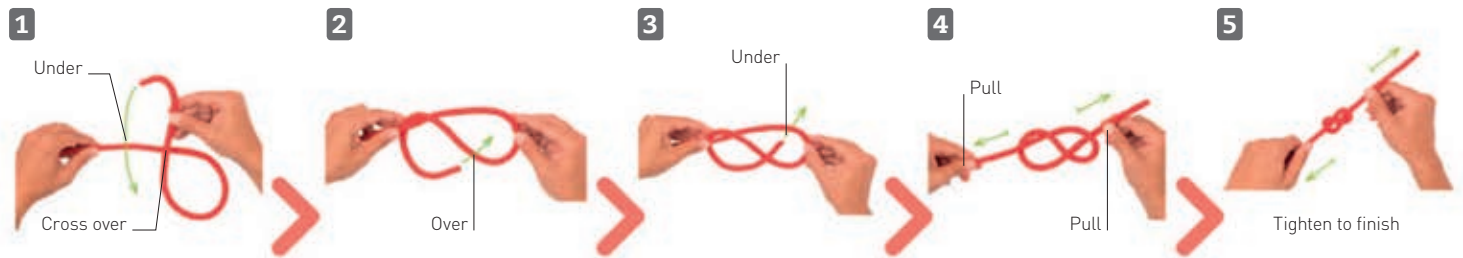
Knowing how to tie knots is a fun skill that is useful in many situations. For activities such as climbing or sailing, ropes tied with the right knots are vital for safety. More everyday uses for knots range from putting up a tent to making decorations or even tying shoelaces.



**SHAPING THE ROPE**  
Bending the rope into different shapes helps to create different knots. The three most commonly used rope shapes are "bight", "loop", and "crossing turn".

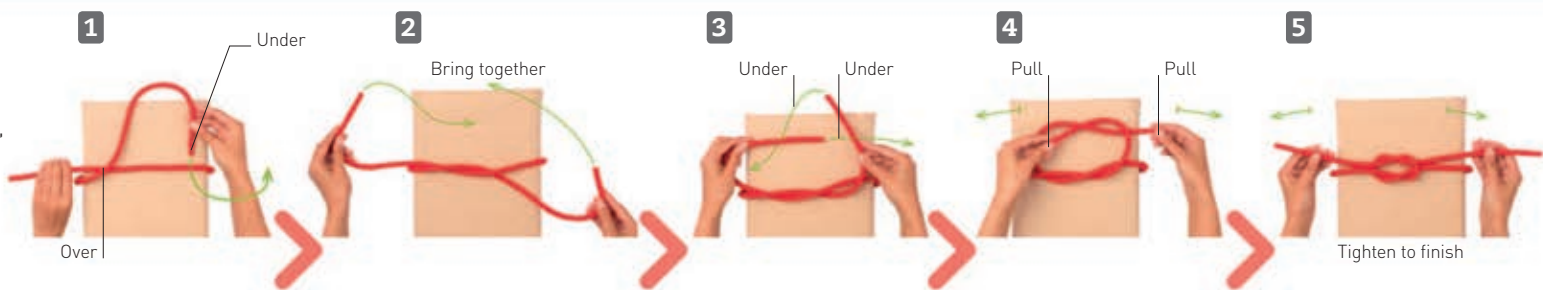
## FIGURE OF EIGHT

Easy to tie and untie, the figure of 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.



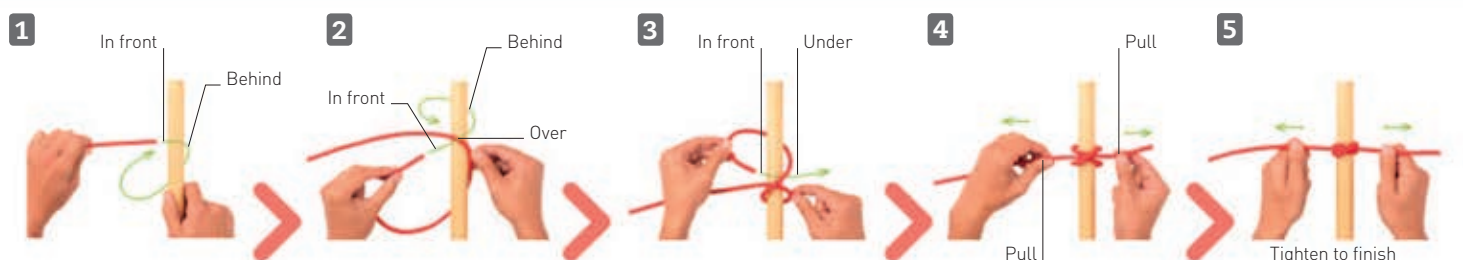
## REEF KNOT

This binding knot is quick to do. It is used for securing rope or string around an object, so is perfect for tying up parcels. Reef knots are also known as square knots.



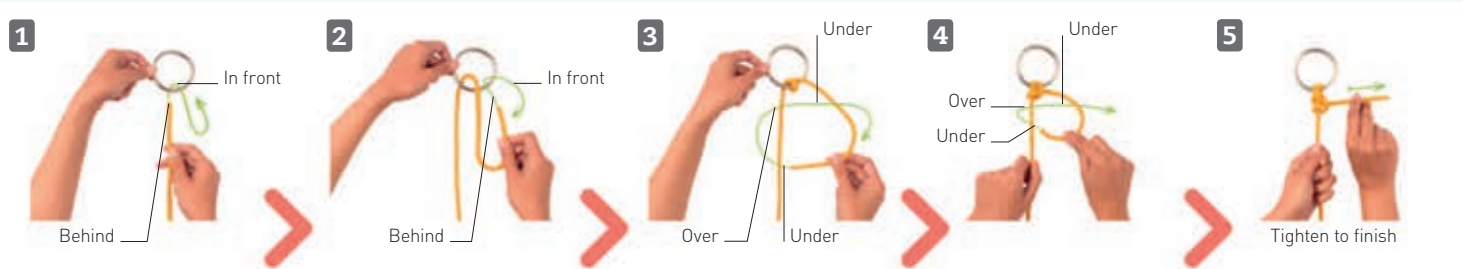
## CLOVE HITCH

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.



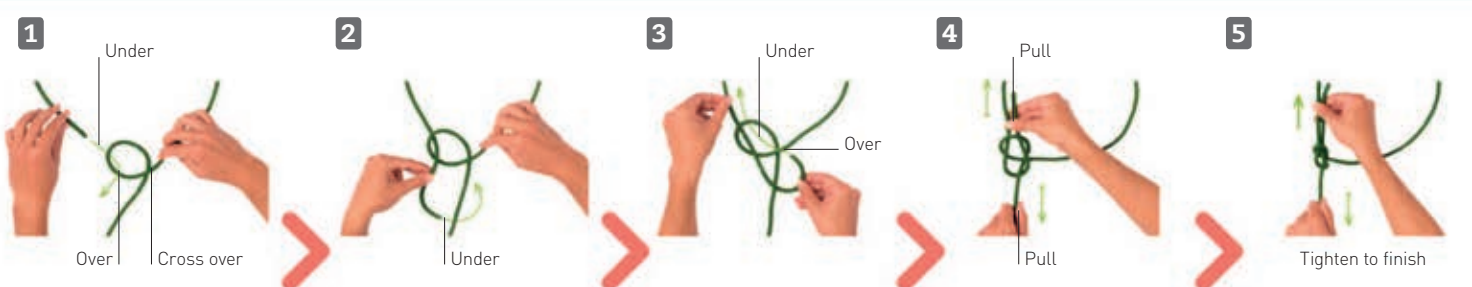
## ROUND TURN AND TWO HALF HITCHES

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 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 slipping through a hole or unravelling 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 OF 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



TURK'S HEAD



THIEF



PACKER'S



TRUE LOVER'S



REEF



SLIPPED REEF



SURGEON'S



GRANNY



TURQUOISE TURTLE



SLIPPED REEF DOUBLE



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 on to fishing lines.



ROLLING HITCH



ICICLE HITCH



SHEER LASHING



SQUARE LASHING



KLEMHEIST



BUNTLINE HITCH



COW HITCH



COW HITCH WITH TOGGLE



ITALIAN 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



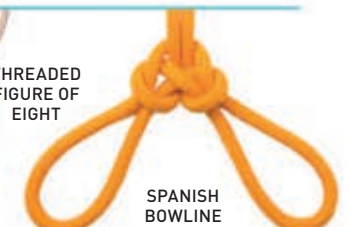
BASIC NET



BLOOD DROPPER



THREADED FIGURE OF 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, packs 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 CHEQUERS

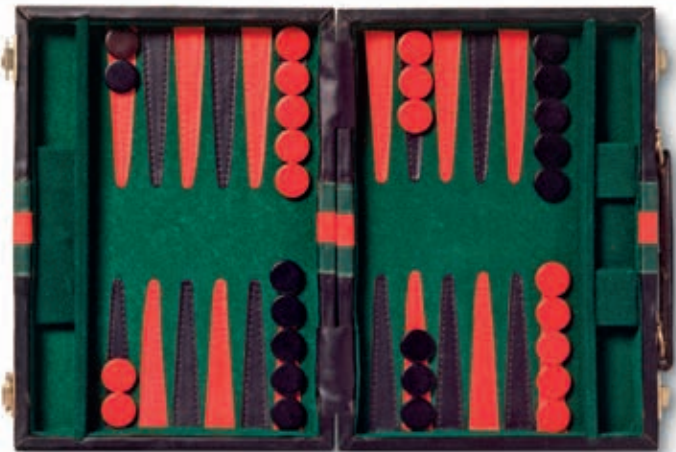
The aim of this game is to race your coloured pegs across the board to the opposite point of the star. You can move along one hole at a time or hop over pegs in your path.

## 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 round 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.

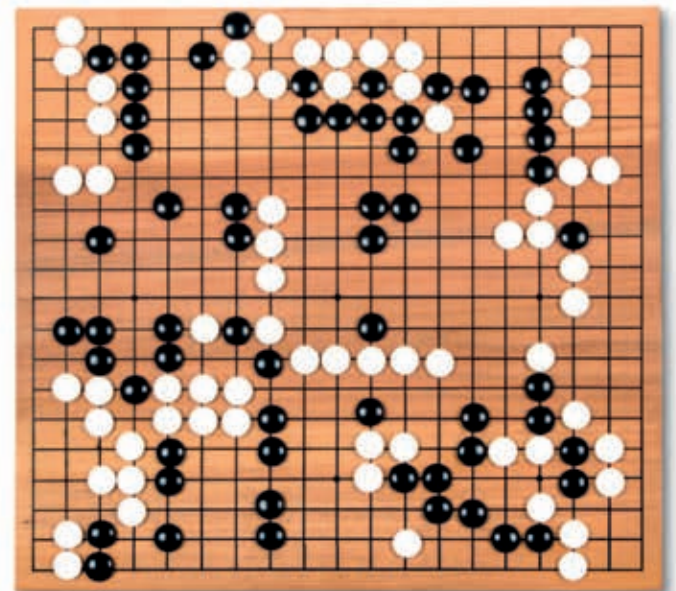


### SNAKES AND LADDERS

Players throw a die to move up the board and, hopefully, land on a ladder to skip rows. But watch out for the snakes!

### 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.



### DRAUGHTS

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 came to 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.



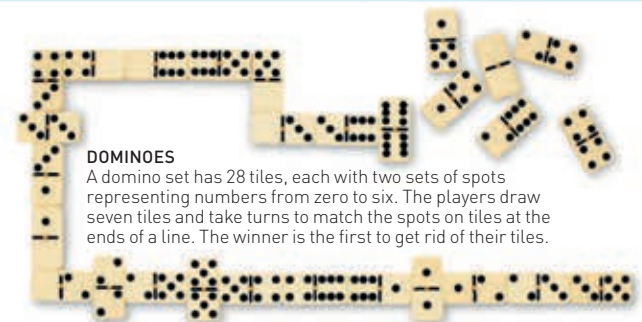
### MAHJONG

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 spots representing numbers from zero to six. The players draw seven tiles and take turns to match the spots on tiles at the ends of a line. The winner is the first to get rid of their tiles.

### 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 centre hole.







JAPANESE HANFUEDA 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
Patience	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

**CHESS CLOCKS**  
These clocks control the time spent on each move. The player stops his own timer after a move and starts his opponent's.



Light square in back corner is always on player's right-hand side

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, two knights, and two 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 colour 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 mitre (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 colour 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 backwards, forwards, left, and right as far as it needs to. Its path has to be clear of pieces of the same colour. 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 forwards 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.

3100 BCE



### Backgammon

A board game similar to backgammon is played.



### Senet in tomb painting

**3100 BCE**  
The oldest known board game, Senet is a favourite pastime in Ancient Egypt.

500 BCE

Pachisi, India's national game, is mentioned in the epic poem *The Mahabharata*.

200 CE

A pottery Go board from this era has been found in Shaanxi Province, China.

600s

An ancestor of the game of chess, Chaturanga is referred to in Indian writings.

900s

Playing cards appear in China's Tang dynasty.



### Mancala

1200s

The first mention of the game of dominoes appears in a Chinese text.

1230

The Scandinavian strategy game Hnefatafl is mentioned in the Norse Saga.



### Draughts

1492

A knight and lady are shown playing draughts in a medieval book.

1600s

A card game called cribbage, played with a scorekeeping board, is invented.

1886

The first World Chess Tournament is held.

1890s

Snakes and Ladders, based on an ancient Indian game, becomes popular in Victorian England.



### Pachisi

1938

Criss Cross Words (later Scrabble) is invented by a US architect.

1970

A code-breaking game for two players called Mastermind is invented.

1978

Space Invaders becomes a blockbuster arcade video game.

1980

Arcade game Pac-Man is released in Japan.



### Rubik's cube

1984

The Trivial Pursuit general knowledge game is a huge success.

2004

World of Warcraft is created — a MMORPG (massively multiplayer online role-playing game).

2015

2011

The multi-award-winning computer game Minecraft is released.



# 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 pack of playing cards and a set of cups and balls are probably the most important. Wands are also popular.

WAND



PACK OF CARDS



SCARVES



CUPS AND BALLS

PIECE OF ROPE

BOW TIE

BAG OF COINS

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 card, glue, a pencil, a handkerchief, a coin, and a clear plastic cup.



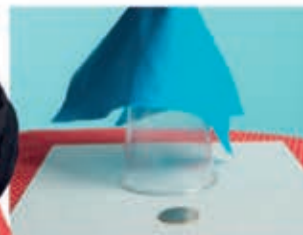
**1 DRAW A CIRCLE**  
Place the plastic cup upside down on one of the pieces of paper or card and draw around it with your pencil. Cut out the circle.



**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. Practise 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 VOILA!**  
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 scarves come in useful, and so does “patter” – 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 enthral audiences.

### THE GREAT LAFAYETTE (1871–1911)

Lafayette was probably the most successful magician of his time. His speciality was dramatic illusions, often performed with his dog Beauty, a gift from Harry Houdini.

### 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 pack of cards. Carry out the first step in secret, then ask for a volunteer.



**1 PREPARE THE DECK**  
Remove all four aces and place them on the top of the pack face down.



**2 FOUR PILES**  
Ask your volunteer to divide the pack 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. Then repeat this for the other piles without aces, and finally for the pile with aces.



**5 REVEAL THE ACES**  
Ask your volunteer to turn over the top card of each pile to reveal the four aces.

## 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.

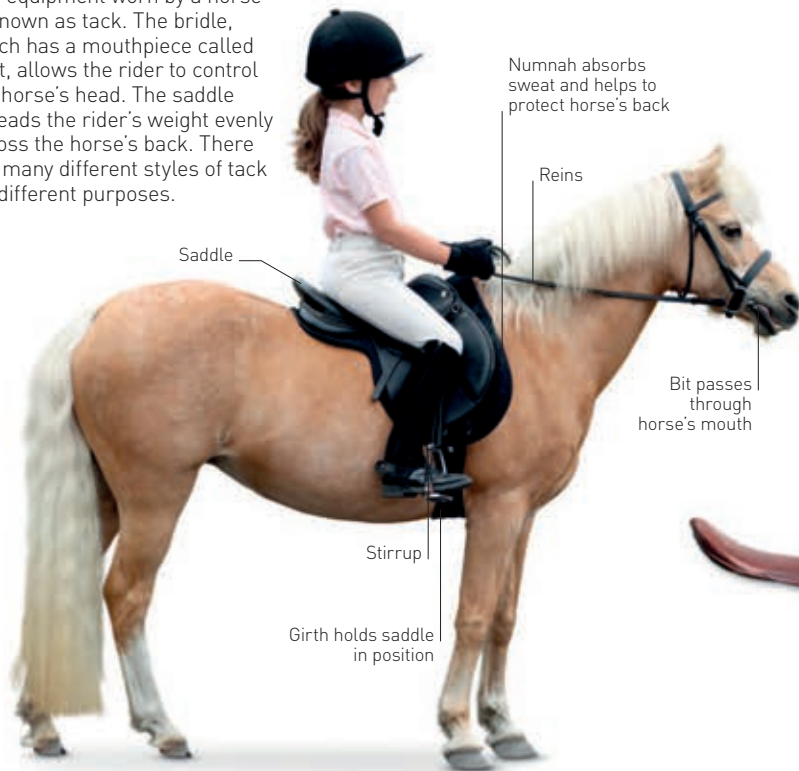


# Horse riding

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 trousers 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 saddle pad or numnah and saddle further forwards than the final position. Move both backwards 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 hoofs.



## FEEDING A HORSE

The natural food of horses is grass, but a hard-working horse needs more. Extra foodstuffs include hay for fibre, 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 round to face forwards. 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 forwards.



**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 forwards.

**THE HIGH-JUMP RECORD FOR A HORSE IS 2.47 M (8 FT 1 1/4 IN)**



## 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 5-6.5 KM/H (3-4 MPH)



TROT: AVERAGE SPEED 13-16 KM/H (8-10 MPH)



CANTER: AVERAGE SPEED 16-27 KM/H (10-17 MPH)



GALLOP: AVERAGE SPEED 40-48 KM/H (25-30 MPH)

## 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 human-like 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 ten minutes. Humans would not appear until the very last fraction of the last second of the hour.



## OUT OF AFRICA

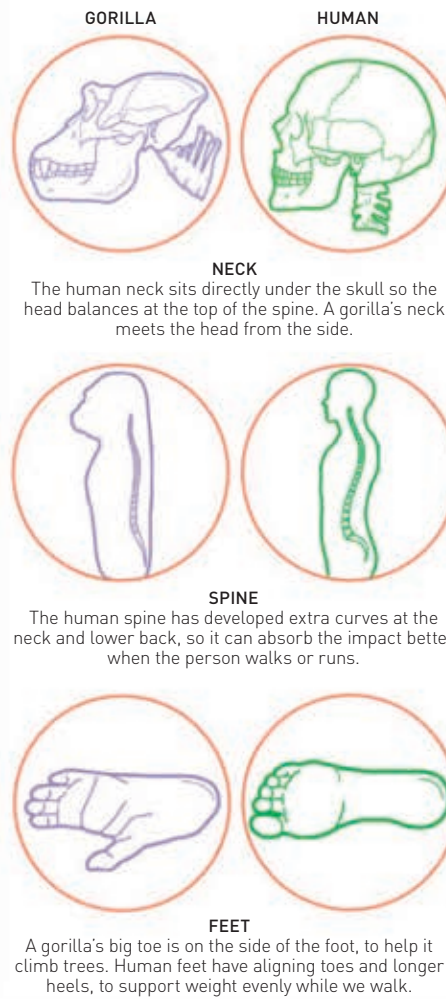
*Homo sapiens*, our species, first evolved in Africa around 150,000 years ago. About 100,000 years later, they began to move away to make new settlements, until humans were living on all the world's continents, except Antarctica.



**KEY**  
→ Migration of *Homo sapiens* around the world  
YA = Years ago

## 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.



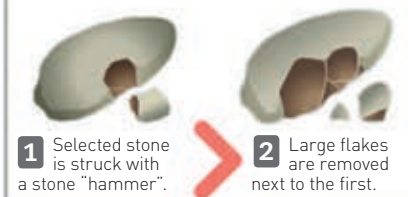
## EARLY TOOLS

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.



**7 MYA (million years ago)**  
**Sahelanthropus tchadensis**  
Thought to be last common ancestor of both chimps and humans.

**6.1 MYA**  
**Orrorin tugenensis**  
Possibly the first ape to walk on two legs.

**4.1 MYA**  
**Australopithecus afarensis**  
Thought to be the ancestor of the genus *Homo*, to which modern humans belong.



**2.2 MYA**  
**Homo habilis**  
Called *habilis* (Latin for "handyman") because they may have been the first species to use tools.

**600,000 YA**  
**Homo heidelbergensis**  
Higher, broader skull to protect a larger brain than earlier species.



**150,000 YA**  
**Homo sapiens**  
Evolved in Africa, then spread worldwide, becoming the only surviving species of the *Homo* genus.

## 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 human-like apes (hominins) that would eventually evolve into modern humans.

**3.3 MYA**  
**Australopithecus africanus**  
Ape-like, with a small brain but human-like teeth.

**1 MYA**  
**Homo erectus**  
As tall as modern humans, with a similar build.



**350,000 YA**  
**Homo neanderthalensis**  
Excellent hunters and tool-makers who thrived in the colder climate of Europe.



## PRESENT





Point for digging

Sharp edge for cutting

**HANDAXE**  
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

SPEAR TIP

FLINT ARROWHEADS

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

STONE SICKLE  
For cutting crops.

TYPICAL BREAD

IRON SICKLE

BRONZE SICKLE

STONE AXE

Used to clear trees before planting crops.

REPLICA OF STONE QUERN

For grinding wheat to make bread.

## ART

Early humans created the world's first art. They used paint made from coloured 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

## 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.
- **GGANTIJA TEMPLES, MALTA**  
Two remarkably well preserved structures, built from limestone during the Neolithic Age (c.3600-3200 BCE).
- **GOBEKLI 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



## 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.

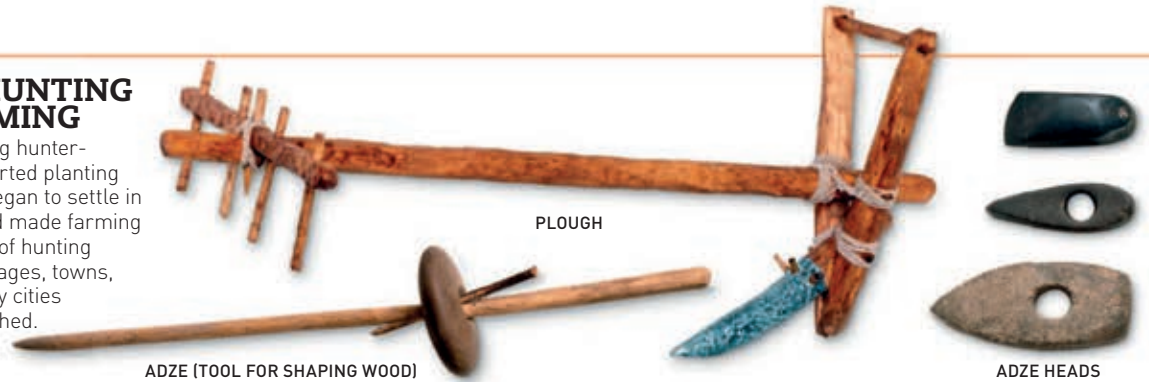


# Early civilizations

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 centre of the world's first empire. In 2330 BCE, the Akkadians conquered many of their neighbouring 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, the capital of the Assyrian Empire. The magnificent palace of King Sargon II covered over 50,000 sq m (538,196 sq ft) and had more than 200 rooms.

### UR

Site of a huge ziggurat (pyramid-shaped temple) and the Royal Tombs, which contained some of the finest Mesopotamian art ever discovered.

## 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

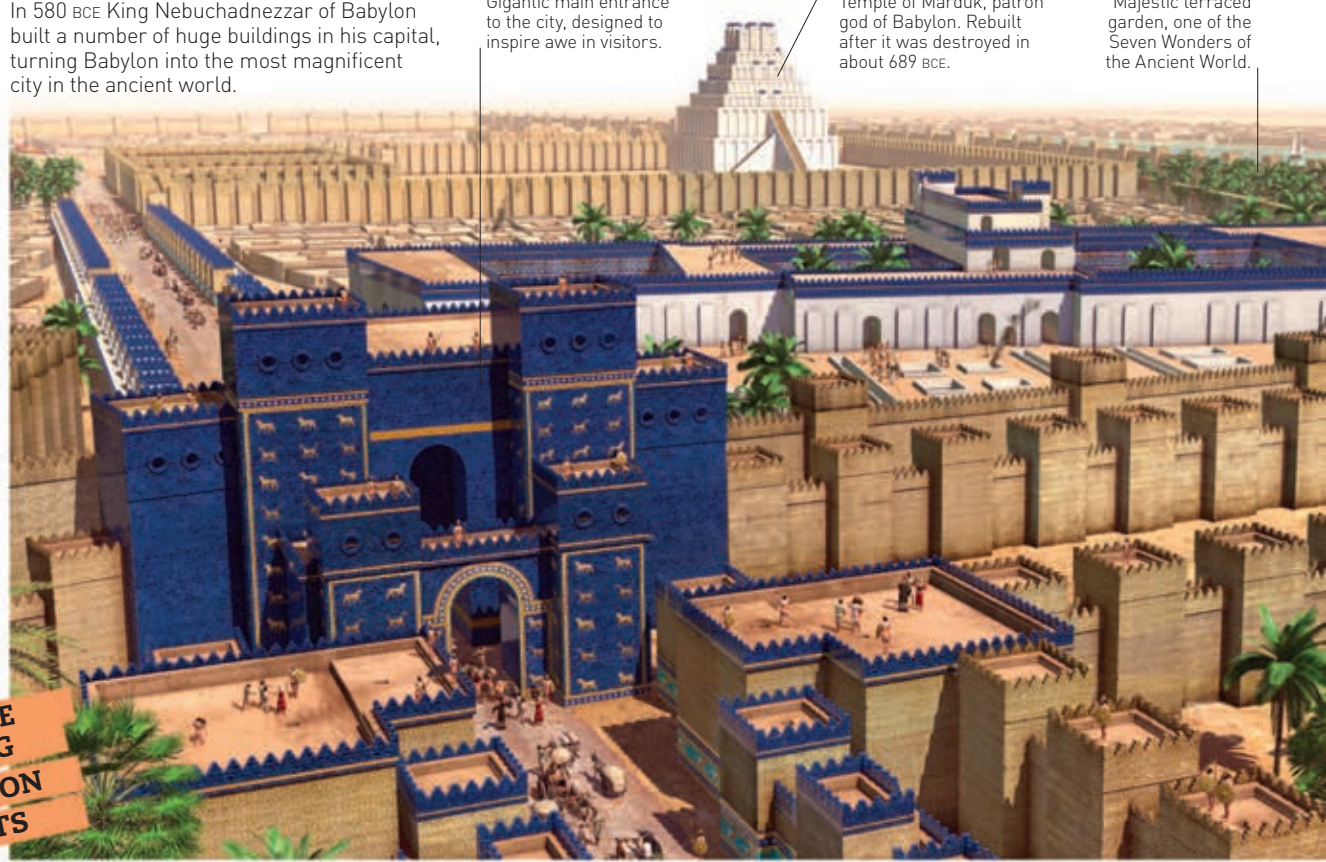
Gigantic main entrance to the city, designed to inspire awe in visitors.

### 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.



**THE SUMERIANS CREATED THE FIRST CALENDAR BY DIVIDING THE YEAR INTO 12, BASED ON THE MOON'S MOVEMENTS**

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

Egypt: the pharaohs unite Egypt into a single state.

2334 BCE

King Sargon of Akkad conquers Sumer, creating the world's first empire.



c.2100 BCE

The great ziggurat (temple) built at Ur.

Ziggurat at Ur



539 BCE

Mesopotamia becomes part of Persia.

7000 BCE

## GRADLE 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.

3200 BCE

Greece: earliest civilizations appear.

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 they were in use in Sumer by 3500 BCE. Sumerians used the wheel vertically on their chariots, and horizontally to make clay pots.

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 survives 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



"RAM IN A THICKET"  
Gold, silver, shell, and lapis ram and shrub.

BEAD BELT

## 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



## 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.1473–1458 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 nine years old. His fabulous gold mask was found in his tomb.



**TUTMOSIS III**  
Reigned c.1479–1425 BCE  
Great military leader who never lost a battle.



**AMENHOTEP III**  
Reigned c.1390–1353 BCE  
Helped to make Egypt prosperous.



**AKHENATEN**  
Reigned c.1353–1336 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

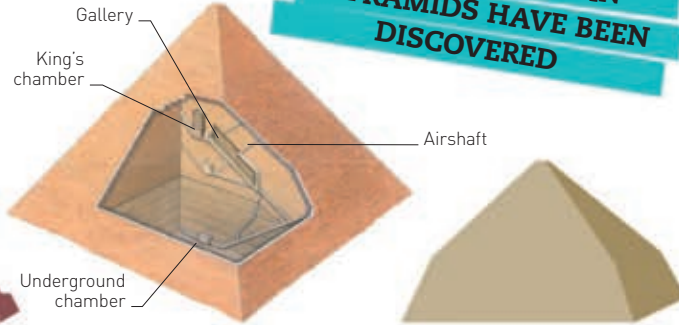
When an Egyptian ruler died the body was buried inside a massive pyramid. Taking up to 30 years to build, pyramids went through various changes of design over the centuries. People who were not royal were buried in simpler tombs.



**MASTABA**  
Box-like brick or stone grave.



**STEPPED PYRAMID**  
An early model, built in layers.



**SMOOTH-SIDED PYRAMID**  
The classic structure, cased with blocks of limestone.

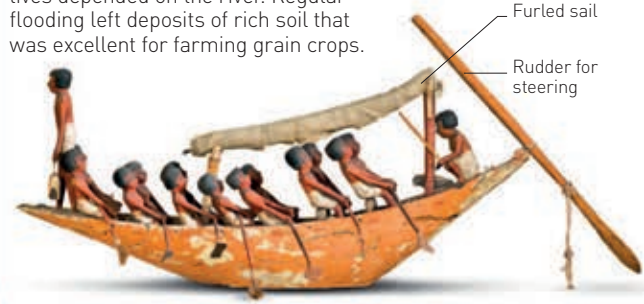


**"BENT" PYRAMID**  
Midway between stepped and smooth.

**MORE THAN 90 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.



**ROWING BOAT**  
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 crumbling away.



**1 PRESERVING**  
After removal, the organs were preserved in canopic jars – pots 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.

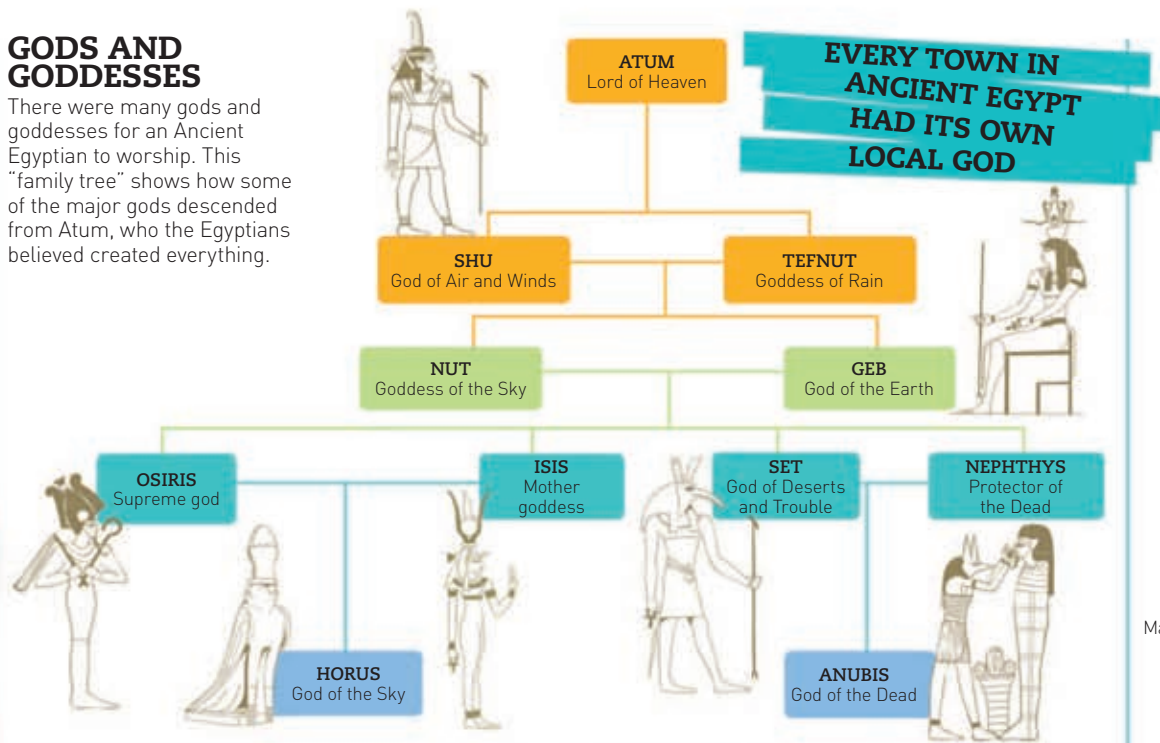


**5 BURIAL**  
The mummy was put in an inner, body-shaped case and then an outer coffin, both decorated with pictures and symbols.



## 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. The "alphabet" seen here 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

## JEWELLERY

The Ancient Egyptians prized jewellery. Rings, necklaces, and amulets in the form of sacred symbols were popular. Jewellery worn by rich people was often made of gold and valuable stones.



WINGED SCARAB AMULET



Egyptian Empire 1549-1069 BCE



GOLD AMULET



EARRING



FINGER RINGS



BEAD NECKLACE

## 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 major dynasties (ruling families), kingdoms, and periods.

### EARLY DYNASTIC PERIOD

c. 3000-2686 BCE  
Organized government under the rule of the pharaohs begins. People start to use hieroglyphs.

3000 BCE



The Sphinx at Giza

### OLD KINGDOM

2686-2125 BCE  
The great pyramids and the Sphinx are built at Giza.

### 1ST INTERMEDIATE PERIOD

2160-2055 BCE  
Many power struggles between dynasties.



Slab for mixing ointment, made around 2000 BCE

### MIDDLE KINGDOM

2055-1650 BCE  
Life is more settled. Improved irrigation produces better crops.



Bead collar

### 2ND INTERMEDIATE PERIOD

1650-1550 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.



Bronze statue, which may have held a cat mummy

### LATE PERIOD

664-332 BCE  
Time of much temple building and animal mummifying.

### PTOLEMAIC DYNASTY

332-30 BCE  
Cleopatra VII, the last pharaoh, dies. Rome conquers Egypt.

30 BCE



Coin showing the head of Cleopatra



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.



Model of a Minoan house

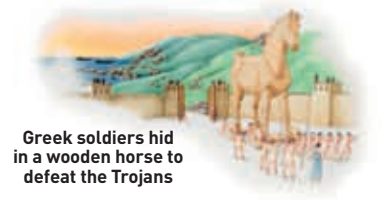
**2200–1450 BCE**  
Height of Minoan palace culture in Crete.

**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 30,000.



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 ten years.

## 2500 BCE

**MINOAN PERIOD**  
2500–1600 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 Mycenaean 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, theatre, 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 jewellery. Well-born women ran the household, helped by slaves.



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 POT



MODELS DRESSED AS ANCIENT GREEKS



SANDAL-SHAPED PERFUME BOTTLE



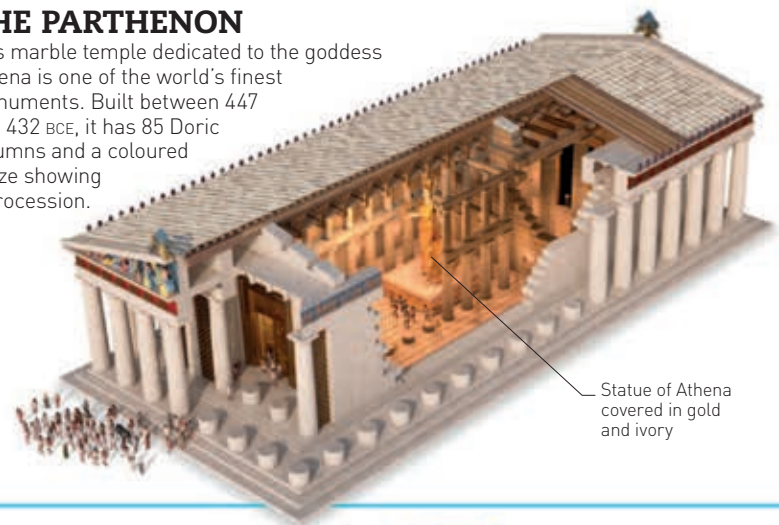
POWDER BOX



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 coloured frieze showing a procession.



Statue of Athena covered in gold and ivory

## OLYMPIC GAMES

The Olympic Games were held in honour 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-metre "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 theatre flourish, especially around the main centre, Athens.

HELLENISTIC PERIOD

323-31 BCE

Alexander the Great begins the Hellenistic Age 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

WAR AND ARMOUR

The main fighting force of the Greek city-states were hoplites, heavily armoured foot-soldiers who carried a large round shield, or *hoplon*. They fought in phalanxes (shield walls), several rows deep, to protect the soldiers.



HOPLITE ARMOUR

WEAPON CALLED "KOPIS" IN SHEATH



XIPHOS, ANCIENT GREEK SWORD



WARRIOR SHIELD (HOPLON)



SOLDIER'S AXE AND SANDAL



ANCIENT GREEK ARMY HELMET

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

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.530 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

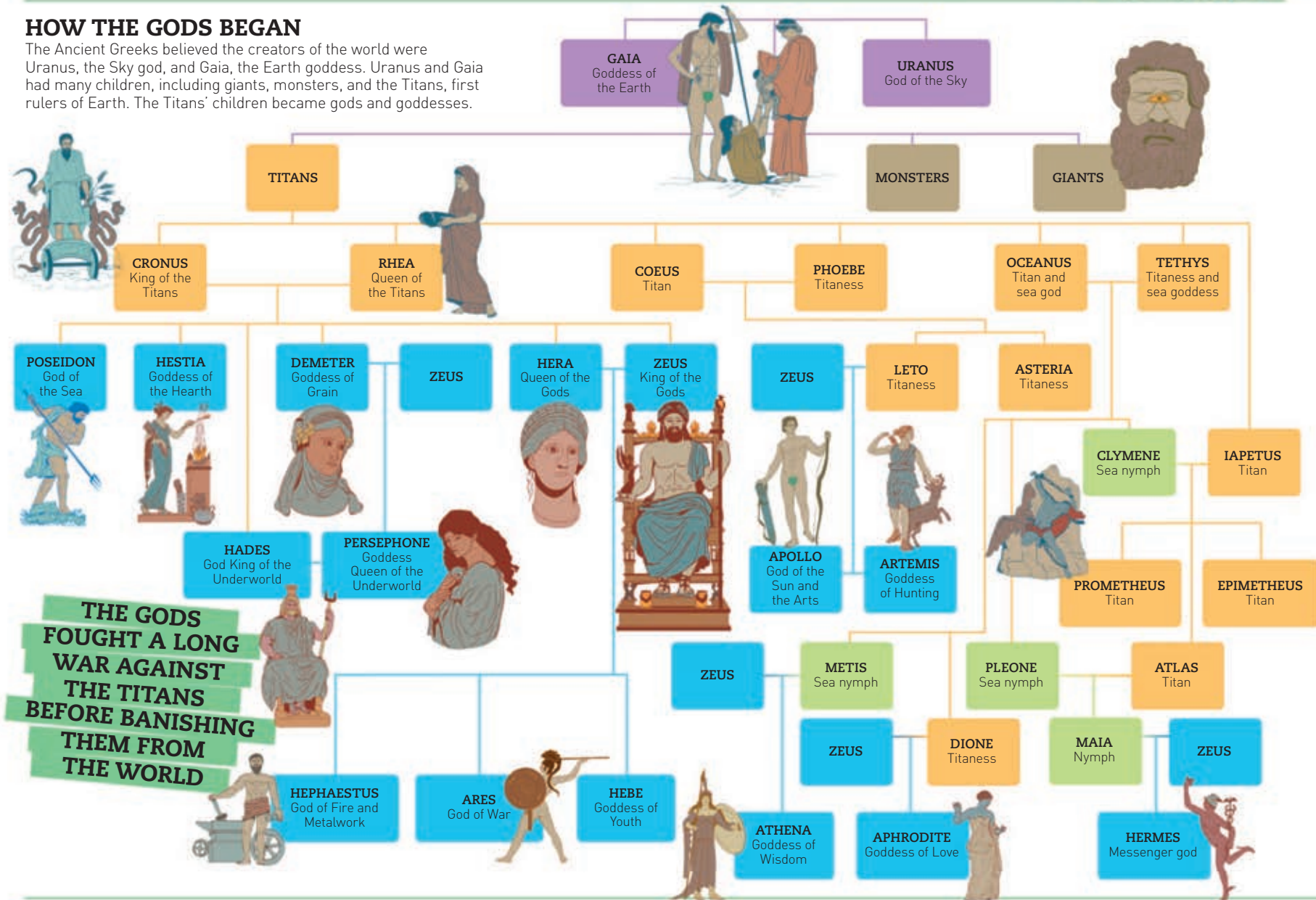
In Greek mythology, the gods were powerful supernatural beings who could make anything and everything happen. There were 12 major gods and goddesses, of whom Zeus was king. The gods lived in their palaces on the top of snow-capped Mount Olympus, the highest mountain in Greece.



MOUNT OLYMPUS

## HOW THE GODS BEGAN

The Ancient Greeks believed the creators of the world were Uranus, the Sky god, and Gaia, the Earth goddess. Uranus and Gaia had many children, including giants, monsters, and the Titans, first rulers of Earth. The Titans' children became gods and goddesses.



## THE UNDERWORLD

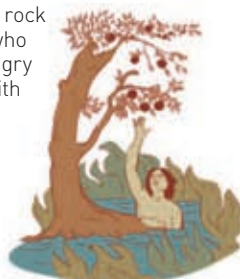
In the myths of Ancient Greece, the realm of the dead was known as the Underworld, a shadowy kingdom ruled by the god Hades. There were demons and monsters there. One of the most frightening was the three-headed dog Cerberus, who stood guard at the gates. The souls of those who had died were ferried to the Underworld in a boat across an ink-black river called the Styx.



CERBERUS

## PUNISHMENTS FROM THE GODS

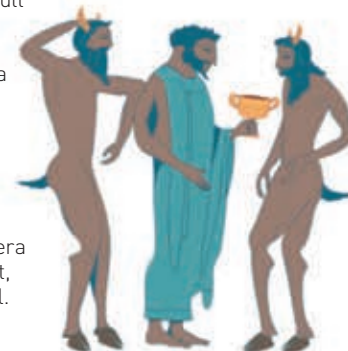
Many people were condemned to perpetual punishment in the Underworld because they had offended the gods. For example, Sisyphus, who had tried to become immortal, was made to push a huge rock uphill for ever. Tantalus, who insulted the gods, felt hungry and thirsty all the time, with food and drink just 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 Chimaera 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.



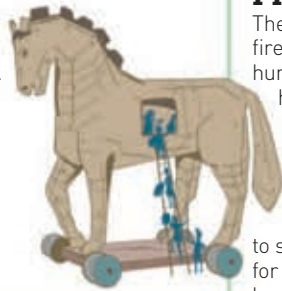
## BELLEROPHON AND PEGASUS

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.



## 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, and then followed the thread to find his way out of the maze.



## 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 for ever, but the hero Heracles 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 was allowed to claim his throne.



## THE 12 LABOURS OF HERACLES

When the hero Heracles went mad and killed his wife, 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. Heracles managed to strangle the beast.

### 2 SLAYING THE HYDRA

The Hydra was a many-headed monster. Every time Heracles 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 gruelling chase, Heracles caught a golden-horned deer belonging to the goddess Artemis.

### 4 THE ERYMANTHIAN BOAR

Heracles defeated this ferocious boar by trapping it in a snowdrift.

### 5 THE AUGEAN STABLES

The filthy stables of King Augeas had never been cleaned. Heracles changed the courses of two rivers to wash all the dirt away.

### 6 THE STYMPHALIAN BIRDS

To get rid of some monstrous birds, Heracles frightened them into the air by playing castanets, and then shot them.

### 7 THE BULL OF KING MINOS

Heracles captured a huge and dangerous bull belonging to the king of Crete.

### 8 THE MAN-EATING MARES

Heracles 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. Heracles dared to steal her valuable belt.

### 10 THE CATTLE OF GERYON

Sent to the edge of the world, Heracles stole the cattle belonging to a giant herdsman.

### 11 GOLDEN APPLES OF HESPERIDES

In yet another theft, Heracles 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, Heracles went to the Underworld and captured the three-headed dog, Cerberus, that guarded the gates. The hero was finally forgiven for his crime.



## DEMETER AND PERSEPHONE

Demeter, 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

## PANDORA'S JAR

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, 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 ODYSSEY

Among the most often-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 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 Forty years later, Rome took parts of Spain and North Africa in the Second Punic War. 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.

**KEY**  
 Roman Empire

## 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.

**GLADIUS**  
 The Roman legionary sword, or gladius, was about 50 cm (20 in) long.



**SHIELD**  
 The legionary shield protected the whole body. Its edge could also be used to strike opponents.



**HELMET**  
 Roman helmets had a metal bowl to protect the head, often with cheek pieces, and a horse-hair crest across the top.

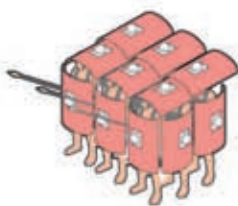
**ARMOUR**  
 Body armour was usually formed of rectangular metal or leather strips.

**KNEE GUARDS**  
 Greaves protected their knees from sword blows.

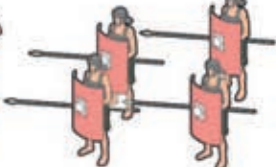
**SANDALS**  
 Soldiers wore leather sandals with nails hammered into the soles.

## TACTICS AND FORMATIONS

The Romans were very effective foot (infantry) soldiers. 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.

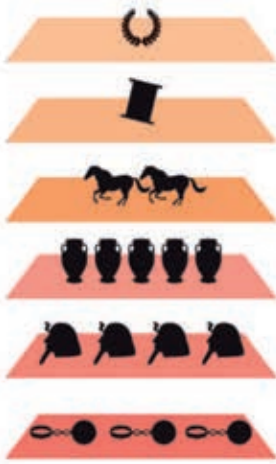


**CAVALRY DEFENCE**  
 The front line held their javelins out at a 45-degree angle to defeat cavalry.



## 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 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 equestrians.

**TRADERS AND WORKERS**  
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

OIL FLASK

GLASS BOTTLE

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

507–27 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.

## 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.

### 261–241 BCE

Rome wins the first Punic War against the North African city of Carthage.



Soldiers in Carthage look at boats burning in 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.

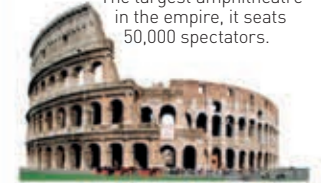


Bust of Julius Caesar

### 80 BCE

One of the great examples of Roman engineering, the Colosseum is finished.

The largest amphitheatre 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 theatre, public baths, and horse races. However, the most popular form of entertainment was gladiatorial contests in arenas such as the Colosseum in Rome.



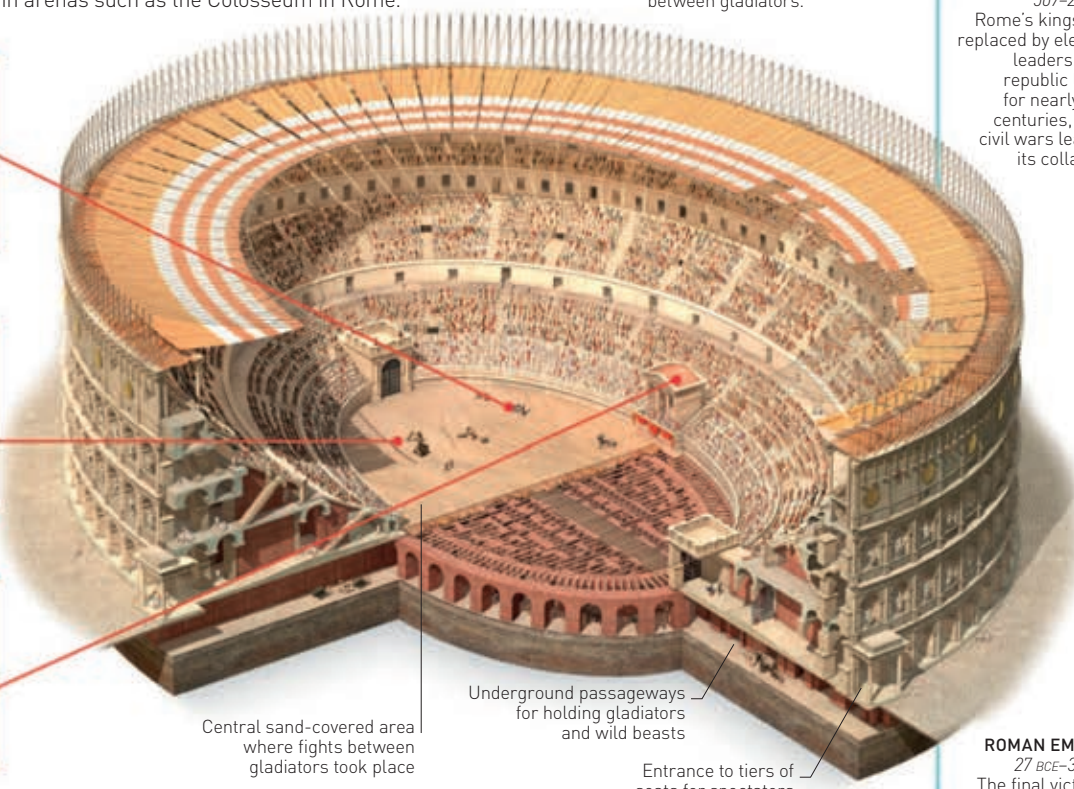
GLADIATORS



UNDERGROUND LIFT



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

## COLOSSEUM

In this huge arena people came to see acrobats, wild beast fights, executions, and battles between gladiators.

## 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	II	III	IV	V
1	2	3	4	5
VI	VII	VIII	IX	X
6	7	8	9	10
L	C	D	CM	M
50	100	500	900	1,000

### EASTERN AND WESTERN EMPIRE

395–476 CE

As the Roman Empire faces new threats, a single emperor cannot defend it. The rule is split between two emperors – one based in Rome and the other in Constantinople.

476 CE



# 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 travelled 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.



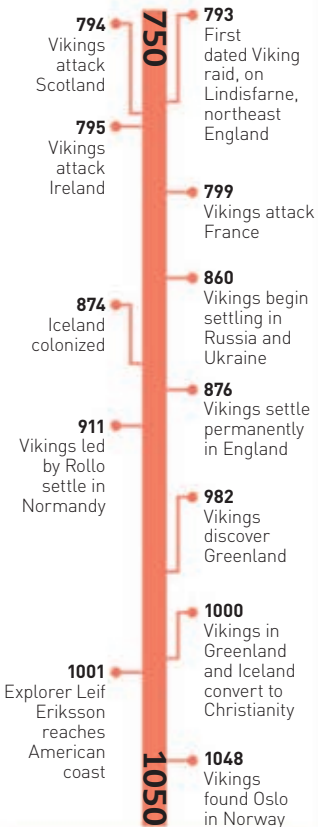
CHILD

MOTHER

MERCHANT

## RAIDING RECORD

The 300-year Viking history is marked out 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 jewellery. 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.



**ARM BAND**  
Solid silver arm ring with moulded beading.



**BUCKLED UP**  
Patterned buckle plate.



**BURIAL CHEST**  
Decorated oak chest made for a ship burial.



**MINI CUP**  
Tiny silver cup with engraved pattern.



**HUNTING HORN**  
Made from the horn of an ox.



**"EASTER" EGG**  
Christian symbol of rebirth from Russia.



**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

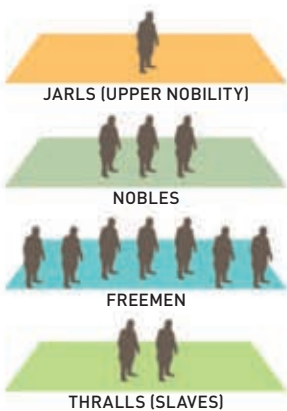
The ancient Norse myths explain how the world and the first people were created. The stories are full of dragons, magic, warring gods, and giants as wild as the Vikings themselves. According to Norse myth, there is a great battle still to come, which will end this world and start a new one.



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, craftsmen, and farmers. Lowest on the scale were slaves, or thralls, many of them prisoners of war.



## RUNES

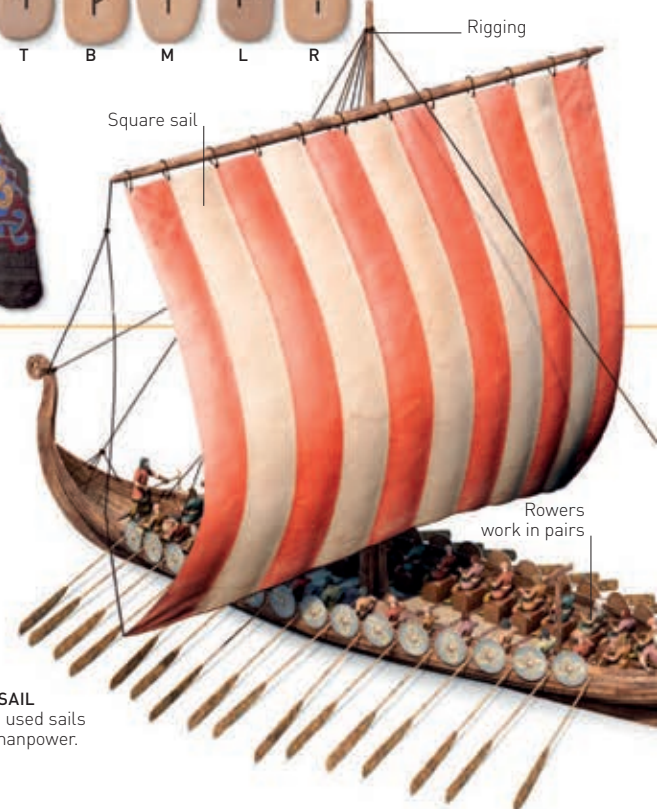
The Vikings used an alphabet of letters known as runes. These runes can be seen today carved into memorial stones, such as the famous Jelling Stones in Denmark, or as messages on pieces of wood and bone.

**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

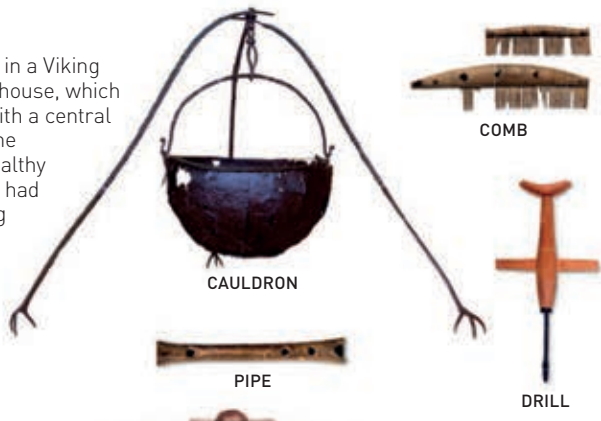
WARRIORS

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



**HOLY CASKET**  
Container for Christian relics.

**ARMS AND ARMOUR**

An axe, a sword, and sometimes bow and arrows were Viking battle gear. An iron helmet and a wooden shield warded off enemy blows.



**FANTASTIC BEAST**  
Gilded bronze fitting from a horse's bridle.



**SILVER WARRIOR**  
Figure of a horseman bearing a sword.

**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 snakepit to die.
- **BJORN JARNSMIDA**  
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.
- **ROLLO**  
In the 9th century, this Norse chief founded a settlement in what is now Rouen in northern France.
- **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.



VIKING KNIFE



LEIF THE LUCKY



SHIELDS



HELMETS



DAGGERS



NORWEGIAN HELMET

Welded iron plates

Chain mail to protect neck



AXES

ARROWS

Longbow



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 4,000 km (2,486 miles) 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, centred in modern-day Peru. These cultures, although different in many ways, all left behind beautiful art and the remains of spectacular cities.



**MACHU PICCHU**  
A remote outpost of the Inca empire, up to half of its 143 buildings may have been used for religious ceremonies.

## 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.
- **TEOTIHUACAN (1–750 CE)**  
Built Teotihuacan, the largest and most impressive city in the ancient Americas.
- **NAZCA (100–800 CE)**  
Best known for the massive pictures and shapes (geoglyphs) they etched on the ground in southern Peru.
- **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 craftsmen. 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 Tenochtitlan in 1325, which became the centre 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.



**CHICHEN ITZA**  
Maya city that was an important trading centre.



**CUZCO**  
The religious and political capital of the Incas.



**TEOTIHUACAN**  
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 Inca and their neighbours 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 Zapotec build Monte Alban as their capital and religious centre.

c.900–1000 CE  
Toltecs build their capital at Tula, Mexico.



Toltec pottery

1325

Aztec city of Tenochtitlan founded on an island in Lake Texcoco.



Tenochtitlan marketplace

1519–21

Explorer and soldier Hernando 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 Olmec 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.

c.1300  
Incas begin to expand their empire through the central Andes.



Cuzco, Inca capital

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 ten 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.



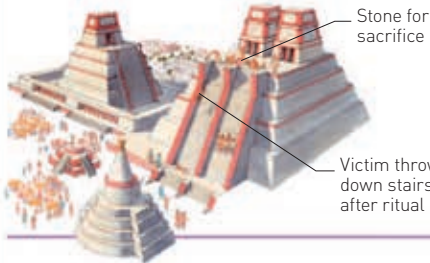
MAMA KILLA  
Inca goddess of the moon.



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.



Stone for sacrifice

Victim thrown down stairs after ritual

## 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**



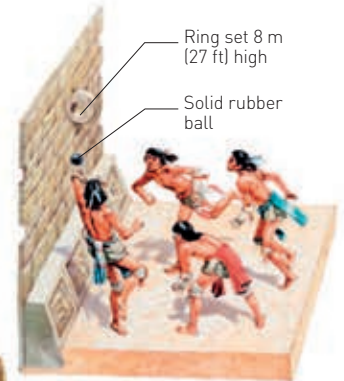
JAGUAR WARRIORS  
For taking captives, Aztec warriors were awarded distinctive costumes.



AZTEC 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.



Ring set 8 m (27 ft) high

Solid rubber ball

## 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  
Teotihuacan, 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, and also 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 further 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.

**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 further into Europe.

**1683**  
The Ottomans are defeated at the Battle of Vienna, starting the decline of the empire.

**2000**

**1300**  
The Ottoman Empire is founded by Osman I in Anatolia, northwest Turkey.



**Edirne mosque**

**1538**  
Ottoman navy wins control of the eastern Mediterranean at the Battle of Preveza.



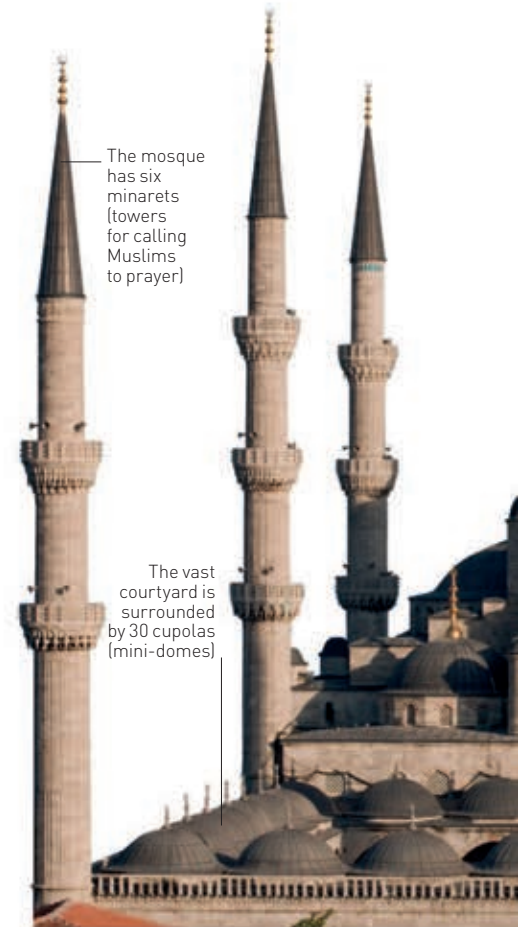
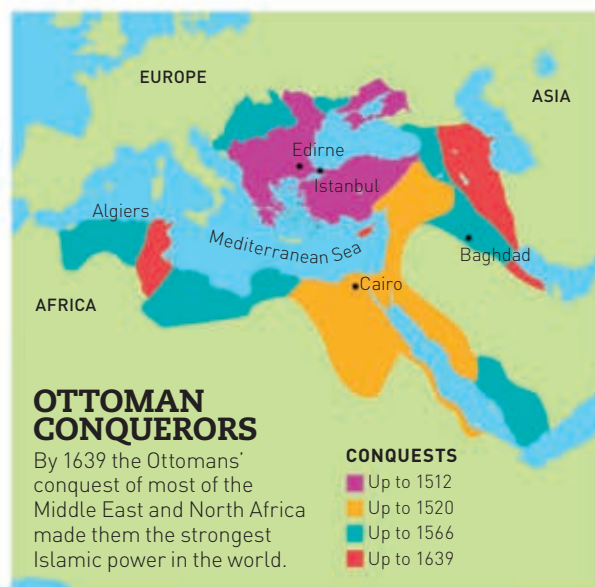
**Suleiman I in battle**



**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) (1432–81)**  
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) (1494–1556)**  
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.
- ABDULMECID I (1823–61)**  
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.

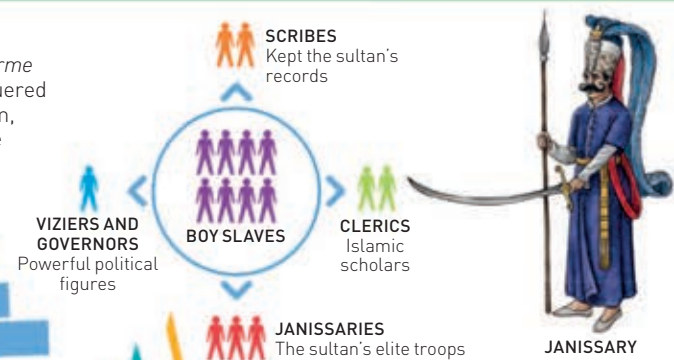


**SULEIMAN I THE MAGNIFICENT**

## THE SULTAN'S LOYAL MEN

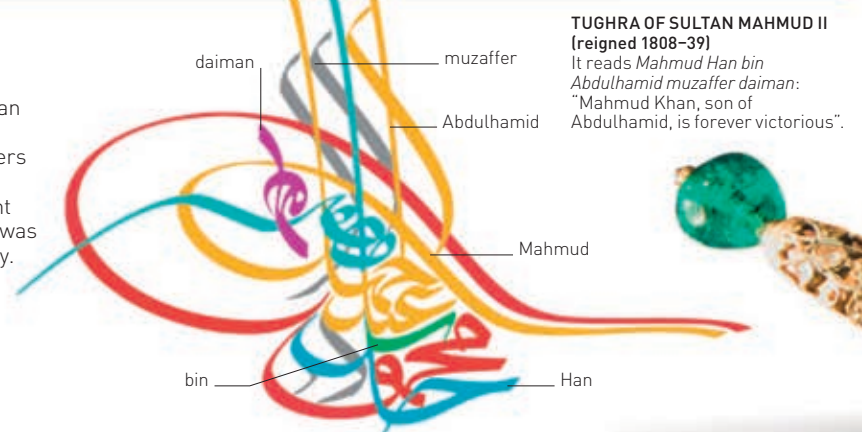
The Ottomans operated a system called *devshirme* (gathering), in which Christian boys from conquered countries were made slaves, converted to Islam, and taught total loyalty to the sultan. They were then trained to do important jobs within the sultan's household and army.

**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 *nışancı* (court calligrapher) on to court papers.





## 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 1609 and 1616.

The central dome is 23.5 m (77 ft) in diameter



**DOLMABAÇE 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 ARMOUR

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 armour.



HIDE AND COPPER CHICHAK (HELMET)



CUIRRASS (BODY PROTECTOR)



STEEL HELMET



MACE, DAGGER, AND SWORD



BREASTPLATE



CHAIN-MAIL ARMOUR



CAVALRY BOOTS



KALKAN (SHIELD)

## JEWELS AND FINERY

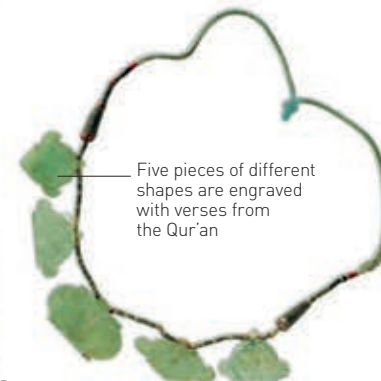
The Ottomans' taste was influenced by the variety of cultures across their vast empire. Jewellery was ornate and generally mixed different metals and gems in one piece. Emeralds and jade were popular because green was associated with the prophet Muhammad.



Hilt is decorated with three Colombian emeralds



**SPOONMAKER'S DIAMOND**  
86-carat, pear-shaped diamond in gold and 49-diamond setting.



Five pieces of different shapes are engraved with verses from the Qur'an

**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.

**1500**

**1526**  
Babur conquers Delhi in northern India. The Mughal age begins.

**1556**  
Babur's grandson, Akbar, becomes emperor.

**1540**  
Humayun, Babur's son, loses power to a rival Afghan dynasty but seizes it back in 1555.

**1605**  
Jahangir becomes emperor on Akbar's death.

**1563**  
Akbar begins to pass laws granting Hindus religious and political freedom.



**Akbar and his Hindu bride**

**1613**  
British East India Company allowed to build a warehouse in Surat, Gujarat.

**1627**  
Jahangir dies at the age of 58.



**Tomb of Mumtaz Mahal**

**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.



**Indian Mutiny, 1857**

## 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. Only a century later, they had lost nearly all their territory.



## 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.



**AKBAR'S TOMB**

### ○ JAHANGIR (1569–1627)

A enthusiastic patron of the arts. His wife, Nur 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.

## ARMOUR 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**

**ARM GUARD**

**MACE**

**TABAR (BATTLE AXE)**

**IVORY GUNPOWDER HORN**

**DAGGERS AND SCABBARD**

**SWORDS**

**TONGI**

## 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.



Constellation Ursa Major, the Great Bear

Band representing the Zodiac

Longitude markings

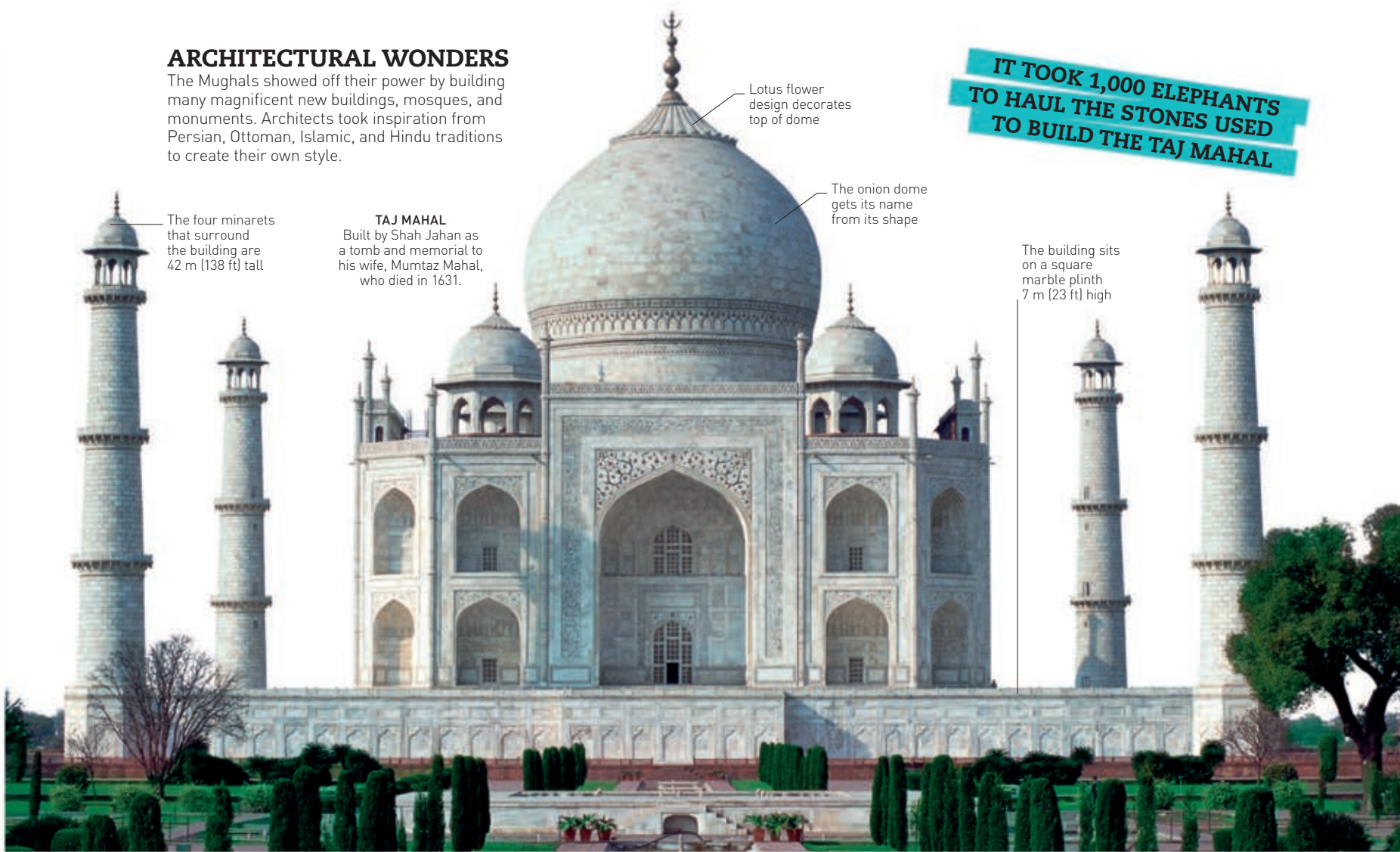
**BRASS CELESTIAL GLOBE (1790–91)**  
Shows the position of the stars and their constellations.



## 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 42 m (138 ft) tall

**TAJ MAHAL**  
Built by Shah Jahan as a tomb and memorial to his wife, Mumtaz Mahal, who died in 1631.

Lotus flower design decorates top of dome

The onion dome gets its name from its shape

The building sits on a square marble plinth 7 m (23 ft) 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 1570, this magnificent garden tomb was the first major building of the Mughal period.



**MOTI MASJID (PEARL MOSQUE)**

Built in Old Delhi (1659–60) by Emperor Aurangzeb, 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).



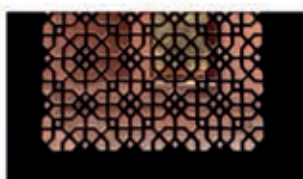
**LEAF GEOMETRIC DESIGN**



**FLOWER DESIGN MARBLE INLAY**



**CALLIGRAPHY ON MOSQUE ENTRANCE**



**OCTAGON AND SQUARE PATTERN**

## DAZZLING CRAFTWORK

Art was greatly valued by the Mughals. The most skilled painters, craftworkers, jewellers, 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**



**ENAMELLED KNIFE HILT**



**JEWEL-INLAID PENDANT**



**JADE JUG**



**MINIATURE PAINTING**

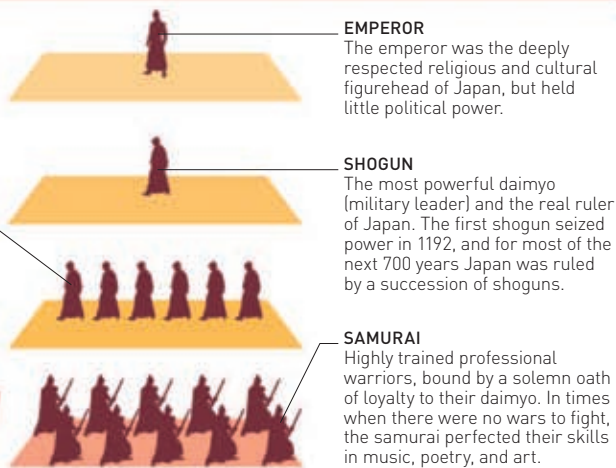


# Imperial Japan

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 honour 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 SEI 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 (1147–99)**  
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 (1301–38)**  
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 (1542–1616)**  
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 neighbours, 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*. Worshippers 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 armour, made from metal scales, allowed for easy movement



SAMURAI SUIT OF ARMOUR, 19TH CENTURY



## SAMURAI CODE

Loyalty and honour 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>	Honour		

## 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 craftsmen produced beautiful work, from delicate ivory carvings to bold, colourful paintings and prints showing city life.



WOODBLOCK PRINT OF EDO BY UTAGAWA HIROSHIGE 1857

## MUSIC AND THEATRE

Going to the theatre and listening to music were popular pastimes for the wealthy. Noh theatre 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



BRASS LANTERN  
18th century



WRESTLER'S  
NETSUKE 1800-50



CERAMIC  
INCENSE  
BURNER  
1600-50



PRINTED  
FAN  
1858



TEA KETTLE  
Edo period



PORCELAIN  
TEA BOWL  
1700-50

**KAMAKURA**  
1185-1333  
This period sees a huge rise in power of the daimyo and the samurai who serve them.

**KENMU**  
1333-36  
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.

**MEIJII**  
1868-1912

**TAISHO**  
1912-26

**SHOWA**  
1926-89

**HEISEI**  
1989-

700

## 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".



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 craftsmen.



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.

2000



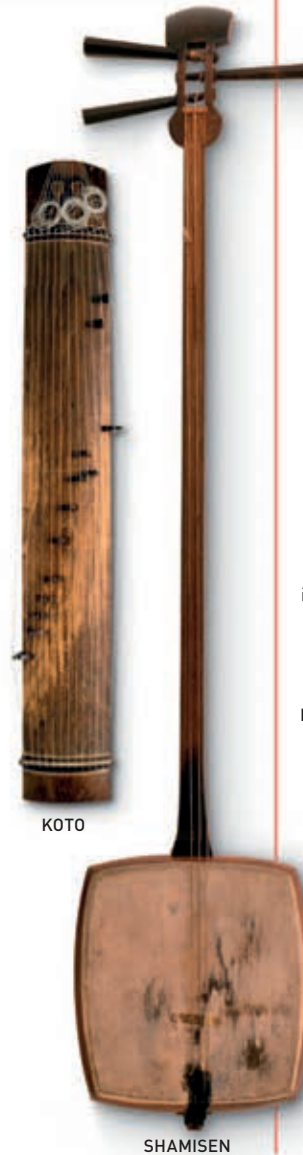
DAGGER  
(WAKIZASHI)

SKEWER

SWORD  
(KATANA)

GLAIVE  
(NAGINATA)

SPEAR



KOTO

SHAMISEN



# 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 8,850 km (5,500 miles) long.

1650 BCE

## 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.

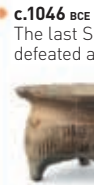
- SHANG**  
c.1650–1046 BCE  
China's first great ruling dynasty.
- ZHOU**  
c.1046–256 BCE  
Feudal system begins: lords rule over the peasants who work on their estates.
- WARRING STATES**  
481–221 BCE  
As the Zhou decline, there is a period of struggle for control of China.
- QIN**  
221–207 BCE  
China is united under one emperor.
- HAN**  
207 BCE–220 CE  
Civil service is established, which will run China for the next 2,000 years.
- 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.
- FIVE DYNASTIES AND TEN KINGDOMS**  
907–960  
China is once again divided into north and south.
- SONG**  
960–1279  
Advances in technology bring wealth and prosperity.
- YUAN**  
1279–1368  
The conquering Mongols establish their own dynasty.
- MING**  
1368–1644  
Exquisite art and crafts are produced throughout the period.
- QING**  
1644–1912  
The empire declines steadily and is eventually overthrown.

**c.1500 BCE**  
Craftsmen learn large-scale production of bronze weapons and tools.



**Bronze wine beaker, Shang dynasty**

**c.1250 BCE**  
Earliest evidence of writing in China.



**Rice pot, Zhou dynasty**

**c.1046 BCE**  
The last Shang ruler is defeated at the Battle of Muye.

**771 BCE**

King You is killed and Haojing, the capital, is overrun by invaders. The Zhou court flees east.



**Confucius**

**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**

**105 CE**

An imperial court official reports the invention of paper.

**c.250**

Buddhism is introduced to China.

**618**

China's golden age begins, a period of great artistic and scientific developments.



**Horse figure, Tang dynasty**

**1100**

China's population grows to about 100 million.



**Porcelain vase, Song dynasty**

**1279**

Mongol invaders, led by Kublai Khan, conquer China.



**Mongol warrior**

**1420**

Beijing is named as the new capital of China.



**Plate, Ming dynasty**

**1839–1860**

In the Opium Wars, China and Western nations battle over trade.

**1912**

2,000 years of imperial rule come to an end when six-year-old emperor, Puyi, is deposed.

## 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 from 1406–21.



**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 neighbouring 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 eight. 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



**SHIP'S RUDDER**  
c.100 CE

## 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





**THE MORTAR USED TO BIND THE BRICKS OF THE GREAT WALL WAS PARTLY MADE FROM RICE FLOUR**



### THE SILK ROAD

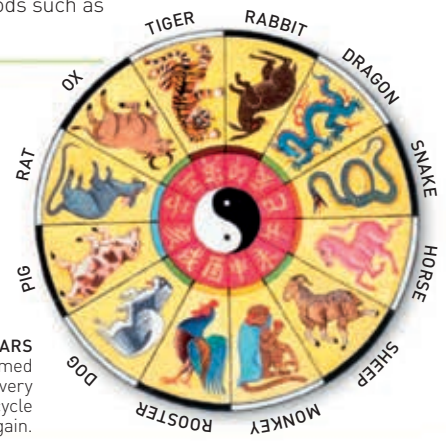
The Silk Road was a route that ran from China across Asia towards Europe. It was protected by the Chinese, so that traders from all over the world could use it safely. Chinese merchants became very rich by exporting goods such as silk, tea, porcelain, and spices.

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.



**PAPER**  
105 CE

**EARTHQUAKE DETECTOR**  
132 CE

**KITE**  
c.550 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**  
1736–95



**PEWTER TEA CADDY**  
18th century



**GLAZED CAMEL**  
618–906 CE



**GLASS BOWL**  
1825–75



**IVORY PUZZLE BOX**  
1800–1900



**PORCELAIN TEAPOT**  
1662–1772



**EMBROIDERED SHOES**  
Many women's feet were tightly bound, to make them as small as possible.

### 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 fibres.



**JADE PENDANTS**



**IVORY FAN**



**CIVIL SERVANT'S HAT**



**SILK ROBE**



# 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 colourful 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 colours, as well as expensive materials and furs.



NOBLEMEN

NOBLEWOMEN

KNIGHT IN DOUBLET AND HOSE

**AN ORDINARY PERSON COULD BE FINED FOR WEARING PURPLE, WHICH WAS A COLOUR FOR ROYALTY ONLY**



COURTIERS

PEASANTS

CHILD

## 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.



BOLTON ABBEY  
England

ST DEMETRIOS OF THESSALONIKI  
Bulgaria

CHATEAU DE BEYNAC  
France

TRAKAI ISLAND CASTLE  
Lithuania

MONT-SAINT-MICHEL  
France

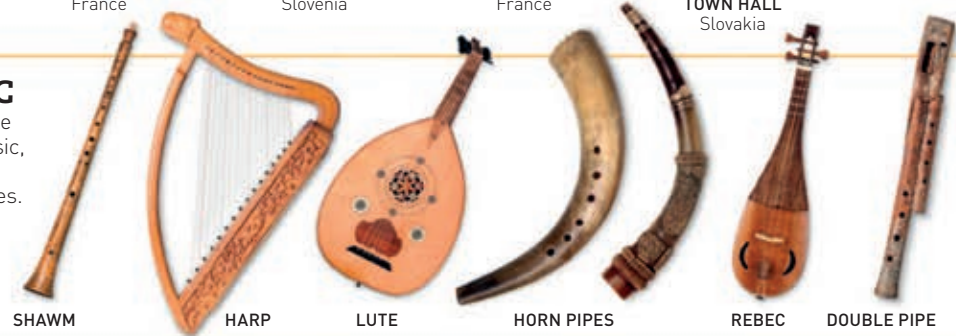
HOLY TRINITY CHURCH  
Slovenia

CHATEAU DE FOUGERES  
France

BARDEJOV TOWN HALL  
Slovakia

## 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.



SHAWM

HARP

LUTE

HORN PIPES

REBEC

DOUBLE PIPE



WALKING LION

CASTLE

FOUR CROSSES

THISTLE

EAGLE

HARPY (DEMON)

DRAGON

BEE

DOLPHIN

OWL

HUNTING DOG

REARING UNICORN

## 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 armour. The symbols were arranged under a system called heraldry. There were strict rules about colours and designs, and who was allowed to use them.



Visor can be raised and lowered

Guard for armpit

Moving plates at shoulder

Cuisse (thigh guard)

Poleyn (knee guard)

Greave (shin guard)

KNIGHT IN FULL ARMOUR



## 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, 1096–99
- 2nd Crusade, 1145–49
- 3rd Crusade, 1189–92
- 4th Crusade, 1202–04

## 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.



**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.

**896** Alfred the Great defeats the Vikings, saving England from invasion.



**Jewel with portrait of Alfred the Great**



**French fortress built for William the Conqueror**



**Church inside Crusader fortress**

**1066** William the Conqueror of Normandy conquers the English at Hastings and becomes king of England.

**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**

**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.

**1347** The disease called the Black Death begins and will kill about half the people in Europe.

**1440s** German craftsman Johannes Gutenberg invents the printing press.

## 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.



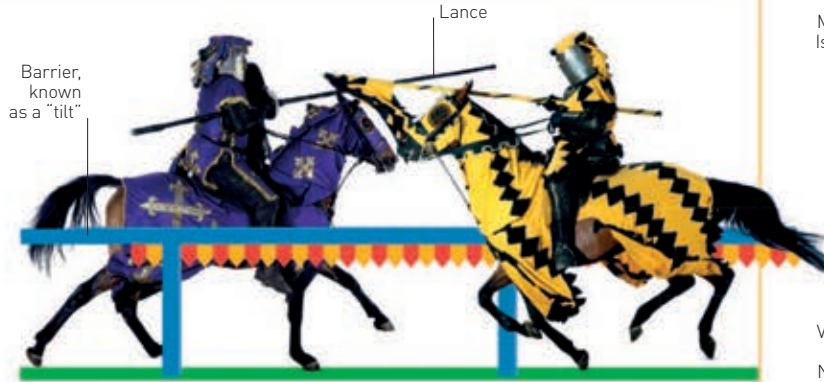
**JOUSTING HELMET**



**VAMPLATE (HAND GUARD)**



**LOCKING-GAUNTLET**

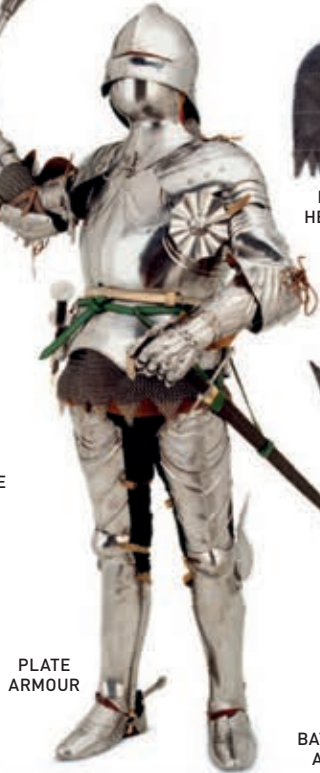


## ARMOUR AND WEAPONS

In the 12th century, knights wore chain-mail armour 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.



**GILDED PLATE ARMOUR**



**PLATE ARMOUR**



**CUIRASSIER**



**ARMET**



**BURGONET**



**BASINET**



**MAIL HELMET**



**MAIL JACKET**



**HORSE HEAD ARMOUR**



**BATTLE AXE**



**POLE AXE**



**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**

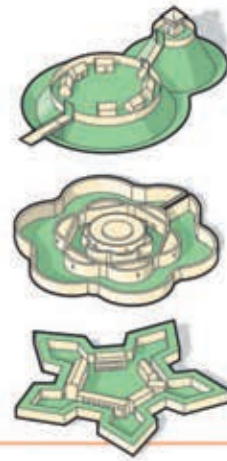


# Castles

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.



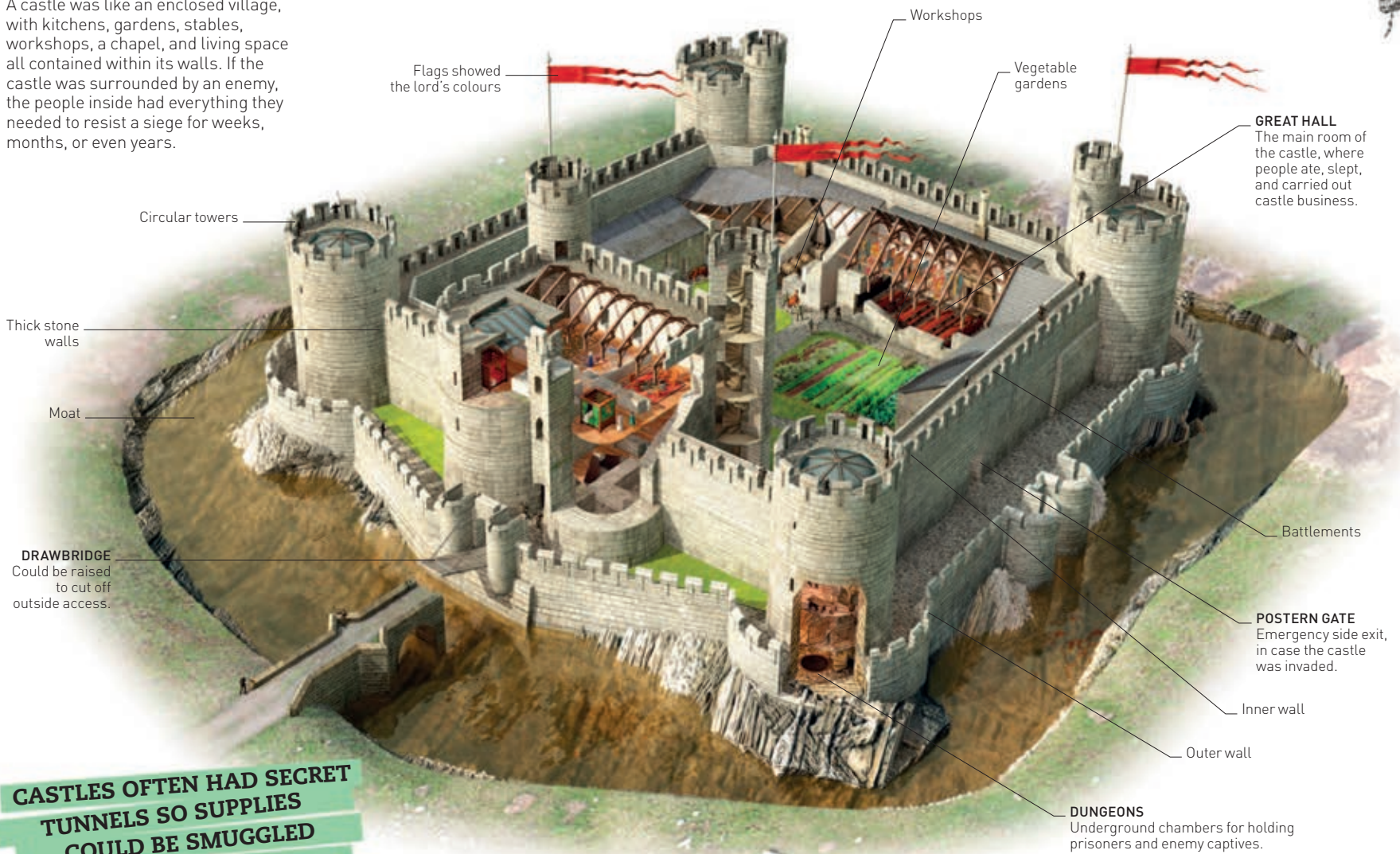
**MOTTE AND BAILEY**  
11th and 12th centuries. A wooden castle is built on a motte (mound), surrounded by a fortified enclosure.

**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.



**CASTLES OFTEN HAD SECRET TUNNELS SO SUPPLIES COULD BE SMUGGLED IN DURING A SIEGE**

## BUILT FOR DEFENCE

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 site his castle on a hillside or cliff top so that he and his men had a good view of anyone approaching.



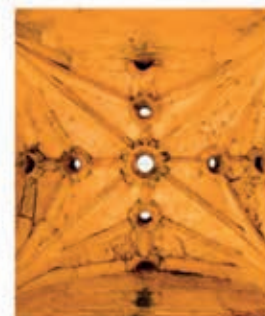
**MOAT**  
A wide, steep-walled ditch around the castle, usually filled with water.



**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.



Stonemason wears a coif (cloth cap) to show his profession

### PULLEY WORK

Workers use a pulley to haul a basket of stone up to where it is needed.

## SIEGE WEAPONS

There were two ways for attackers to overcome the defences of a castle.

They could either take it by force by battering down the gate, climbing the walls, or tunnelling under the defences. 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.



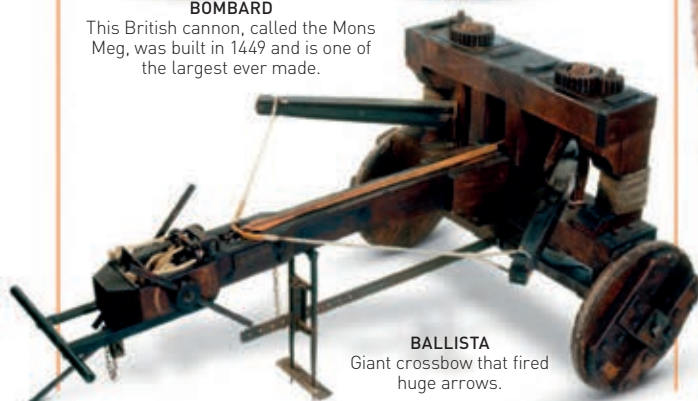
### BOMBARD (CANNON)

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, craftsmen, 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 seven, 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 armour 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



BAGOT GOAT



GOOSE



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)



SAUMUR CASTLE, FRANCE (10TH-16TH 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 towards 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



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.



Statue on the tomb of Pope Julius II

1503

Pope Julius II commissions many artists, including Michelangelo and Raphael, to create work for him in Rome.

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 Andrea Vesalius publishes the first textbook about the human body and how it works.



Woodcut portrait of Andreas Vesalius

1546

Michelangelo 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 is 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

## FLYING MACHINE

Leonardo da Vinci's design for the ornithopter, a human-powered aircraft.

## 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.



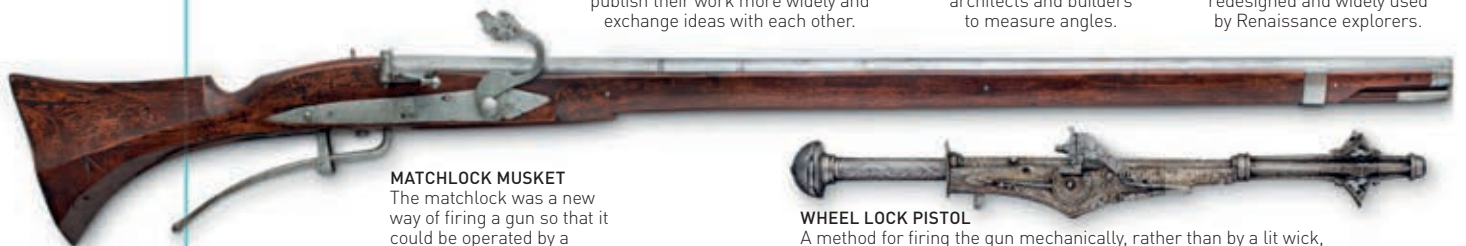
THEODOLITE

An instrument to help architects and builders to measure angles.



ASTROLABE

An ancient navigation aid, redesigned and widely used by Renaissance explorers.



## MATCHLOCK MUSKET

The matchlock was a new way of firing a gun so that it could be operated by a single person.

## WHEEL LOCK PISTOL

A method for firing the gun mechanically, rather than by a lit wick, it was safer and more portable than the matchlock weapon.



## MUSICAL INSTRUMENTS

Music was the main form of entertainment in Renaissance Europe. Composers experimented with new instruments and different ways of singing in harmony.



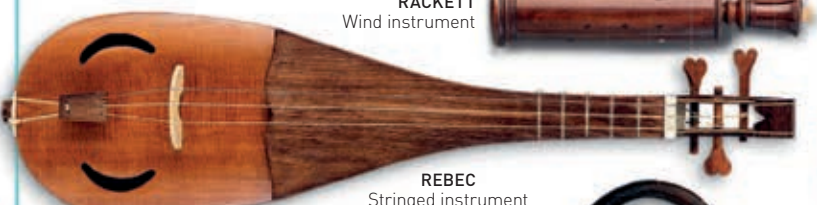
**RAUSCHPFEIFE**  
Reeded wind instrument



**BASS RECORDER**  
Wind instrument



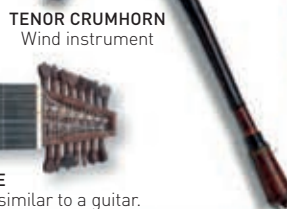
**RACKETT**  
Wind instrument



**REBEC**  
Stringed instrument played with a bow.



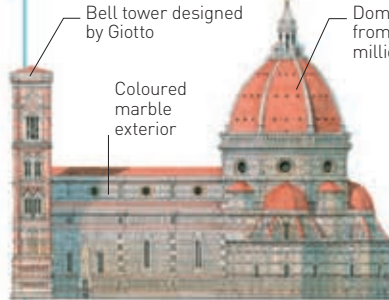
**LUTE**  
Stringed instrument, similar to a guitar.



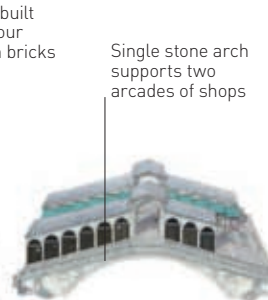
**TENOR CRUMHORN**  
Wind instrument

## 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

Dome built from four million bricks

Coloured marble exterior

Single stone arch supports two arcades of shops



**VIRGIN AND CHILD** (c.1480)  
Carlo Crivelli

## A REVOLUTION IN ART

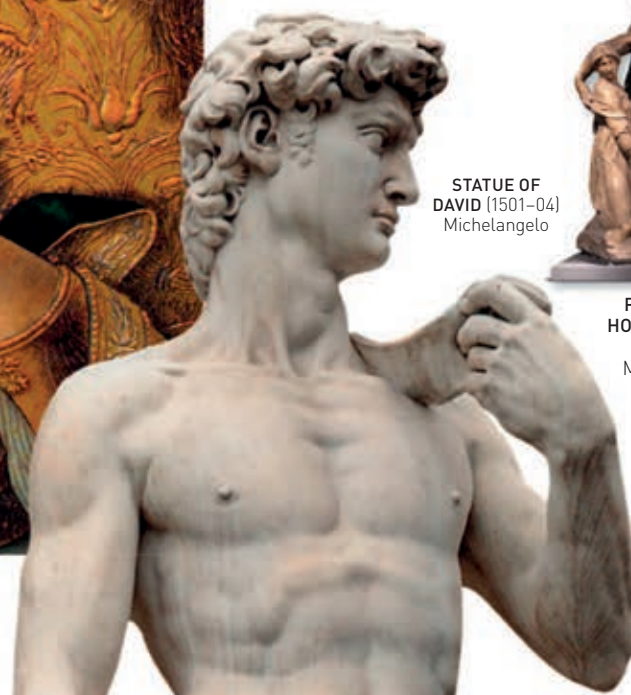
A way of thinking called humanism became popular during the Renaissance. Humanism's focus on the experiences and achievements of real human beings had a huge influence on artists. They started to portray people, including religious figures, as realistically as possible, and to place them in more everyday situations.



**MONA LISA** (1503–06)  
Leonardo da Vinci



**FRESCO (WALL PAINTING) OF THE QUEEN OF SHEBA** (1466)  
Piero della Francesca



**STATUE OF DAVID** (1501–04)  
Michelangelo



**PIETA (MARY HOLDING JESUS)** (1553)  
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 further 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 further 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 modern-day 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.

1519-21

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 man 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 modern-day 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

1577-80

Englishman Sir Francis Drake circumnavigates the globe (sails round the world).



Statue of Sir Francis Drake

1642

Abel Tasman explores Van Diemen's Land (now Tasmania).



Deep-sea diving helmet

1819

Augustus Siebe invents a helmet that enables divers to work at a depth of 60 m (196.8 ft).



Arctic explorer's sealskin hood and gloves

1911

Norwegian Roald Amundsen and his team reach the South Pole.



Amundsen arriving at the South Pole

1969

Neil Armstrong, commander of USA's Apollo 11 mission, sets foot on the moon.



Apollo 11 commemoration badge

# Exploration

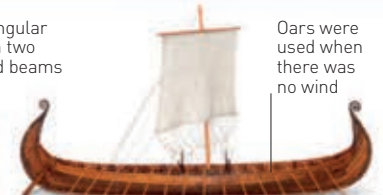
The first explorers set sail in search of new places to buy and sell goods. Later, people led expeditions to get rich, to claim territory for their country or religion, to make scientific discoveries, or simply for the thrill of adventure.

## 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.



PHOENICIAN TRADING SHIP

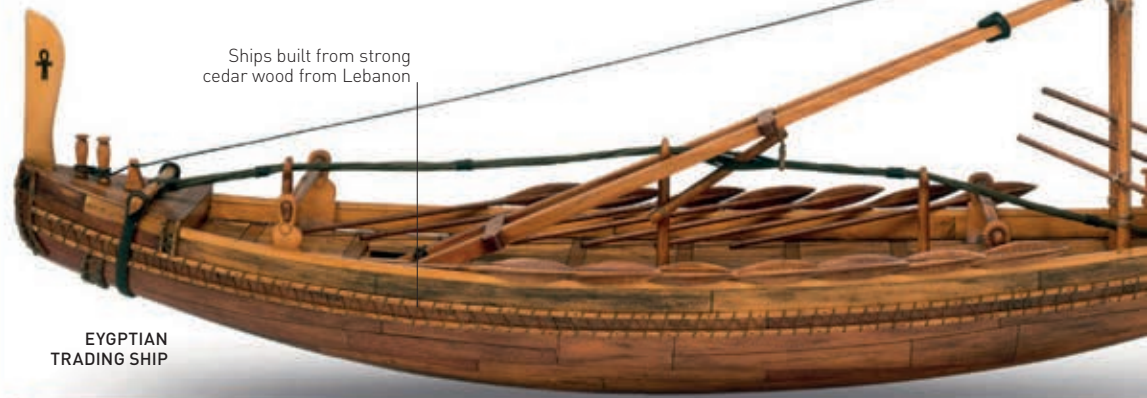


VIKING LONGSHIP

Rectangular sail on two curved beams

Oars were used when there was no wind

Ships built from strong cedar wood from Lebanon



EGYPTIAN TRADING SHIP

## 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 160 KM (100 MILES) 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.



**MAGNETIC COMPASS**  
18th century, Italy.



**ASTROLABE**  
Allowed sailors to use the stars to navigate.



**LODESTONE**  
The earliest type of magnetic compass.



**GLOBE**  
For calculating routes and bearings.



**TELESCOPE**  
Used to identify landmarks from a distance.



**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 favours 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 round 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 round 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**

- HERNAN CORTES (1485–1541)** A Spanish conquistador (soldier), Cortés first travelled to Mexico to set up a trading colony for Spain, but ended up destroying the entire Aztec Empire in Central America.

- 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.



**SIR WALTER RALEIGH**



## 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.



**INUIT (ESKIMO) KNIVES WITH BONE HANDLE**  
Made of steel from the abandoned ship of Sir John Franklin, who failed to find a sea route through the Arctic Ocean, north of Canada.



**WINDPROOF HOOD**  
Worn by Sir Ernest Shackleton on his South Pole attempt of 1907–08.



**CLASP KNIFE AND SEXTANT**  
Used by Captain Robert Scott on his South Pole expedition of 1912.



**CROSS-COUNTRY SKIS**  
Used by Captain Scott in his first South Pole expedition, 1901–04.



**POLAR SLEDGE**  
Eight-man sledge from an Arctic expedition in 1875.



# 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 1566–68, 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

▶ 1640–60



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 ten years, England was a republic ruled by Lord Protector Oliver Cromwell.

▶ 1648–53

## 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.

◀ 1936–39

## SPANISH CIVIL WAR

This revolt against the Spanish government led to civil war. On one side were nationalists led by General 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 1939–75

◀ 1930

## BRAZILIAN REVOLUTION

Economic hardship, powerful landlords, and demands for workers' rights led to revolution in Brazil in 1930. A provincial governor called Getúlio Vargas seized power. A dictator at first, he introduced reforms that modernized Brazil and earned him the nickname "Father of the Poor".



GETULIO VARGAS: BRAZILIAN PRESIDENT 1930–45, 1951–54

◀ 1918–23

## GERMAN REVOLUTION

A series of revolutions shook Germany immediately after World War I (1914–18). 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 tsar (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.

▶ 1946–49

## CHINESE REVOLUTION

From the 1920s onwards, 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

▶ 1953–59



REVOLUTIONARY CHE GUEVARA BECAME A WORLDWIDE HERO

## CUBAN REVOLUTION

An armed revolution led by Fidel Castro and Che Guevara overthrew the USA-backed dictatorship of President Batista. Cuba became a revolutionary socialist state and later a Communist country.

▶ 1956

## HUNGARIAN REVOLUTION

After World War II (1939–45), 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 25 April 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



▶ 1974–77

## 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.



▶ 1775–83

### 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



THE STORMING OF THE BASTILLE, A PRISON IN PARIS, 14 JULY 1789

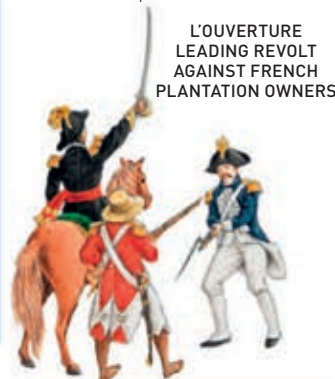
### FRENCH REVOLUTION

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 XV 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.



LOUVERTURE LEADING REVOLT AGAINST FRENCH PLANTATION OWNERS

▶ 1806–24

### 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

### XINHAI REVOLUTION

During the Xinhai Revolution, nationalists overthrew the Manchu dynasty in China, ending 2000 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



◀ 1910–20

### MEXICAN REVOLUTION

The Mexican Revolution started as a protest against the dictatorship of President Porfirio Díaz, but soon spiralled into an armed revolution that lasted around ten 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

◀ 1866–68



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”, in 1848 more than 50 uprisings broke 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.

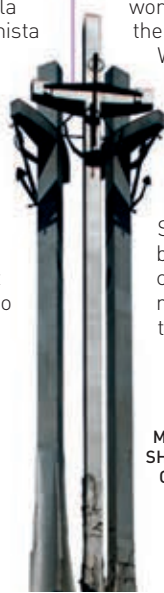


THE HUNGARIAN TRICOLOUR FLAG, A SYMBOL OF THE 1848 REVOLUTION

▶ 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. They introduced new socialist reforms. Later, rebel groups called the Contras fought back against the Sandinistas, who lost power in 1990.



MONUMENT TO THE SHIPYARD WORKERS, GDANSK, POLAND

▶ 1980–81

### SOLIDARITY IN POLAND

Revolution broke out in Poland when the independent trade union Solidarity organized workers' strikes, under the leadership of Lech Walesa. 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.

▶ 1986



YELLOW RIBBON

### YELLOW REVOLUTION

The Yellow Revolution was a series of mass popular protests in the Philippines against the corrupt regime of President Marcos. In this non-violent revolution, more than two million Filipinos demonstrated for greater democracy, displaying yellow ribbons as a symbol of protest. Marcos departed and was replaced by Corazon Aquino.

▶ 1988–91

### EASTERN EUROPE

By the late 1980s protests were spreading through the Soviet satellite states of Eastern Europe, as protesters demanded 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

▶ 2004–05

### ORANGE REVOLUTION

Taking its name from 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. As a result the election was repeated and anticorruption candidate Yushchenko was elected.

EACH DAY 5,000 TONNES OF PORRIDGE AND 10,000 LOAVES WERE SUPPLIED TO ORANGE REVOLUTION PROTESTERS IN UKRAINE

▶ 2010–12

### ARAB SPRING

Starting in 2010, a wave of pro-democracy uprisings took place in the Middle East and North Africa – Tunisia, Egypt, Libya, the Yemen, and Syria – that challenged some of the region's authoritarian governments. Protesters were met with violence, but regimes in Tunisia and Egypt were toppled.



# US Presidents

Since the office was created in 1789, there have been 43 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 USA, 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**

1789–97  
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**  
1841–45

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**  
1845–49

Greatly expanded the territory of the USA, adding Texas, Wisconsin, and Iowa as states, and taking over land in the west that would become New Mexico and California.



**ZACHARY TAYLOR**  
1849–50

Successful military general who commanded US forces in the war against Mexico (1846–48). Died of cholera a year after taking office.



**MILLARD FILLMORE**  
1850–53

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**  
1853–57

Allowed new states to decide for themselves whether to allow slavery, which angered many and edged the USA ever closer to civil war.



**CHESTER A ARTHUR**  
1881–85

Brought in a law that meant that civil servants were hired purely for their ability rather than because of their political connections.



**GROVER CLEVELAND**  
1885–89; 1893–97

The only president ever to serve two non-consecutive terms – he lost an election, then was voted back in again four years later.



**BENJAMIN HARRISON**  
1889–93

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**  
1901–09

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**  
1909–13

A lawyer by profession, he set up the postal savings bank and passed a law allowing states to collect income tax.



**DWIGHT D EISENHOWER**  
1953–61

Led the Allied armed forces in World War II. During his two terms of office, the US economy thrived.



**JOHN F KENNEDY**  
1961–63

His work to reform civil rights and promote racial equality was cut short when he was shot dead in Texas.



**LYNDON B JOHNSON**  
1963–69

Brought in the Civil Rights Act, but faced opposition for sending more troops into the war in Vietnam.



**RICHARD NIXON**  
1969–74

Ended the Vietnam War and improved relations with the USSR. His term ended in disgrace after political corruption was uncovered.



**GERALD FORD**  
1974–77

Unexpectedly became vice-president, then president, during an era of scandals. His honesty helped restore the image of the presidency.



**JIMMY CARTER**  
1977–81

President during a difficult period for the USA, both at home and abroad. After his term in office, he became a respected statesman.





**THOMAS JEFFERSON**

**1801-09**  
The main author of the Declaration of Independence, which stated that the colonies would no longer accept British rule.



**JAMES MADISON**

**1809-17**  
Helped draw up the US Constitution, which set out America's laws and guaranteed certain rights for its citizens.



**JAMES MONROE**

**1817-25**  
Remembered for the Monroe Doctrine, which declared that the USA would resist attempts by other countries to establish colonies in the Americas.



**JOHN QUINCY ADAMS**

**1825-29**  
Son of a previous president, John Adams. After his presidency, he became a strong campaigner against slavery.



**ANDREW JACKSON**

**1829-37**  
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**

**1837-41**  
After financial panic and stock market crash led to economic depression, Van Buren became unpopular and was not re-elected.



**JAMES BUCHANAN**

**1857-61**  
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**

**1861-65**  
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**

**1865-69**  
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**

**1869-77**  
A hero of the Civil War, he was an inexperienced politician whose presidency was overshadowed by scandal and corruption.



**RUTHERFORD B HAYES**

**1877-81**  
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**

**1913-21**  
Took the USA 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**

**1921-23**  
An unpopular president who was dogged by rumours of financial wrongdoing. He died suddenly, before an investigation could begin.



**CALVIN COOLIDGE**

**1923-29**  
Honest, hard-working, and modest, he was fondly nicknamed "Silent Cal". Under his presidency, the US economy boomed.



**HERBERT HOOVER**

**1929-33**  
Shortly after his election, the USA began an era of serious economic depression. Hoover was blamed and did not win a second term.



**FRANKLIN D ROOSEVELT**

**1933-45**  
Led the USA 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**

**1945-53**  
Authorized the dropping of two nuclear bombs on Japan, which ended World War II. Took the USA to war with Korea.



**RONALD REAGAN**

**1981-89**  
An ex-Hollywood star, he helped to end the Cold War. He was shot by a would-be assassin but recovered.



**GEORGE H W BUSH**

**1989-93**  
An oil tycoon and ex-head of the CIA, he took the USA and its allies into the first Gulf War with Iraq (1990-91).



**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**

**2001-09**  
After the terrorist attacks of 9/11, he ordered the invasion of Afghanistan and declared the War on Terror.



**BARACK OBAMA**

**(2009-)**  
The first African American president. His healthcare reforms were disliked by opponents, and led to stalemate in government.

**A US PRESIDENT CAN ONLY BE ELECTED TWICE, SERVING UP TO TEN YEARS**







12-14 APRIL 1861

The first battle of the Civil War, fought at Fort Sumter, South Carolina, is a victory for the Confederates.



Union flag

11-16 FEBRUARY 1862

Ulysses S Grant leads a Union victory at the Battle of Fort Donelson, Tennessee.



Ulysses S Grant

4 JULY 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.

15 NOVEMBER-21 DECEMBER 1864

Union General Sherman sweeps through Georgia, ending victoriously at the port of Savannah.

1 FEBRUARY 1865

Lincoln signs the 13th Amendment, which formally abolishes slavery in the USA.

9 APRIL 1865

Confederate General Lee surrenders to Union General Grant. The Civil War is over.

21 JULY 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).

8-9 MARCH 1862

The Battle of Hampton Roads, off the coast of Virginia, sees the first combat between ironclad warships.

17 SEPTEMBER 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.

1-3 JULY 1863

The Union side halts the Confederates' advance at the Battle of Gettysburg, Pennsylvania.

8 NOVEMBER 1864

Lincoln is re-elected US president for a second term of office.



Lincoln Memorial

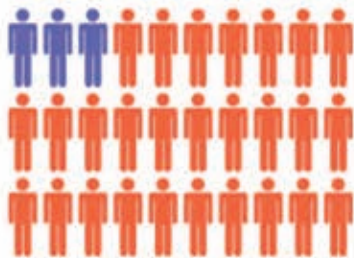
14 APRIL 1865

Lincoln is shot while at the theatre by John Wilkes Booth. He dies a day later.

1865

## 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 (1809-65)

As US president, Lincoln led his country through the war, abolished slavery, and saved the Union.

### ULYSSES S GRANT (1822-85)

General Grant led the Union army from 1862 onwards. 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 (1808-89)

A soldier and senator, Davis was the president of the Confederate States of America.

### ROBERT E LEE (1807-70)

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.



TIN OF COFFEE ESSENCE



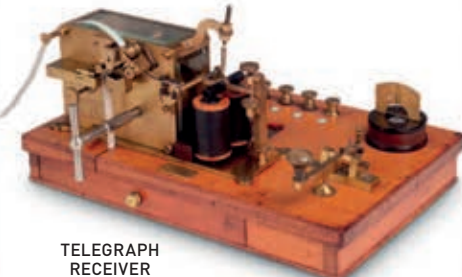
BLOCK OF TEA



ROPE



SLEEPING CAP



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 USA. The first English colony is founded 20 years later in Roanoke.

**1756-63**

The Seven Years War sees Britain become the world's largest colonial empire, gaining America and India in the global conflict.

**1775-81**

The American states win independence from the British after the American War of Independence.



The American constitution

**1810-26**

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".

**1945**

By the end of the World War II, the empires of Italy, Germany, and Japan collapse.

**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 kilometres of land across the globe.

**1 BRITISH EMPIRE**

33.7 million sq km (13 million sq miles) in 1922.



**2 SPANISH EMPIRE**

19.4 million sq km (7.5 million sq miles) in 1740.



**3 FRENCH EMPIRE**

12.9 million sq km (5 million sq miles) in 1938.



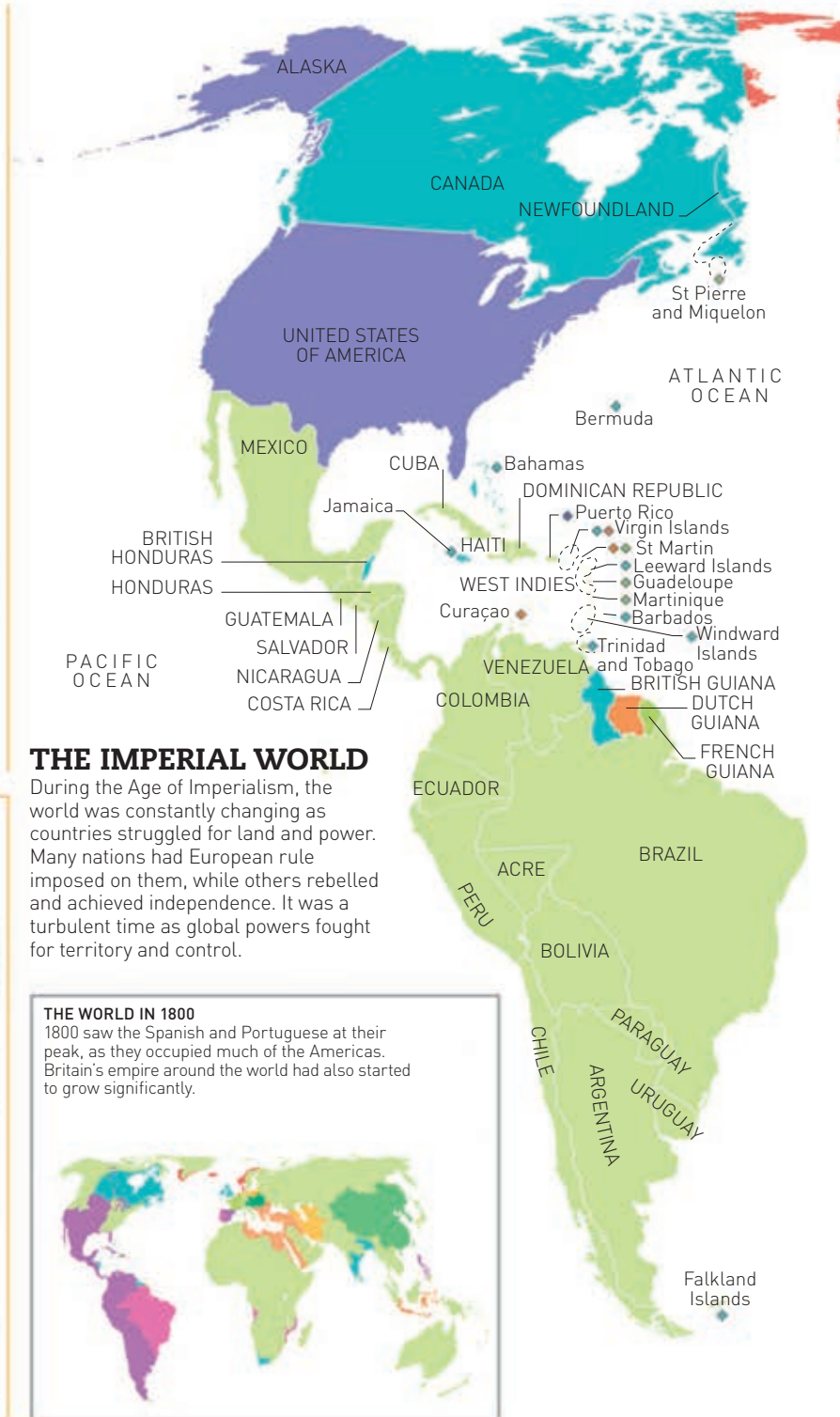
**4 PORTUGUESE EMPIRE**

10.4 million sq km (4 million sq miles) in 1821.



**5 ITALIAN EMPIRE**

3.6 million sq km (1.4 million sq miles) in 1942.



## THE IMPERIAL WORLD

During the Age of Imperialism, the world was constantly changing as countries struggled for land and power. Many nations had European rule imposed on them, while others rebelled and achieved independence. It was a turbulent time as global powers fought for territory and control.

**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.



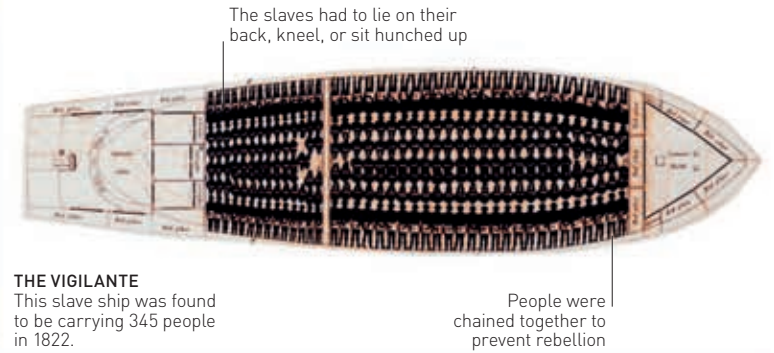
## TRADE

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.



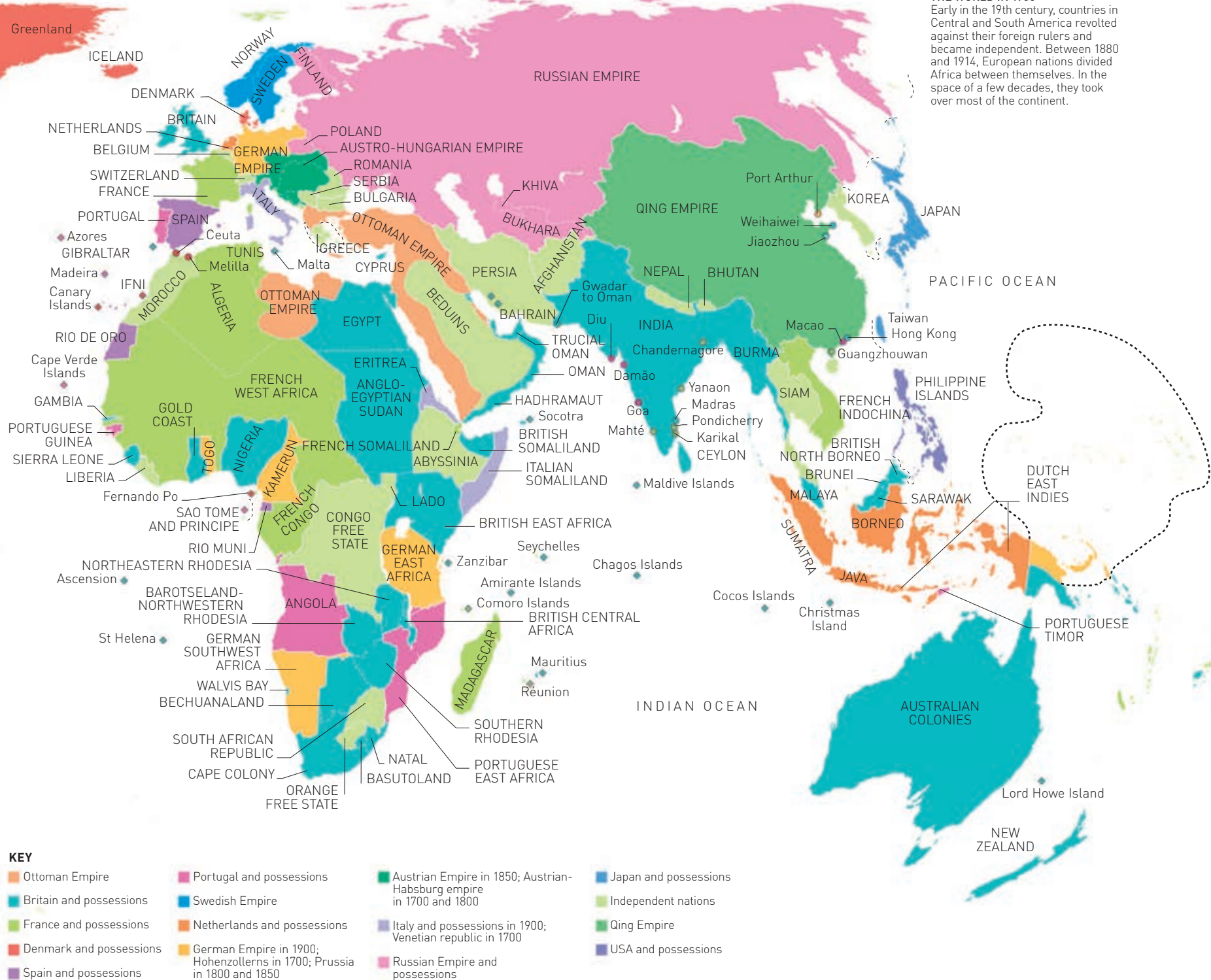
## SLAVERY

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.



## 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.





# 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. The leader of one, Egbert, became the first king of England. Throughout the Saxon period, powerful kings fended off Viking raids, but England was ruled by Viking monarchs for over 25 years.



**OFFA**  
757-96  
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**  
802-39  
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.

757-96	OFFA	955-59	EADWIG
802-39	EGBERT	959-75	EDGAR
839-56	AETHELWULF	975-78	EDWARD II "THE MARTYR"
856-60	AETHELBALD	979-1013 AND 1014-16	AETHELRED II "THE UNREADY"
860-66	AETHELBERT	1013-14	SVEIN
866-71	AETHELRED I	1016	EDMUND II "IRONSIDE"
871-99	ALFRED "THE GREAT"	1016-35	CANUTE
899-924	EDWARD "THE ELDER"	1035-40	HAROLD I "HAREFOOT"
925-40	ATHELSTAN	1040-42	HARDICANUTE
940-46	EDMUND I	1042-66	EDWARD III "THE CONFESSOR"
946-55	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 under them. The manufacturing and merchant classes rose in status, and architecture, literature, and theatre blossomed. Playwright William Shakespeare was a leading light.



**ELIZABETH I**  
1558-1603  
Strong-willed Elizabeth was a clever politician with loyal followers. Under her reign trade, exploration, and prosperity increased.



**HENRY VIII**  
1509-47  
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.



**MARY I**  
1553-58  
Nicknamed Bloody Mary, Henry VIII's eldest daughter burned protestants after she seized the throne, and restored the Roman Catholic Church.

1485-1509	HENRY VII TUDOR
1509-47	HENRY VIII
1547-53	EDWARD VI
1553	LADY JANE GREY
1553-58	MARY I
1558-1603	ELIZABETH I

## 1461-85

### 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 invented the first printing press in this period.

1461-70	EDWARD IV
1471-83	EDWARD IV
1483	EDWARD V
1483-85	RICHARD III

1399-1413	HENRY IV
1413-22	HENRY V
1422-61	HENRY VI
1470-71	HENRY VI



**HENRY VI**  
1422-61 AND 1470-71  
After losing his father's gains in France, a failing mind cost Henry VI the throne for a time.

**RICHARD III**  
1483-85  
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.



## 1603-1749

### 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**  
1603-25  
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.



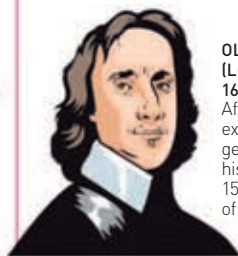
**CHARLES I**  
1625-49  
This stubborn king believed in his divine right to rule and stamped on any opposition. Defeated by Oliver Cromwell in the Civil War, he was tried and executed by his parliament.

## 1649-59

### 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.

1649-53	REPUBLIC
1653-58	OLIVER CROMWELL (LORD PROTECTOR)
1658-59	RICHARD CROMWELL (LORD PROTECTOR)



**OLIVER CROMWELL (LORD PROTECTOR)**  
1653-58  
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 the Catholic faith but fled when William of Orange was invited to restore rights in the Glorious Revolution.

1660-85	CHARLES II
1685-88	JAMES II
1689-94	WILLIAM III OF ORANGE AND MARY II (JOINTLY)
1694-1702	WILLIAM III
1702-14	ANNE

**CHARLES II**  
1660-85  
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 the first Prime Minister to German-speaking George I, and Britain 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.

1714-27	GEORGE I
1727-60	GEORGE II
1760-1820	GEORGE III
1820-30	GEORGE IV
1830-37	WILLIAM IV
1837-1901	VICTORIA

**GEORGE I**  
1714-27  
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"**  
871-99

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**  
1016-35

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 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.

1066-87	WILLIAM "THE CONQUEROR"
1087-1100	WILLIAM II
1100-35	HENRY I
1135-54	STEPHEN

**WILLIAM "THE CONQUEROR" 1066-87**  
Called "The Conqueror" because he conquered England, William 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.



## 1399-1461

### 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**  
1413-22

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.

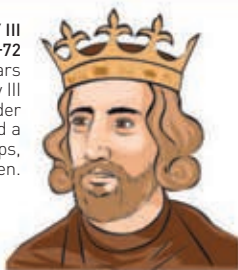


**EDWARD I "LONGSHANKS"**  
1272-1307

This warrior king fought many battles to unite England and Scotland. A model parliament was formed during his reign.

**HENRY III**  
1216-72

After provoking civil wars with his barons, Henry III was defeated by their leader de Montfort, who formed a parliament of lords, bishops, knights, and freemen.



**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 to settle the rights of people, Church, and monarchy.



**RICHARD I "THE LIONHEART"**  
1189-99

This crusading king spent most of his reign fighting for Christianity in the Holy Lands. Imprisoned by the Emperor of Germany, he was returned for a huge ransom and was eventually killed in France.

## 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.

1154-89	HENRY II
1189-99	RICHARD I "THE LIONHEART"
1199-1216	JOHN I
1216-72	HENRY III
1272-1307	EDWARD I "LONGSHANKS"
1307-27	EDWARD II
1327-77	EDWARD III
1377-99	RICHARD II

## 1901-10

### 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 like the first automobile were taking Britain into the modern age.



**GEORGE III**  
1760-1820  
The Americans won independence and England fought France in the Napoleonic Wars during George's reign.



**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.



**EDWARD VII**  
1901-10

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.



**WILLIAM IV**  
1830-37

Many more people got the vote under William IV, and slavery was abolished throughout the British Empire.

## 1910-

### WINDSORS

George V changed his surname to Windsor during the 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 60 years.

1910-36	GEORGE V
1936	EDWARD VIII
1936-52	GEORGE VI
1952-	ELIZABETH II



**GEORGE VI**  
1936-52

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 current queen remains head of the Commonwealth (former colonies) and is popular around the world. Prince William and Catherine, Duchess of Cambridge, and their children lead a new generation of royals.



# 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.



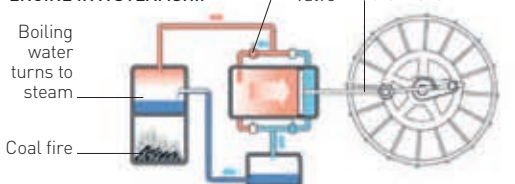
IRONBRIDGE, SHROPSHIRE

Site of the world's first iron bridge, built by Darby's grandson in 1781.

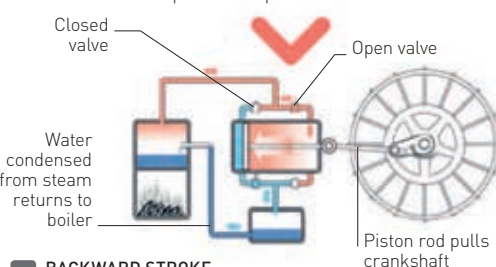
## STEAM POWER

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 forwards.



**2 BACKWARD STROKE**  
The steam now enters the cylinder through the valve on the right and pushes the piston back.

## CANALS

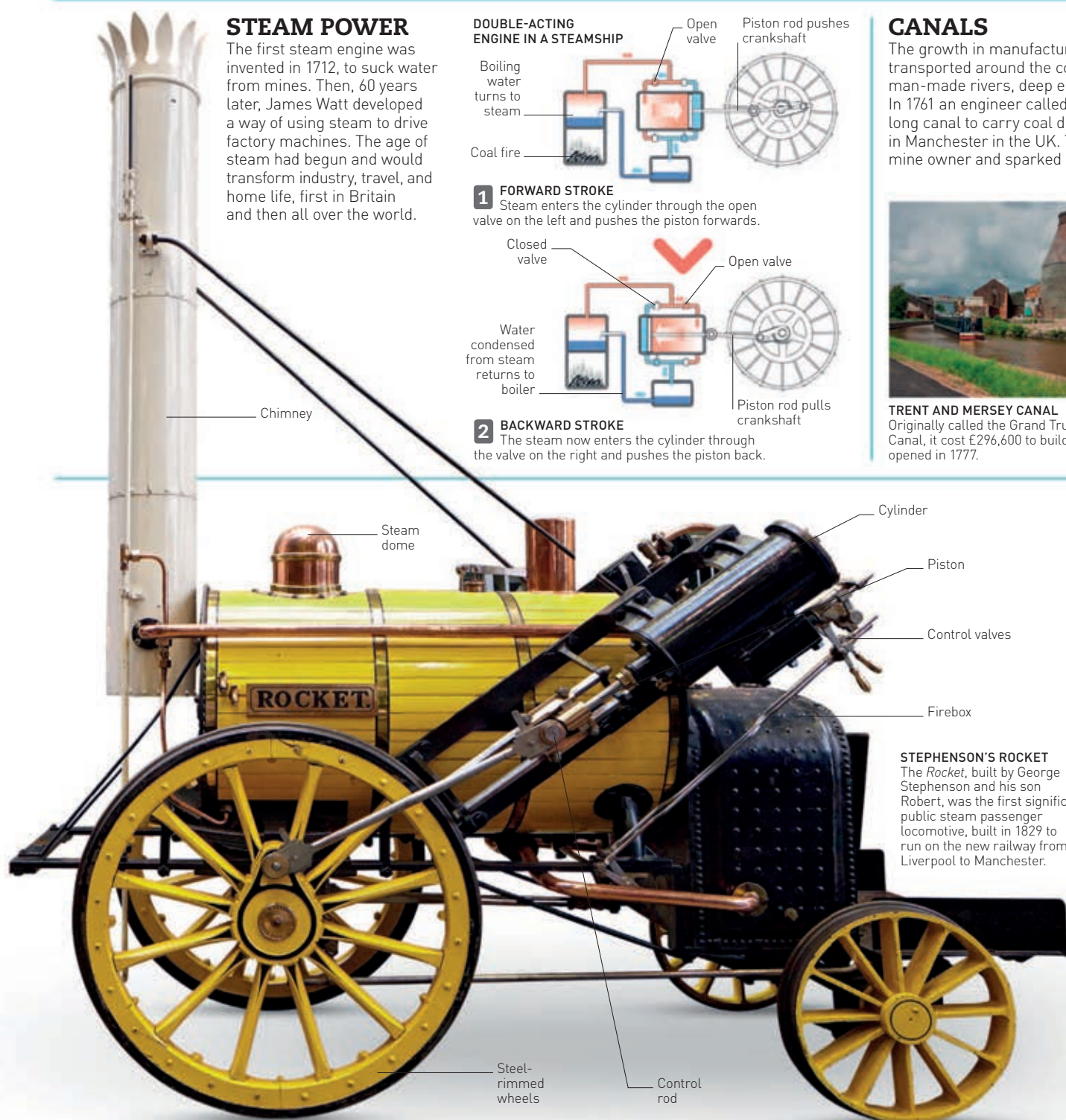
The growth in manufacturing meant there were more goods to be transported around the country, and canals were the answer – man-made rivers, deep enough to cope with large, heavy barges. In 1761 an engineer called James Brindley built a 16 km (10 mile) long canal to carry coal direct from a mine in Lancashire to sell in Manchester in the UK. 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 were 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

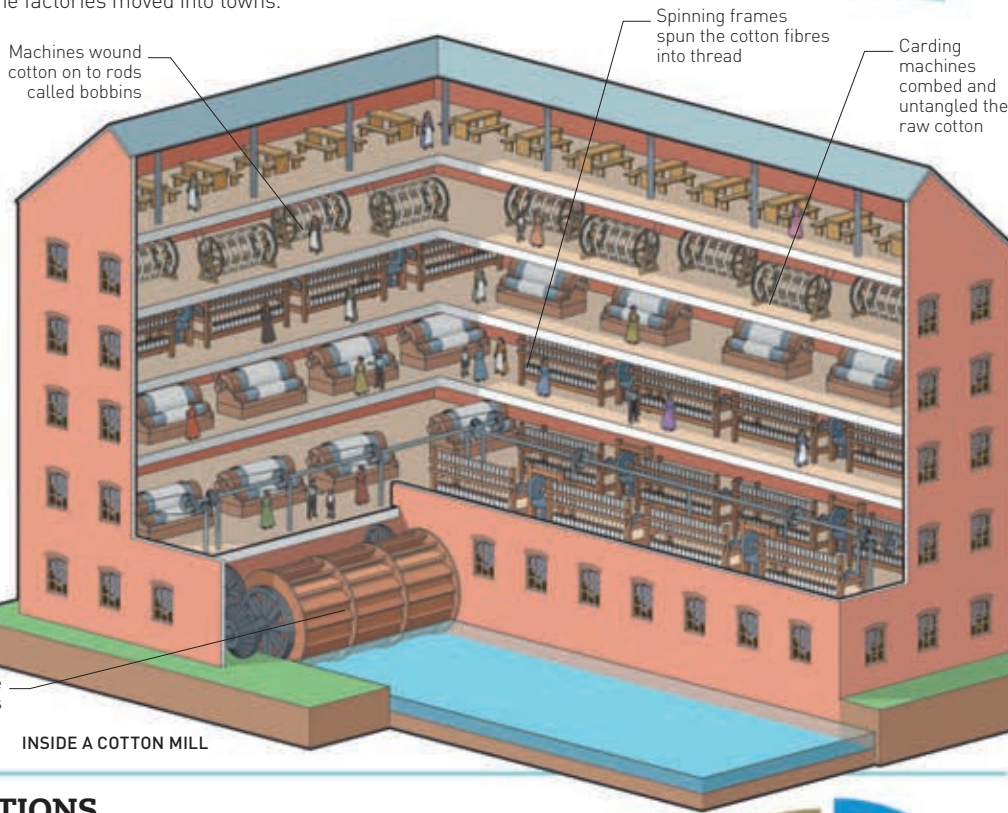
Traditional industries such as cotton and textiles were transformed by the Industrial Revolution. Machines were developed that could make raw cotton into thread in a fraction of the time it had taken craft workers in the past. At first, the machines were powered by water, so mills and factories were 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

**THE NEW SPINNING MACHINES PRODUCED COTTON 1,000 TIMES FASTER THAN A HUMAN WORKER COULD**

## 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.

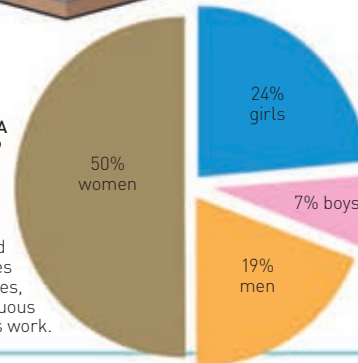


### PIT CHILDREN

Children worked deep underground in coal mines, pulling heavy wagons along tracks.

### WORKERS IN A COTTON MILL, 1859

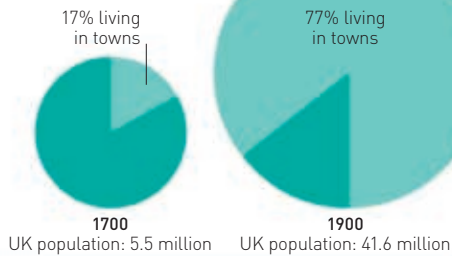
A third of mill workers were children, aged as young as five. They wriggled between machines to clear blockages, which was strenuous and dangerous work.



## RISE OF THE NEW TOWNS

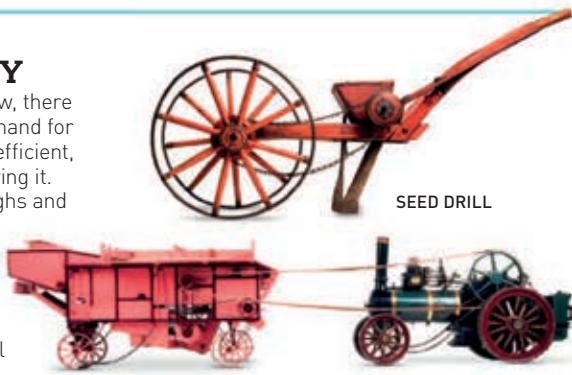
As more and more factories were built, towns grew and housing, schools, and shops were built near to where people worked. Small towns quickly became large, factory-dominated cities, which attracted even more people in search of work.

### 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 ploughs and threshing machines appeared in the 1820s, then in 1831, American Cyrus McCormick invented a mechanical grain harvester.



STEAM THRESHING MACHINE

## 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 (1732–92)**  
Invented the water frame for spinning thread or yarn, then set up the first water-powered cotton mill in England.
- RICHARD TREVITHICK (1771–1833)**  
In 1804 Trevithick 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 HUMPHREY DAVY (1778–1829)**  
English chemist and inventor. He developed the Davy lamp, a light to help miners detect dangerous gases underground.
- ISAMBARD KINGDOM BRUNEL (1806–59)**  
An engineer who built bridges, tunnels, railways, and the world's biggest ship at the time, the *Great Eastern*.



RICHARD TREVITHICK

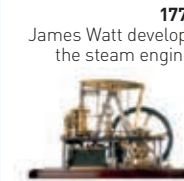
## TIMELINE OF A REVOLUTION

The invention of steam power was a turning point in history. It also sparked major developments in other areas, including communications, transport, and construction.

- 1709**  
Coke, a product of coal, is first used to produce iron.
- 1712**  
Thomas Newcomen builds the first steam-powered engine.
- 1764**  
James Hargreaves invents the spinning jenny, a machine for spinning yarn.
- 1771**  
Richard Arkwright builds the first water-powered cotton mill.
- 1774**  
James Watt develops the steam engine.
- 1798**  
Gas lighting is introduced in factories, so they can operate throughout the night.
- 1800**  
Italian Alessandro Volta invents the first electric battery.
- 1805**  
Engineer Thomas Telford completes the Pontcysyllte Aqueduct, the longest and highest in Britain.
- 1807**  
The first commercial steamboat, *Savannah*, launches in America.
- 1815**  
Sir Humphry Davy invents a lamp that is safe to use in gas-filled mines.
- 1825**  
The Stockton and Darlington Railway opens, the world's first public steam railway.
- 1837**  
The first electric communication device, the five-needle telegraph, is invented.
- 1841**  
William Fox Talbot patents his invention of the "calotype" (photographic negative).
- 1844**  
George Stephenson, engineer of the Stockton and Darlington railway.
- 1855**  
Englishman Henry Bessemer invents a machine to make steel cheaply.
- 1859**  
The electric telegraph, invented by William Cooke and Charles Wheatstone.
- 1876**  
Alexander Graham Bell invents the telephone.



Arkwright's mill in Derbyshire, UK



Replica of the Watt steam engine



Davy lamp



The electric telegraph, invented by William Cooke and Charles Wheatstone



George Stephenson, engineer of the Stockton and Darlington railway



Volta's battery, called the "Voltaic Pile"



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 world. 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

**28 JUNE, 1914**  
Archduke Franz Ferdinand of Austria-Hungary is assassinated, with his wife, Sophie, in Serbia. A month later, Austria-Hungary declares war on Serbia.

**12 AUGUST, 1914**  
One by one, countries take sides until war has broken out over most of Europe.



Lifebelt from the RMS Lusitania

**7 MAY, 1915**  
Germany sinks the RMS Lusitania, a luxury British passenger ship, killing more than 1,000 passengers.

**23 MAY, 1915**  
Italy enters the war on the side of the Allies and prepares to invade its neighbour, Austria-Hungary.



**1 JULY, 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

**17 DECEMBER, 1917**  
Following a revolution in Russia, the new government makes peace with Germany and leaves the war.



Russian helmet plate

**3 NOVEMBER, 1918**  
German sailors mutiny. Austria-Hungary makes peace with the Allies.

**28 JUNE, 1919**  
The Treaty of Versailles is signed and the war officially ends.

## 1914 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.

**24 DECEMBER, 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.



Fortified turret, Verdun, France

**12 FEBRUARY, 1916**  
Battle of Verdun begins.

**31 MAY, 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.

**6 APRIL, 1917**  
President Woodrow Wilson leads the USA into the war on the side of the Allies.

**15 JULY, 1918**  
Second Battle of the Marne begins, near Paris.

**3 AUGUST, 1918**  
The Allies win the Battle of the Marne. The German army collapses.

**11 NOVEMBER, 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.

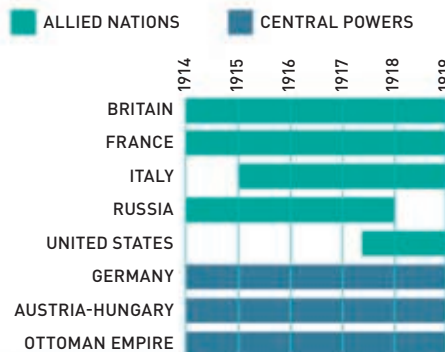
**KEY**  
 Neutral  
 Allied Nations  
 Central Powers  
 Western Front  
 Eastern Front



EUROPE IN 1914

## 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

1 JULY - 18 NOVEMBER 1916	21 FEBRUARY - 18 DECEMBER 1916	11 JULY - 10 NOVEMBER 1917
Battle of the Somme	Battle of Verdun	Third Battle of Ypres (Passchendaele)
<b>1,219,201</b>	<b>976,000</b>	<b>848,614</b>

1,219,201

976,000

848,614

TOTAL CASUALTIES FROM THE BLOODIEST BATTLES OF WWI

## TRENCHES

Both sides built long trenches as a defence 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.



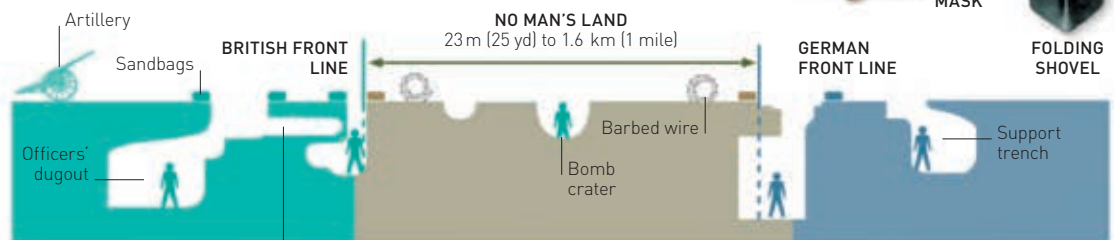
MESS TIN

TRENCH AXE

SEWING KIT

GAS MASK

FOLDING SHOVEL



Communication trench

CROSS-SECTION OF A TYPICAL WORLD WAR I BATTLEFIELD





BRITISH SOPWITH PUP



GERMAN ALBATROSS D.Va

## WAR IN THE AIR

Powered flight was barely ten 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

USA



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

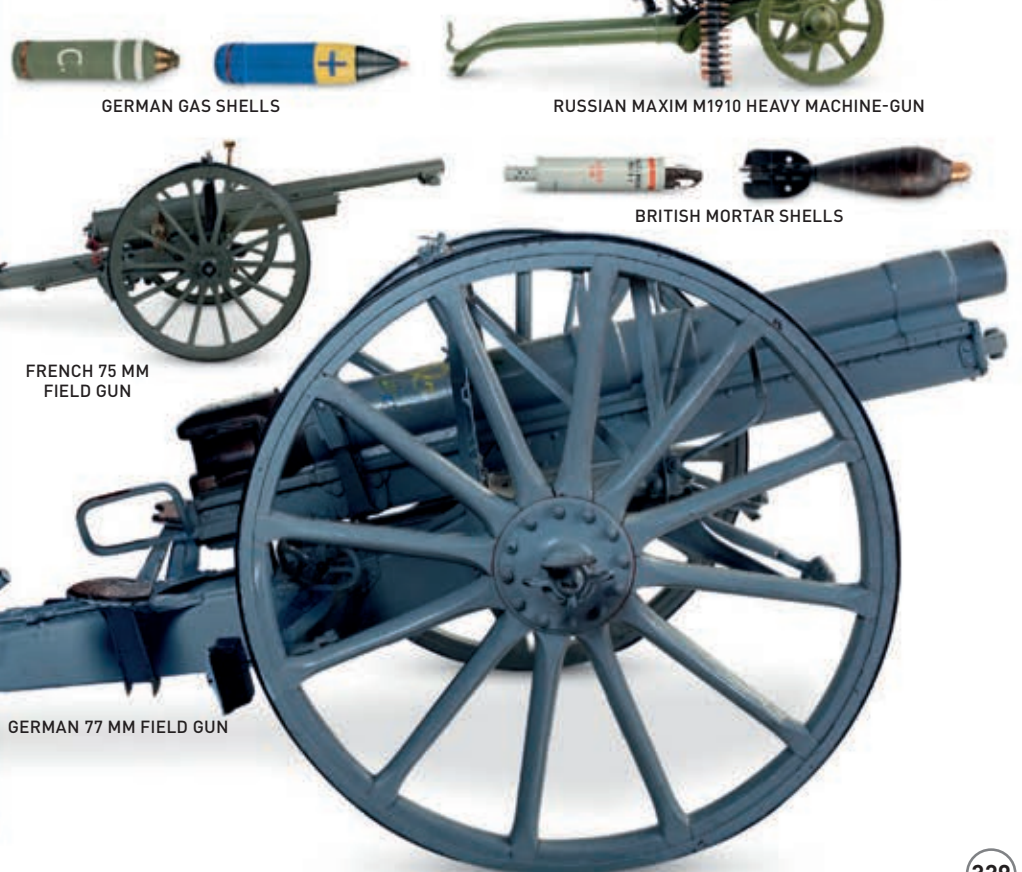
BRITISH LEE ENFIELD RIFLE

ITALIAN CARCANO CARBINE RIFLE

GERMAN SCHWARZLOSE MACHINE-GUN

## 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 ten 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 USA 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

**1 SEPTEMBER 1939**  
Germany, led by Nazi leader Adolf Hitler, invades Poland.



**10 MAY 1940**  
Winston Churchill becomes Prime Minister of Great Britain.



**27 SEPTEMBER 1940**  
Germany, Italy, and Japan join forces as the Axis Alliance.

Statue of Theodore Roosevelt



**8 DECEMBER 1941**  
President Roosevelt takes the USA into the war against the Axis Alliance.

**3 SEPTEMBER 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.

**JULY-OCTOBER 1940**  
Battle of Britain: German and British aircraft fight for control of the skies; Britain is the winner.

**SEPTEMBER 1940-MAY 1941**  
The Blitz (German bombing raids on British cities) kills more than 60,000 civilians.



**7 DECEMBER 1941**  
Japan mounts a surprise attack on the US Navy at Pearl Harbor, Hawaii.

# World War II

In September 1939 Germany, led by dictator Adolf Hitler, 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 USA joined the Allies. In 1943 Italy surrendered, then changed sides to fight on the side of the Allies.



## THEATRES 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 the USA and Japan 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.



## 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.



## FIGHTING MEN

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.





**4-7 JUNE 1942**  
The USA defeats Japan's navy at the Battle of Midway in the Pacific Ocean, halting the Japanese advance.

**Soviet medal for the Battle of Stalingrad**



**2 FEBRUARY 1943**  
Soviet troops are victorious at Stalingrad and begin to march on Germany.



German V1 flying bomb, 1944

**25 AUGUST 1944**  
Paris is liberated by the Allies from German occupation.

**7 MARCH 1945**  
Allied troops cross the river Rhine and enter Germany.



Model of "fat man" atomic bomb, dropped on Nagasaki

**6-9 AUGUST 1945**  
USA drops atomic bombs on the Japanese cities of Hiroshima and Nagasaki.

**1945**



Japanese Aichi D3A bomber plane

**19 AUGUST 1942**  
Germany launches an attempt to take over the Soviet city of Stalingrad.

**13 MAY 1943**  
The Axis armies in North Africa surrender.

**25 JULY 1943**  
Italian dictator Mussolini is overthrown. A month later, the Allies invade mainland Italy, leading to Italy's surrender.

**6 JUNE 1944**  
D-Day: Allied forces land in Normandy, France, and begin to advance inland.



Badge worn by Jews in Latvia

**27 JANUARY 1945**  
Soviet army liberates the Auschwitz death camp in Poland.

**7 MAY 1945**  
Following Hitler's suicide a week earlier, Germany surrenders.

**15 AUGUST 1945**  
Japan announces its intention to surrender. On 2 September they sign 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 per cent of its population, and whole cities across Europe were left in ruins. The Nazis and their sympathizers executed six million Jewish people. This brutal, systematic murder is now known as the Holocaust. In Japan two nuclear bombs, dropped by the USA, 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 1940-41, 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 armoured 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/USA



M2 HALF-TRACK CAR USA



BMW R12 MOTORCYCLE Germany



WHITE SCOUT CAR USA



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 USA 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, USA



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 USA 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.



**EUROPE 1955**  
 ■ Warsaw Pact countries  
 ■ NATO countries  
 ■ Other USSR allies  
 ■ Other USA allies



**WARSAW PACT**  
Formed by the USSR in 1955, in opposition to NATO.



## NATO LEADERS

In 1949 the USA 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 USA 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 USA, but was ousted as Soviet leader by rivals in 1964.



**FIDEL CASTRO**  
Led a Communist revolution in Cuba in 1959. The USA supported many attempts to remove him from power.

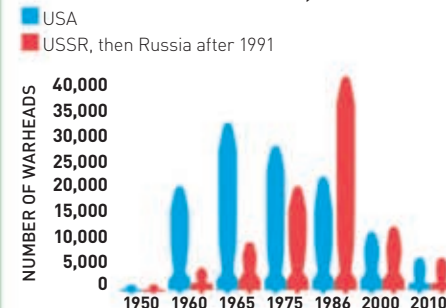


**MIKHAIL GORBACHEV**  
Became leader of the USSR in 1985, and introduced many reforms that helped bring an end to the Cold War.

## 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.

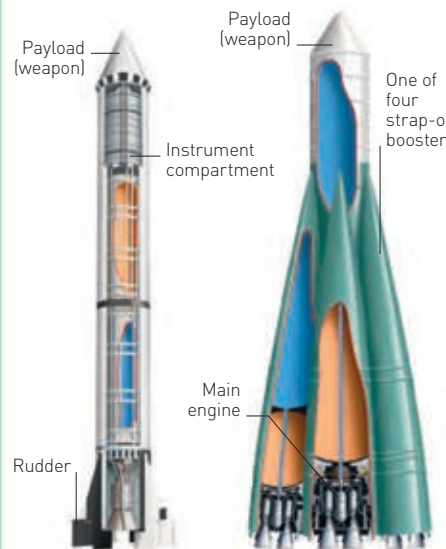
### NUCLEAR WEAPON STOCKPILES, 1950-2010



USS VIRGINIA (SSN-74) NUCLEAR SUBMARINE (USA)



AKULA-CLASS NUCLEAR SUBMARINE (USSR)



**PGM-11 REDSTONE (USA)** 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, USA, France, and USSR. In 1961 the Soviets built a 2 m (6.5 ft) high wall enclosing 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, USA'S COUNTER-INTELLIGENCE FORCE



LOGO OF THE KGB, SOVIET SPY AGENCY



LOCKHEED SR-71 BLACKBIRD RECONNAISSANCE PLANE



LOCKHEED U2 RECONNAISSANCE SPY PLANE



MIKOYAN-GUREVICH MIG-25 "FOXBAT" INTERCEPTOR PLANE



MIKOYAN-GUREVICH MIG-23 INTERCEPTOR PLANE

## SPACE RACE

Both the USA 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 man on the Moon.

### FIRST SATELLITE TO ORBIT EARTH: USSR

On 4 October 1957, the Soviets launched *Sputnik 1*. The USA launched their first satellite *Explorer 1* four months later.

### FIRST MAN IN SPACE: USSR

On 12 April 1961, Yuri Gagarin was the first man to orbit the Earth in his spacecraft, *Vostok 1*.



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 USA another 20 years to send Sally Ride up in the space shuttle *Challenger*.

### FIRST "SPACE WALK": USSR

On 18 March 1965, Alexei Leonov spent about ten minutes floating outside his spacecraft, *Voskhod 2*. The Americans lost out again, by just three months.

### FIRST PERSON TO LAND ON THE MOON: USA

On 20 July 1969, Neil Armstrong, Commander of the Apollo 11 moon mission, stepped out of the lunar landing module, *Eagle*, and on to 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. The USA 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 ARMOURD VEST



US MARINES SUNGLASSES



M16 AUTOMATIC RIFLE (USA)



US MARINES CAMOUFLAGE JACKET AND TROUSERS



US MARINES TROPICAL BOOTS



VIETCONG HAT

VIETCONG FIGHTER'S TUNIC AND TROUSERS



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 post-war future. Germany is split into four zones of Allied occupation.

### MARCH 1946

British ex-prime minister Winston Churchill describes the division between Communist and non-Communist countries as an "iron curtain".

### MARCH 1947

US President Truman declares the Truman Doctrine; that it was the USA's duty to fight Communism all over the world.

### JUNE 1948

The Soviets try to squeeze the other Allies out of Berlin by blockading the city, forcing the Allies to airlift in supplies.



Memorial to Berlin Airlift

### MAY-OCTOBER 1949

Communist East Germany and capitalist West Germany are founded.

### OCTOBER 1949

Mao Zedong declares the foundation of the Communist People's Republic of China.



Book by Mao Zedong, Chinese communist leader

### JUNE 1950

The Korean War begins; USSR and USA take opposing sides.



Sputnik satellite

### OCTOBER 1956

The USSR invades Hungary to put down an anti-Communist uprising.

### OCTOBER 1957

USSR launches Sputnik, the first satellite to orbit Earth.



Statue of Che Guevara, one of Cuba's leaders at the time of the Missile Crisis

### AUGUST 1961

Soviets build the Berlin Wall.

### OCTOBER 1962

USA and USSR face off in the Cuban Missile Crisis.

### MARCH 1965

USA sends 200,000 troops to fight in Vietnam.

### MAY 1972

USA and USSR sign a treaty agreeing to limit their nuclear weapons.

### JULY-AUGUST 1980

USA boycotts the Moscow Olympic Games in protest at the Soviet invasion of Afghanistan.



Berlin Wall memorial

### NOVEMBER 1989

Berlin Wall is torn down.

### DECEMBER 1989

The Cold War is declared over.

1990

## GLOBAL FLASHPOINTS

The effects of the Cold War were felt all over the world, as the USA and USSR backed different sides in various conflicts and uprisings.



### KOREA 1950-53

The USA 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 USA 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 USA.



# 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.

## 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 ANDRE**  
This British army officer was hanged as a spy in 1780 during the American War of Independence.
- **JAMES ARMISTEAD LAFAYETTE**  
A former African slave, Lafayette was a double agent in the War of Independence.
- **MATA HARI**  
Dutch dancer Mata Hari was executed for spying for Germany in World War I (1914–18).
- **VIRGINIA HALL**  
After helping the British in World War II (1939–45), this US spy joined the CIA.
- **THE ROSENBERGS**  
This American husband and wife were executed in 1953 for passing secrets to the Soviet Union.



MATA HARI

**THE FICTIONAL SPY JAMES BOND WAS CREATED BY IAN FLEMING IN 1953**

Lighter flips open to reveal camera



LIGHTER CAMERA



WRISTWATCH CAMERA



INSECTOHTOPER (FLYING SURVEILLANCE CAMERA)



DCD-1 (CIA SUBMINIATURE CAMERA)



WRAL (CIA SUBMINIATURE CAMERA)



MOLLY (CIA SUBMINIATURE CAMERA)



MICRODOT CAMERA

## 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.

## 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.



RADIO WRISTWATCH KGB



PORTABLE MILITARY RADIO



CIA WRISTWATCH MICROPHONE



MEZON RECORDING DEVICE



PEN-TOP MICROPHONE

## CODES AND CIPHERS

Keeping communications secret and intercepting enemy messages were prime concerns during World War 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.



HANDKERCHIEF WITH SECRET WRITING



HOTEL LAMP TRANSCEIVER



ATTACHE CASE RADIO



M-94 CIPHER DEVICE



MORSE CODE KEY



LETTER-REMOVING DEVICE



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 War 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.



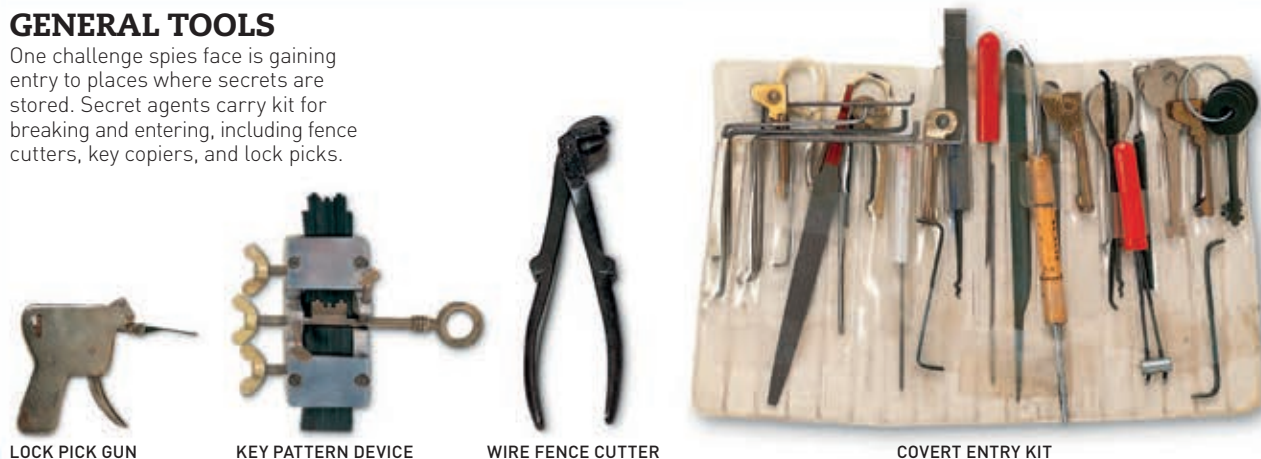
## WEAPONS

Used to threaten and wring out information, to silence an enemy for good, or for self-defence, guns and other weapons are an espionage essential. For some missions, they may be carried openly; on others, they must be carefully disguised.



## GENERAL TOOLS

One challenge spies face is gaining entry to places where secrets are stored. Secret agents carry kit for breaking and entering, including fence cutters, key copiers, and lock picks.












## 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, USA**  
The Central Intelligence Agency (CIA) focuses on foreign threats to the USA. 
- **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. 
- **M16, UK**  
Formally called the Secret Intelligence Service, M16 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. 



# Index

## A

- Aamodt, Kjetil Andre 262  
aardvarks 146  
Abdülmejid I, Sultan  
    300  
Aboriginal culture 192  
abyssal zone, ocean 152  
Abyssinian cats 137  
acacia trees 146, 147  
accordions 211  
acid rain 176  
acids 29  
Acropolis (Athens) 189  
acute angles 48  
Adams, John 318  
Adams, John Quincy 319  
adaptable plants 80  
adaptation 33  
adders 111  
addition 46  
*The Adventures of Tom Sawyer*  
    (Twain) 220  
adzes 186  
aeroplanes 44  
Afghan hounds 135  
Afghanistan 333  
    flag 197  
Africa 190–1  
    early man 284  
    European empires 322  
    flags 196  
    food 224  
    population 180, 190  
    savanna 146  
    size 178  
    slavery 323  
African wild ass 139  
African Americans, soldiers  
    in US Civil War 321  
agoutis 124  
agriculture *see* farming  
Ahmet Fountain (Istanbul) 301  
air pressure 175  
Aira Caldera (Japan)  
    161  
Airbus 380 63  
aircraft 60–3  
    Cold War 333  
    World War I 328–9  
    World War II 330  
airships 63  
Akbar, Emperor 302  
Akhenaten 288  
Akkad 286  
Alaska, earthquake 162  
Albania, flag 197  
albatrosses 150–1  
*Albertosaurus* 77  
*The Alchemist* (Coelho) 221  
Alcock, John 63  
alders 85  
Alexander the Great 291  
Alfred the Great 309, 325  
algae 69  
algebra 47  
Algeria 190  
    flag 196  
Alhambra Palace (Spain) 219  
alkali metals 31  
alkaline earth metals 31  
Allied Powers 330  
alligators 112–13  
*Allosaurus* 76, 77  
alloys 28  
alpacas 141, 187  
alphabet, runic 296  
alpine skiing 262  
amaryllis 81  
Amazon rainforest 145, 187  
Amazon River 186, 187  
amber 72, 169  
ambulances 55, 328  
Amenhotep III 288  
American football 247, 250–1  
American Revolution 317  
Americas, Ancient  
    ammonites 70–1, 72–3  
    amnesia 41  
*Amphibamus* 71  
amphibians 104–5  
    frogs and toads 104–5  
    prehistoric 78, 79  
    rainforest 144–5  
    savanna 147  
    skeletons 132  
    tree of life 68  
Amundsen, Roald 194, 314  
anacondas 111, 145, 187  
anatomy *see* bodies  
*Anchisaurus* 74  
ancient monuments 285  
Andalucian horses 138  
Andes Mountains 186, 187  
Andorra, flag 197  
André, John 334  
anemonefish 98  
anemones 83, 143, 153  
Angel, Chriss 279  
Angel Falls (Venezuela) 186  
angelfish 98, 153, 155  
Angkor Wat (Cambodia) 183,  
    219  
anglerfish 153  
angles 48  
angling 270–1  
Anglo Saxons 324–5  
Angola, flag 196  
*Animal Farm* (Orwell)  
    220  
animals  
    biology 33  
    coral reefs 154–5  
    deserts 148–9  
    endangered 177  
    farm 140–1  
    forests 142–3  
    how life began 70–1  
    life on Earth 159  
    migration 122–3  
    Oceania 193  
    oceans 152–3  
    polar regions 150–1  
    prehistoric 78–9  
    rainforest 144–5  
    relationships 153  
    savanna 146–7  
    tree of life 68–9  
    *see also* dinosaurs  
*Ankylosaurus* 75  
*Anne of Green Gables* (Montgomery)  
    220  
anole lizards 109  
*Anomalocaris* 78  
anostomus 99  
Antarctic Treaty 195  
Antarctica 194–5  
    population 195  
    size 178  
    wildlife 150–1  
anteaters 68, 145, 147  
antennae  
    butterflies and moths 94  
    crustaceans 90  
anthocyanins 228  
antibiotics 45  
Antigua and Barbuda, flag 196  
Antonov AN-225 63  
ants 93, 143, 149  
*Anurognathus* 78  
*Apatosaurus* 74  
apes 126–7  
Apollo spacecraft 15, 16, 17,  
    314, 333  
Appaloosa horses 138  
Apple Flower Festival (Denmark)  
    205  
apples 199  
aquamarine 169  
aquatic snails 97  
aqueducts, Roman 295  
Arab Spring 317  
Arabian horses 138  
*Arabian Nights* 221  
Arabic 206  
arachnids 88–9  
archaea 69, 159  
*Archelon* 70  
archer fish 98  
arches, formation of 165  
Archimedes 291  
architecture *see* buildings  
arcs 48  
Arctic char 99  
Arctic Ocean 153, 171  
Arctic poppies 151  
Arctic terns 122, 123,  
    151  
Arctic wildlife 150  
Arctic willow 151  
Ardennais horses 138  
area  
    Africa 190  
    Antarctica 195  
    Asia 183  
    Earth's surface 178  
    Europe 188  
    geometry 48, 49





North America 184  
 Oceania 193  
 South America 186  
*Argentavis* 78  
 Argentina 187  
   bread 232  
   flag 196  
   football 248  
*Argentinosaurus* 74  
 Aristarchus 18  
 Aristotle 18, 33, 223, 291  
 Arkwright, Richard 327  
 armadillos 68  
 Armenia, flag 197  
 arms and armour  
   Ancient Greece 291  
   Ancient Rome 294  
   Aztec 299  
   early civilizations 287  
   medieval Europe 308–9  
   Mughal 302  
   Ottoman 301  
   Renaissance 312  
   Samurai warriors 305  
   siege weapons 311  
   spies 335  
   US Civil War 320–1  
   Viking 297  
   World War I 329  
   World War II 330–1  
 Armstrong, Neil 16, 314, 333  
 army, Roman 294  
 arrowheads 80  
 art and crafts  
   Ancient Americas 299  
   Ancient Greece 290  
   early civilizations 287  
   early human 285  
   Imperial China 306, 307  
   Imperial Japan 305  
   Mughal Empire 303  
   Ottoman 301  
   Renaissance 313  
   the story of art 208–9  
   Viking 296–7  
 Artemis 293  
 arthropods 68  
 Arthur, Chester A. 318  
 ash trees 85

Asia 182–3  
   flags 197  
   food 225  
   population 180, 183  
   size 178  
 Asian cats 137  
 ASIS (Australia) 335  
 aspens 85, 143  
 asphodels 82  
 ass, African wild 148  
 Asteroid Belt, missions to 16  
 asteroids 11, 14  
 Aston Martin 51  
*Astraspis* 71, 78  
 astrolabes 312, 315  
 astronomy 18–19  
   Mughal 302  
   Northern skies 20–1  
   Southern skies 22–3  
 Atacama Desert 187  
 Athens (Greece) 189, 290  
 athletics 260–1  
 Atlantic Ocean 153, 171  
 atmosphere, Earth's 158, 159  
 atmospheric circulation 172–3  
 atolls 154  
 atomic bombs 330, 331  
 atomic numbers 30  
 atoms 25, 28  
 aubergines 199  
*Aucasaurus* 76  
 Augean Stables 293  
 August Revolution (Vietnam) 316  
 Augustine of Hippo 223  
 auks 117, 151  
 Aurangzeb, Emperor 302  
 aurorae 19, 26  
 Australia 192–3  
   area 193  
   flag 197  
   food 225  
   meat 238  
   population 193  
 Australian Rules football 247  
*Australopithecus afarensis* 284  
 Austria  
   cheese 230  
   flag 197  
 Austria-Hungary, World War I 328

averages 47  
 avocets 117  
 axial tilt, Earth's 150, 178  
 Axis Powers 330  
 Azerbaijan, flag 197

**B**

Babbage, Charles 43  
 baboons 127  
 Babur, Emperor 302  
 Babylon 286  
 backgammon 276, 277  
 bacon 238  
 bacteria 70, 159  
   tree of life 69  
 badgers 133, 142  
 badminton 257  
 bagels 233  
 Bahá'í 203  
 Bahamas, flag 196  
 Bahrain, flag 197  
 balalaikas 211  
 bald eagles 116, 118, 150  
 baleen whales 130  
 Balinese-Javanese cats 137  
 ball lightning 175  
 ball sports 246–7  
   water-based 266  
 ballet 214, 216–17  
 ballistas 311  
 balloons, hot-air 62  
 ballroom dancing 215  
 balls 246, 247  
   football 248  
   racket sports 256–7  
 bananas 199  
 bandfish 98  
 bandros 127  
 bandy 247  
 Bangladesh, flag 197  
 baobab trees 147  
*Barapasaurus* 75  
 Barbados, flag 196  
 barbets 176  
 Barents, William 315  
 bark 84  
 barley 198  
 barn owls 119, 142  
*Baronyx* 73, 76, 77  
 Baroque art 208  
 barracudas 155

barrier reefs 154  
 baseball 247, 252–3  
 basenjis 134  
 bases 29  
 Bashkir ponies 139  
 basketball 246, 254–5  
 bass clef 212  
 basset hounds 135  
 bassoons 210  
 Bastille (Paris) 317  
 bateleurs 118  
 baths, Roman 295  
 bats 133, 143, 145  
 batteries 26, 187  
 battleships 329  
 bayonets 320, 329  
 beach volleyball 246  
 beaches 164  
 beagles 135  
 beaked whales 131  
 beaks 116, 117  
   birds of prey 118  
 beans 198  
 bears 143, 151, 184  
 Beaufort scale 173  
 beavers 125  
 Bedlington terriers 134  
 bee orchids 83  
 beech trees 85, 143  
 beef 238  
   Argentine 187  
 Beehive Cluster 20  
 beekeeping 141  
 bees 93  
 beetles 92, 133, 143, 147, 149  
 Belarus, flag 197  
 Belgium, flag 197  
 Belize, flag 196  
 Bell, Alexander Graham 327  
 Belle Epoque, fashion 243  
 Bellerophon 293  
 belly dancing 215  
 beluga whales 131, 151  
 Bengal cats 136  
 Benin, flag 196  
 Bentley cars 50  
 Beowulf 221  
 Berlin Airlift 333  
 Berlin Wall 317, 332  
 berries 226  
 Bhutan, flag 197  
 biathlons 263

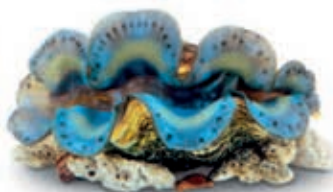




- Bichon Frise 135  
 Bichon Yorkies 135  
 bicycles 64–5  
 Big Bang 10–11  
 Bikaner Camel Festival (India) 204  
 billy dogs 135  
 binary code 42  
 biodiversity 142  
 biofuels 177  
 biology 32–3  
 birch trees 85  
 bird-of-paradise plant 81  
 birds 116–17  
   adaptation 33  
   desert 149  
   eggs 114–15  
   feathers 116, 120–1  
   flight 116, 121  
   forests 142–3  
   migration 122, 123  
   polar regions 150–1  
   prehistoric 78  
   rainforest 144–5  
   savanna 146–7  
   skeletons 132  
   spreading seeds 227  
   Stymphalian 293  
   tree of life 69  
 birds of paradise 117, 121, 144  
 birds of prey 116, 118–19  
 birdwing butterflies 94, 95  
 Birman cats 137  
 birthstones 168  
 bites, snake 111  
 bits (tack) 280  
 black holes 11  
 black mambas 111  
 black smokers 153  
 black widow spiders 88, 89  
 blackbirds 121, 143  
 Blaine, David 279  
 blennies 98  
 Blériot, Louis 63  
 the Blitz (London) 331  
 blood vessels 34  
 blue cheeses 231  
 Blue Mosque (Istanbul) 219  
 blue sharks 100  
 blue whales 131  
 bluebells 81, 82, 143  
 bluebirds 121  
 bluebottles 93  
 bluefish 98  
 BMX bikes 264  
 BND (Germany) 335  
 board sports 267  
 boars 143, 311  
   Erymanthian 293  
 boas 110–11, 144  
 boats 45  
   anatomy of 268–9  
   Egyptian 288  
 bob cats 129  
 bobsleigh 263  
 bodies  
   birds 116  
   cats 136  
   chemical composition 30  
   crocodilians 112  
   crustaceans 90  
   dogs 134  
   fish 98  
   human 34–41  
   insects 92  
   lizards 108  
   meat-eating dinosaurs 76  
   plant-eating dinosaurs 74  
   rodents 124  
   sharks 100  
   slugs and snails 97  
   snakes 110  
   spiders 88  
 body systems 35  
 Body-painting Festival (Austria) 204  
 Bolívar, Simón 317  
 Bolivia 186, 187  
 Bollywood style 214–15  
 Bolt, Usain 261  
 Bolton Abbey (England) 308  
 bombardment 329  
 bombardars 311  
 Bombay cats 137  
 Bombay duck 236  
 bombers 60–1  
 Bond, James 334  
 bone marrow 37  
 bones 34, 35, 36–7  
 bonobos 127  
 bonsai trees 85  
 bony fish 99  
*The Book Thief* (Zusak) 221  
 books 220–1, 312  
 Booth, John Wilkes 321  
 boreal evergreen forests 142  
 Borneo 183  
 Bosnia & Herzegovina, flag 197  
 Boston terriers 134  
 Botswana, flag 196  
 Botticelli, Sandro 313  
 bottlebrush 80  
 bottlenose dolphins 130  
 boules 246  
 bowhead whales 150  
 bowline 274, 275  
 bowling 247  
 bowls 247  
 boxer crabs 153  
 boxfish 98, 153  
 boxing 272  
 Boyd, Belle 321  
 Boyle, Robert 29  
 brachiopods 71  
 Brahms Crater (Mercury) 12  
 brain, human 34, 40–1  
 brain coral 154  
 brass instruments 210  
 brassicas 198  
 Brazil  
   area and population 181, 186  
   flag 196  
   food production 198  
   football 248  
 Brazilian Revolution 316  
 breaching, whales 131  
 bread 232–3  
 bridge 277  
 bridles 280  
 brioche 233  
 bristlecone pines 85  
 Britain see United Kingdom  
 British Empire 322  
 British shorthair cats 137  
 Brittany dogs 134  
 brittle stars 153  
 broccoli 199, 228  
 bromeliads 145  
 Brown, Arthur 63  
 Brunei, flag 197  
 Brunel, Isambard Kingdom 327  
 Buchanan, James 319  
 Budapest (Hungary) 189  
 Buddhism 202, 214, 307  
 buffaloes 146–7  
 Bugatti cars 51  
 bugles 210  
 bugs, true 92  
 buildings  
   castles 310–11  
   earthquake-proof 163  
   great 218–19  
   medieval Europe 308  
   Mughal 303  
 Bulgaria, flag 197  
 bull boxers 135  
 bull terriers 134  
 Bullard, Eugene Jacques 63  
 bulldogs 135  
 bullet ants 145  
 bullet trains 57  
 bullfrogs 147  
 buntings 151  
 burbot 99  
 Burj Khalifa (Dubai) 219  
 Burkina Faso, flag 196  
 Burmese cats 137  
 Burundi, flag 196  
 Bush, George H.W. 319  
 Bush, George W. 319  
 bushbabies 127  
 bustards 117  
 buttercups 83  
 butterflies 93, 94–5, 185  
   migration 122  
   rainforest 144–5  
 butterfly fish 155  
 butterfly weeds 83  
 butterwort 81  
 buzzards 118, 132  
 Byzantine art 208

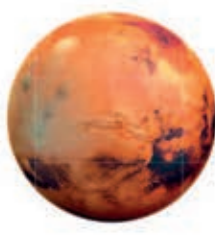
## C

- cabbages 198  
 cacti 80, 148, 149  
 caecilians 105  
 Caesar, Julius 295  
 caimans 113, 132  
 Cairn terriers 134  
 caldera lakes 171  
 calderas 160, 161  
 calendar  
   Chinese 307  
   Roman 295  
 calligraphy  
   Arabic 300  
   Chinese 306





- Calypso 293  
*Camarasaurus* 74  
Cambodia 183  
  flag 197  
Cambrian explosion 70  
camels 141, 148, 190  
  cheese 231  
cameras, spies 334  
Cameroon, flag 196  
*Camptosaurus* 75  
Canaan dogs 134  
Canada 184  
  area 181  
  flag 196  
  food production 198  
  meat 238  
canals 326  
canasta 277  
cancan 214  
cane toads 105, 147  
canoeing 267  
canopy, rainforest 144–5  
canter 281  
Canterbury Cathedral (England) 202  
Canute, King 325  
Cao Dai 203  
Cape Town (South Africa) 191  
Cape Verde, flag 196  
capuchin monkeys 126  
capybaras 144–5, 147  
caracals 128, 148  
caracaras 119  
carbon 31  
carbon dioxide 80  
Carboniferous Period 71  
*Carcharodon* 71  
*Carcharodontosaurus* 70–1, 77  
card games 276–7  
card tricks 278, 279  
Carnac (France) 285  
Carnation Revolution (Portugal) 316  
carnival 204–5  
carnivores 68, 69  
carnivorous plants 81  
Carolinas 134  
carotenoids 228  
carrots 199  
cars 44, 50–1  
Carter, Jimmy 318  
Carthage 295  
cartilaginous fish 99  
Caspian Sea 171  
cassava 198  
Cassini spacecraft 17  
casting (fishing) 271  
castles 310–11  
  Imperial Japan 304  
  medieval Europe 308  
castor beans 81  
Castro, Fidel 316, 332  
casualties  
  US Civil War 320, 321  
  World War I 328  
  World War II 331  
catalytic converters 51  
Caterpillar crawlers 52–3  
caterpillars 95  
catfish 99  
cats 69, 133, 136–7  
  wild 128–9  
cattle 140, 187, 191, 311  
cattle ranches 145  
*Caudipteryx* 76  
cauliflowers 199  
cavalry defence 294  
cave spiders 88  
caves, formation of 165  
caviar 237  
cavy-like rodents 124–5  
Cayley, George 63  
cedars 85, 143  
celebrations 204–5  
celestial sphere 19  
cellos 211  
cells 32, 34  
cement mixers 54  
Cenozoic Era 70–1  
centaurs 292  
centipedes 68  
Central African Republic, flag 196  
ceramics  
  Ancient Americas 299  
  Ancient Greece 209, 290  
  early civilizations 287  
  Imperial China 306, 307  
  Imperial Japan 305  
  invention of pottery 44  
  Mughal 303  
  Ottoman 301  
  prehistoric 285  
ceratopsians 74–5  
*Ceratosaurus* 76  
cereals 198  
Ceres 19  
Cerro Aconcagua (Argentina) 186  
cha-cha 215  
Chad, flag 196  
challah 233  
*Chama* 71  
chambered shells 103  
Chamberlain, Joshua 321  
Chamberlain, Wilt 255  
chameleons 109, 132, 144  
Chandayaan-1 Spacecraft 17  
*changement* 217  
Chantilly Tiffany cats 137  
chariots 287  
Charlemagne 309  
Charles I, King 316, 324  
Charles II, King 324  
*Charlotte's Web* (White) 221  
chars 99  
Chartreux cats 136  
Charybdis 293  
Château de Beynac (France) 308  
Château de Fougères (France) 308  
cheese 198, 230–1  
cheetahs 129, 146  
chemical reactions 29  
chemicals, cleaning 176  
chemistry 28–9  
cherry blossom 183  
cherry trees 85  
Chesapeake Bay retrievers 134  
chess 277  
chestnuts 85  
Chevrolet cars 50  
Chichen Itza (Mexico) 163, 185, 296  
chickens 140, 199, 239, 311  
chicks 114–15, 117  
Chihuahuas 135  
Chile  
  bread 232  
  earthquake 162  
  flag 196  
  pasta 235  
chillies 199  
Chimaera 292  
chimpanzees 127, 133, 144  
Chimu people 298  
China 182, 183  
  area 181  
  art 209  
  early civilizations 286  
  flag 197  
  food production 199  
  Imperial 306–7  
  population 183  
  revolutions 316, 317  
  space programme 15, 17  
chinchillas 125  
Chincoteague ponies 139  
Chinese chequers 276  
Chinese New Year 205  
Chinese Revolution 316  
chipmunks 125  
chipokae 99  
chitons 97, 103  
chlorophyll 80, 228  
chordates 69  
chords 48  
Chow Chows 134  
Christ Church (London) 218  
Christianity 202  
Christmas 205  
chromosomes 32  
chromatography 28  
chrysalis 95  
Churchill, Winston 330, 333  
CIA (USA) 333, 335  
ciabatta 232  
ciambella mandorlata 233  
cinder cones 160  
ciphers 334  
circles 48, 49  
circuits 26  
circumference 48  
*Citipati* 76  
Citroëns 50  
citrus fruit 199, 226  
city-states  
  Greek 290  
  Italian 312  
Civil War  
  English 316  
  US 320–1  
civilizations  
  Ancient Americas 298–9  
  Ancient Egypt 288–9  
  Ancient Greece 290–1  
  early 286–7  
  Imperial China 306–7  
clams 68, 97, 237  
clarinets 210  
classical dance 214  
classification  
  biology 33  
  of life 69





- clefs 212  
 Cleopatra VII 288, 289  
 Cleveland, Grover 318  
 climate 172–3  
   extreme 179  
 climate change 33, 146, 172, 174  
 Clinton, Bill 319  
 clothing  
   Ancient Greeks 290  
   Imperial China 307  
   medieval Europe 308  
   men's fashions 240–1  
   motorbike 58  
   sailing 268  
   Vikings 296–7  
   women's fashions 242–3  
 cloud forest 145  
 clouds 171, 173  
 clover 82  
 clown triggerfish 98, 152, 155  
 clownfish 99, 153, 155  
 clubs 329  
 cluster flowers 82  
 Clydesdale horses 138  
 co-ordination 41  
 coal 326  
 coastal deserts 148  
 coastal redwoods 84  
 coatis 145  
 coats, horses 139  
 coats of arms 308  
 cobra lilies 81  
 cobras 110, 144, 148  
 cockatoos 117  
   feathers 120  
 cocker spaniels 134–5  
 cockerpoos 135  
 cockroaches 71, 72  
 cocoa 323  
 cocoa trees 85, 145  
 coconuts 199  
 cod 98–9  
 codes 334  
*Coelophysis* 76  
 coffee 323  
 coins  
   Ancient Greece 290  
   tricks 278, 279  
 cold deserts 148  
 Cold War 332–3  
 cold waves 174  
 cold-blooded creatures 110  
 collies 135  
 colocolos 128  
 Colombia, flag 196  
 Colosseum (Rome) 219, 295  
 colours 25  
   vegetables 228  
 colubrids 110–11  
 Columbus, Christopher 314, 315  
 combat sports 272–3  
 combustion 29  
 comets 11  
 Commonwealth (1649–59) 324  
 communications, US Civil War 321  
 Comoros, flag 196  
 companion dogs 135  
 compasses, magnetic 268, 315  
 composite numbers 47  
 computers 42–3, 45  
 condors 118  
 conductors 27  
 cones 49  
 Confederates 320–1  
 Confucianism 203, 307  
 Confucius 203, 222  
*Confuciusornis* 70  
 Congo, flag 196  
 conifers 69, 80  
 Connemara ponies 139  
 conservation 177  
   wild cats 128  
 constellations 19, 20–3  
 constrictors 111  
 construction vehicles 54  
 consumers 177  
 contemporary art 209  
 continents  
   Africa 190–1  
   Antarctica 194–5  
   Asia 182–3  
   Europe 188–9  
   North America 184–5  
   Oceania 192–3  
   size of 178  
   South America 186–7  
 Cook, Captain James 314  
 Cooke, William 327  
 Coolidge, Calvin 319  
 coordinates 178  
 coots 117  
 Copernicus, Nicolaus 18  
*Coppélia* 216  
 cor anglais 210  
 coral reefs 154–5, 158, 193  
 coral snakes 110  
 corals 71, 72, 153, 169  
 core  
   Earth's 158  
   Moon 14  
 core fruit 226, 227  
 corgis 135  
 cormorants, fishing with 271  
 corncrakes 117  
 cornsnakes 110  
 Cortés, Hernán 299, 315  
 Corvus constellation 22  
*Corythosaurus* 75  
 Costa Rica  
   flag 196  
   rainforest 185  
 costumes  
   ballet 216  
   dancing 215  
 Cottee, Kay 269  
 cotton 323  
   mills 327  
 cottongrass 151  
 countries  
   biggest and smallest 181  
   flags 196–7  
 course plotters 268  
 court style clothing 240–1  
 courts  
   baseball 254  
   racket sports 256–7  
   tennis 258  
 covert feathers 121  
 cows 140, 199, 311  
   cheese 231  
 coyotes 143, 149  
 crab apples 85  
 Crab Nebula 20  
 crabs 90–1, 102, 133, 153, 237  
 cranes (birds) 117  
 cranes, truck-mounted 55  
 craters, lunar 14  
 crawlers 52–3  
 crayfish 91, 237  
 Cretaceous Period 70–1  
 cribbage 277  
 cricket 246  
 crickets 92, 149  
 crime, medieval Europe 309  
 crinoids 70  
 crispbread 232  
 Croatia, flag 197  
 crocodiles 68, 112–13, 144, 185  
   eggs 115  
 Cromwell, Oliver 316, 324  
 croquet 247  
 cross-country skiing 262  
 crossbills 143  
 crossbreeds, dogs 135  
 crotchets 212  
 crows 132  
 cruisers, motorbike 58–9  
 the Crusades 309  
 crust  
   Earth 158, 159  
   Moon 14  
 crustaceans 90–1  
   skeletons 133  
   tree of life 68  
 Crux constellation 23  
 Cryolophosaurus 76  
 Cuba  
   Cuban Revolution 316  
   flag 196  
 cubed numbers 46  
 cubes 49  
 Cubism 209  
 cuboids 49  
 cuckoos 116  
 cucumbers 199  
 culture 200–43  
   architecture 218–19  
   art 208–9  
   celebrations 204–5  
   dance 214–17  
   fashion 240–3  
   food 224–39  
   language 206–7  
   literature 220–1  
   music 210–13  
   philosophy 222–3  
   religion 202–3  
 cuneiform 212  
 curares 145  
 Curie, Marie 29  
 Curiosity rover 17  
 curlews 121  
 current, electrical 26  
 cusk eels 153  
 cuttlefish 97, 152, 237  
 Cuzco 298  
 cyber spies 335  
 cycads 81





cycling 264–5  
 see also bicycles  
 Cyclopes 293  
 cylinders 49  
 cymbals 25  
 cymric cats 137  
 cypress trees 85  
 Cyprus  
 flag 197  
 meat 238  
 Czech Republic, flag 197  
 Czechoslovakia 333

## D

da Gama, Vasco 315  
 dachshunds 135  
 daddy long-legs 88  
 daffodils 81  
 dahlias 81  
 Daimyo 304  
 dairy produce 198  
 daisies 82, 83  
 Dali, Salvador 209  
 Dallol (Ethiopia) 179  
 dalmatians 135  
 damselflies 93  
 dance 214–15  
 ballet 216–17  
 dandelions 143  
 dandies 241  
 dandy horses 65  
 Danish warmbloods 138  
 Dante the Great 279  
 Danube River 189  
 Daoism 307  
 dark energy 11  
 dark matter 11  
 dark zone, ocean 152–3  
 Darwin, Charles 33, 315  
 Davis, Jefferson 321  
 Davy, Sir Humphry 327  
 Day of the Dead (Mexico) 205  
 de Beauvoir, Simone 223  
 Dead Sea (Israel) 183  
 deadly nightshade 81  
 deadly webcap 87  
 Dean, Christopher 263  
 deathcap 87  
 decathlon 261  
 deciduous trees 85, 142  
 decimals 47

deer 143, 147  
 defence  
 castles 310–11  
 crabs 90  
 fish 99  
 plant-eating dinosaurs 75  
 tortoises 107  
 defenders  
 American football 251  
 football 248, 249  
 deforestation 176, 177  
*Deinonychus* 76, 77  
*Deinotherium* 79  
 Delhi (India) 180  
 deltas 164  
 dementia 41  
 Demeter 293  
 Democratic Republic of Congo,  
 flag 196  
 Denali National Park (Alaska) 184  
 Denmark  
 bread 232  
 flag 197  
 meat 238  
 deposition 164  
 dermis 34  
 Derrida, Jacques 223  
 dervishes 214  
 Descartes, René 222  
 desert cats, Indian 129  
 desert roses 148  
 deserts 148–9, 158–9, 176  
 Devon rex 137  
 Devonian Period 71  
 DGSE (France) 335  
 diameter 48  
 diamonds 166, 169, 191  
*The Diary of a Young Girl* (Frank) 220  
*Dicraeosaurus* 75  
 diesel trains 56–7  
 digestive system 35  
 diggers 55  
 digital telescopes 43  
*Dimetrodon* 70–1, 78  
*Dimorphodon* 78  
 dinosaurs 70–1  
 extinction 33  
 fossils 72–3  
 meat-eating 76–7  
 plant-eating 74–5  
 Dior, Christian 242  
*Diplodocus* 74, 75

discus 261  
 distance events (athletics) 261  
*Distichodus* 99  
*Ditomopyge* 78  
 diving 266  
 division 46  
 Diwali 204–5  
 Djibouti, flag 196  
 DNA 34  
 dobermanns 135  
 dodgeball 246  
 dodos 33  
 dogs 134–5  
 fishing with 271  
 Dolmabahçe Palace (Istanbul) 300–1  
 dolphins 130–1, 152, 154–5  
 fishing with 271  
 Dominica, flag 196  
 Dominican Republic, flag 196  
 dominoes 276  
*Don Quixote* (Cervantes) 221  
 donkeys 139, 141  
 doppler radar 173  
 dormice 125, 143  
*Dorudon* 131  
 double basses 211  
 doves 117, 121  
 dragonflies 93, 133  
 Drake, Sir Francis 314  
 draughts 276, 277  
*Dream of the Red Chamber* (Cao  
 Xueqin) 221  
 dressage 281  
 dresses 242–3  
 dribbling  
 basketball 255  
 football 249  
 dried fish 236  
 droughts 174  
 drums 210, 211  
 Dry Valleys (Antarctica) 179  
*Dryosaurus* 75  
 Dubois, W.E.B. 223  
*Dubreuillosaurus* 77  
 ducks 117, 132, 140, 143, 239  
 feathers 121  
 dugongs 68, 152  
 Dumbbell nebula 20  
 dumpers 54  
 dunes 148  
 dung beetles 147  
 dunnocks 117

Duomo (Florence) 313  
 durians 227  
 dust storms 174  
 Dutch Revolt 316  
 dwarf planets 11

## E

eagle owls 116, 119  
 eagles 116, 118, 132, 144  
 Earhart, Amelia 62  
 early warning systems  
 (earthquakes) 163  
 Earth 11, 13, 158–9  
 axial tilt 150, 178  
 how life began 70–1  
 our physical world 178–9  
 our political world 180–1  
 water on 170–1  
 earthquakes 162–3  
 detectors 307  
 earthworms 68  
 East Timor, flag 197  
 Easter 205  
 Eastern Europe, revolutions 317  
 echidnas 148  
 echinoderms 71  
 skeletons 133  
 tree of life 68  
*Echmatocrinus* 70  
 economy, and empires 322  
 Ecuador, flag 196  
 Edinburgh Festival (Scotland) 204  
 Edison, Thomas Alva 27  
*Edmontia* 75  
*Edmontosaurus* 75  
 Edward I (“Longshanks”), King 325  
 Edward VII, King 325  
 eels 98–9, 122, 152  
*Efraasia* 74  
 Egbert 324  
 egg-laying mammals 68  
 eggs 114–15  
 amphibians 104, 105  
 birds 114–15,  
 116, 117  
 butterflies 95  
 crocodylians 112  
 fish 237  
 insects 93  
 reptiles 115  
 turtles 107





- Egypt, Ancient 286, 288–9  
 art 209  
*Book of the Dead* 220  
 trade 314
- Egypt, flag 196
- Egyptian mau 137
- Eid-al-Fitr 204
- Eiffel Tower (France) 189
- Einstein, Albert 25, 41
- Eisenhower, Dwight D. 318, 332
- El Greco 208
- El Salvador, flag 196
- Elasmosaurus* 79
- electric eels 26
- electric trains 57
- electricity 26–7  
 hydroelectric power 171
- electromagnetic spectrum 25
- electromagnetism 26
- electrons 28
- elements 30–1
- elephants 68, 147, 191  
 evolution 79  
 skeleton 132–3
- Elizabeth I, Queen 324
- Elizabeth II, Queen 325
- Elizabethan clothing 241
- elms 85
- elves 175
- Ely, Eugene Burton 63
- email 43
- embryos 114
- emeralds 168
- emergency vehicles 55
- emergent layer, rainforest 144–5
- emotions 41
- Empire State Building (New York)  
 218
- emus 146, 193
- Encrinurus* 78
- endangered species 177
- endocrine system 35
- energy  
 electricity 26–7  
 for life 32  
 renewable 177  
 types of 25
- England  
 English Revolution 316  
 football 248  
 monarchs 324–5
- English language 206
- Enigma machines 334
- environment, danger to 176–7
- Eocaecilia* 70
- Eomaia* 70
- Eoraptor* 76
- Eothyris* 71
- Epic of Gilgamesh* 220
- epidermis 34
- Equatorial Guinea, flag 196
- equipment  
 American football 250  
 baseball 252  
 basketball 254  
 fishing 270–1  
 racket sports 256–7  
 skiing 262  
 spies 334–5  
 tennis 258  
 US Civil War 320–1
- Equus* 138
- Erasthenes 18
- Erik the Red 297
- Eriskay ponies 139
- Eritrea, flag 196
- ermine 150
- erosion 164–5
- eruption styles, volcanoes 160
- Erta Ale (Ethiopia) 160
- ESA 15, 17
- escapology 279
- Eskimo rolls 267
- eskrima 272
- Estonia, flag 197
- Etemenaki Ziggurat (Babylon) 286
- Ethiopia  
 Ethiopian Revolution 316  
 flag 196
- eucalyptus 143
- eudicots 83
- Eudimorphodon* 78
- Euoplocephalus* 74, 75
- Euparkeria* 78
- Europe 181, 188–9  
 empires 322–3  
 flags 197  
 food 225  
 medieval 308–9  
 population 180, 188  
 Renaissance 312–13  
 revolutions 316, 317  
 size 178  
 space programme 15, 17
- European eels 122
- European Revolutions 317
- even-toed hoofed animals 68
- eventing 281
- events  
 cycling 264, 265  
 sprint 261
- Everglades (Florida) 185
- evergreen trees 85, 142
- Evert, Chris 259
- evolution 33  
 first humans 284  
 horses 138  
 prehistoric animals 79  
 whales 131  
 wolves and dogs 134
- excavators 55
- Exmoor ponies 139
- exoskeletons 132, 133
- exosphere 159
- Exotic Shorthair cats 137
- exploration 314–15, 322
- Expressionism 209
- extinction 33, 78
- eye glasses 45
- eyes  
 birds of prey 118  
 cats 136  
 dogs 135  
 horses 139  
 human 35  
 insects 92, 93  
 sharks 101  
 snakes 110
- F**
- facial expressions 38
- factories 327
- falcons 119, 149, 151
- family (classification of life) 69
- fangtooth 152
- fans 305
- Faraday, Michael 27
- farming  
 domestic animals 141  
 early civilizations 286  
 first humans 285  
 and habitat loss 145, 146  
 Industrial Revolution 327  
 tractors 52–3  
 year on the farm 52
- fashion  
 men's 240–1  
 women's 242–3
- Fatehpur Sikri (India) 303
- fault lakes 171
- faults, geological 59, 162
- feathers 116, 120–1
- Federer, Roger 259
- fencing 272, 273
- fennec foxes 148
- fer-de-lance 110, 111
- ferns 69, 70, 71, 81, 143
- Ferrari cars 50–1
- Ferrel cell 173
- fertilizers 52
- Festival of the Pig (France) 24
- festivals 204–5
- Feynman, Richard 25
- Fibonacci Sequence 46
- fiddler crabs 91
- field guns 329
- fields  
 American football 250  
 baseball 252
- FIFA World Cup 249
- fig trees 85
- figure skating 263
- Fiji, flag 197
- Fillmore, Millard 318
- filtering 28
- filters, whales 130
- finches 143
- fingers 36
- Finland  
 cheese 230  
 flag 197
- fins 98, 100
- fire engines 55
- firearms 329, 330
- The Firebird* 216
- firefish 154
- firs 85
- fish 98–101  
 coral reefs 154–5  
 eggs 115  
 as food 236–7  
 oceans 152–3  
 polar regions 150  
 prehistoric 78–9  
 sharks 100–1  
 skeletons 132  
 tree of life 68





fish owls 119  
 fishing 270–1  
 fishing cat 128  
 fjords 189  
 flags 196–7  
   prayer 202  
 flamingoes 121, 185  
 flatbreads 232  
 flat fish 237  
 flavours  
   bread 232–3  
   cheese 230  
 fledglings 117  
 Fleming, Ian 334  
 flies 93  
 flight  
   aircraft 60–3, 312  
   birds 116, 121  
 flightless birds 116  
 floats (fishing) 271  
 flooded rainforest 145  
 flooded savanna 146  
 floodplains 164  
 floods 174  
 Florence (Italy) 313  
 flowers 82–3  
   flowering plants 69, 80–1  
   vegetables 228  
 Flowers, Thomas 43  
 flutes 25, 210  
 fly-fishing 271  
 flying foxes 145  
*Flying Scotsman* 56  
 flying snakes 111  
 flying squirrels 124, 125  
 focaccia 232  
 fog 174  
 folding bicycles 65  
 folk dancing 214  
 food  
   Antarctic food web 150  
   around the world 224–5  
   bread 232–3  
   cheese 230–1  
   fish 236–7  
   fruit 226–7  
   horses 280  
   meat 238–9  
   pasta 234–5  
   plants 80  
   vegetables 228–9  
   where food comes from 198–9

food web 33  
 football 247, 248–9  
 Forbidden City (Beijing) 306  
 force 24  
 Ford, Gerald 318  
 Ford cars 50  
 forest floor, rainforest 144–5  
 forests 142–3, 159  
   destruction of 177  
   rainforest 144–5  
   see also trees  
 the Forties, clothing 240, 242  
 fossil fuels, burning 176  
 fossils 70, 71, 72–3, 89  
 Fox Talbot, William 327  
 fox terriers 134  
 foxes 143, 148, 151  
 foxface fish 98  
 fractions 47  
 France  
   cheese 230  
   cycling 265  
   flag 197  
   football 248  
   French Empire 322  
   French Revolution 317  
   meat 238  
   World War I 328, 329  
   World War II 330–1  
 Franco, General Francisco 316  
 Franklin, Benjamin 27  
 freestyle skiing 262  
 French horns 210  
 French Polynesia, fish 236  
 frescoes 209  
 freshwater crocodile 113  
 freshwater fish 99  
 freshwater fishing 270  
 friction 24  
 frigatebirds 186  
 frilled lizards 109  
 fringing reefs 154  
 Frobisher, Martin 314  
 frogs 68, 104–5, 147  
 frogspawn 104  
 the Fronde 316  
 fronts, weather 172–3  
 fruit 83, 199, 226–7, 228  
 FSB (Russia) 335  
 fuel injection systems 51  
 fungi 33, 86–7, 159

forests 143  
 tree of life 68–9  
 funnel-web spiders 88, 89

## G

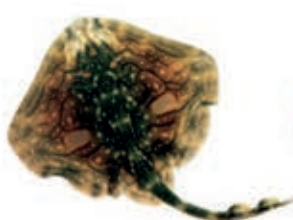
Gabon, flag 196  
 Gaboon vipers 145  
 Gaelic football 247  
 Gagarin, Yuri 16, 314, 333  
 galagos 127  
 galahs 149  
 Galápagos Islands 186  
 Galápagos tortoise 106  
 galaxies 10, 22  
 Galilei, Galileo 18  
*Gallinimus* 76  
 gallinules 117  
 gallop 281  
 Galunggung (Java) 161  
 Gambia, flag 196  
 game birds 116  
   feathers 120  
   meat 239  
 games  
   Aztec 299  
   board 276–7  
   card 276–7  
   computer 43  
 Gandhi, Mahatma 322  
 Ganesh 202  
 Ganges, River (India) 182  
 Gangnam style 214  
 Garfield, James 319  
 garfish 98–9, 152  
*Gargoyleosaurus* 75  
 garlic 198  
 garter snakes 111  
*Gasosaurus* 76  
*Gastonia* 75  
 gatehouses 310  
 gazelles 146  
 geckos 108, 132, 144  
 geese 117, 140, 151, 311  
   feathers 121  
   migration 123  
 gemstones 166, 168–9  
 genes 32  
 Genesis spacecraft 17  
 Genghis Khan 302  
 gentlemen's clothing 241  
 genus 69

Geoffroy's cats 128  
 geography 156–99  
   climate and weather 172–5  
   continents 182–95  
   Earth 158–9  
   earthquakes 162–3  
   environment in danger 176–7  
   flags 196–7  
   food production 198–9  
   landscape 164–5  
   our physical world 178–9  
   our political world 180–1  
   rocks and minerals 166–9  
   volcanoes 160–1  
 geometry 48–9  
 George I, King 324  
 George III, King 325  
 George VI, King 325  
 Georgia, flag 197  
*Geosaurus* 78  
 geothermal energy 177  
 gerbils 124  
 Germany  
   bread 232  
   cheese 230  
   Cold War 332–3  
   flag 197  
   football 248  
   German Revolution 316  
   World War I 329  
   World War II 330–1  
 germination 80  
 Geryon, cattle of 293  
 Ggantija Temples (Malta) 285  
 Ghana, flag 196  
 gharials 112, 113  
 gherkins 199  
 Ghirlandaio, Domenico 313  
 ghost crabs 90  
 giant clams 97, 102, 153  
 giant tortoises 186  
 gibbons 127, 145  
 gila monsters 148  
 gills 98, 104  
 ginkgo trees 69, 81, 85  
*Giraffatitan* 74  
 giraffes 146, 147  
*Giselle* 216  
 glaciation 164, 167  
 gladiators 295  
 gladioli 81, 82  
 glass 29





- gliders 63  
 global warming 174, 176  
 globes 315  
 glockenspiels 211  
 gloves, baseball 252  
*Glyptodon* 79  
 gnus 147  
 Go game 276  
 goal posts, American football 250  
 goalkeepers, football 248, 249  
 goats 141, 239, 311  
   cheese 231  
 Göbekli Tepe (Turkey) 285  
 gods and goddesses  
   Ancient Americas 299  
   Ancient Egypt 289  
   Ancient Greece 291, 292  
   early civilizations 287  
 godwits, bar-tailed 123  
 gold 323  
 Golden Fleece 293  
 Golden Gate (San Francisco) 185  
 golden retrievers 134  
 Golden Temple (Amritsar) 203  
 goldendoodles 135  
 goldfish 99  
 golf 146  
 goliath birdeater tarantulas 89  
*Goniatites* 78  
 Gorbachev, Mikhail 332  
 Gordon, John Brown 321  
 gorges 164, 165  
 gorillas 127, 133, 144–5, 284  
 Gormley, Antony 209  
 goshawks 118  
 Goths 295  
 Gotland ponies 139  
 Graf, Steffi 259  
 Grafström, Gillis 263  
 Grand Canyon (USA) 185  
 granite 166–7  
 Grant, Ulysses S. 319, 321  
 grapes 199  
 grass 82–3  
 grasshoppers 92  
 grasslands 146–7, 158  
 gravity 24  
 Great Barrier Reef (Australia) 193  
 Great Dark Spot (Neptune) 13  
*Great Expectations* (Dickens) 220  
 The Great Lafayette 279  
 Great Pyramid (Egypt) 218  
 Great Red Spot (Jupiter) 12  
 Great Wall of China 183, 218, 306–7  
 great white shark 101  
 Greece  
   Ancient 286, 290–1  
   art 209  
   bread 232  
   cheese 230  
   flag 197  
   myths 292–3  
   pasta 235  
 greenhouse effect 176  
 greenhouse gases 175  
 Greenland dogs 134  
 Grenada, flag 196  
 grenades 329  
 grenadiers, Pacific 152  
 greyhounds 135  
 Griffith-Joyner, Florence 260  
*Grimms' Fairy Tales* 221  
 grooming tools, horses 280  
 ground squirrels 125  
 group behaviour, monkeys and apes 126  
 groupers 153  
 grouse 116, 120, 239  
 guerezas 127, 145  
 Guevara, Che 316, 333  
 Guggenheim Museum (Bilbao) 218–19  
 Guinea, flag 196  
 guinea fowl 120  
 guinea pigs 124, 141  
 Guinea-Bissau, flag 196  
 guitars 211  
 gulls 117, 121  
 gum trees 85, 147  
 gundogs 134  
 gunpowder 45, 307  
 guns 312, 320–1, 329, 335  
 gurnards 98, 152  
 Guru Granth Sahib 203  
 Guyana  
   fish 236  
   flag 196  
**H**  
 habitats 158–9  
   coral reefs 154–5  
   deserts 148–9  
   destruction/loss 33, 146  
   forests 142–3  
 oceans 152–3  
   polar 150–1  
   rainforest 144–5  
   savanna 146–7  
   slugs and snails 97  
 hadal zone, ocean 153  
 Haflinger ponies 139  
 Hagia Sophia (Istanbul) 219  
 hailstones 175  
 hailstorms 174  
 hair 38  
 hairless cats 137  
 hairless dogs 134  
 hairstreak butterflies 95  
 Haiti  
   flag 196  
   Haitian Revolution 317  
*Haka* 215  
 Hakouichthys 78  
 Halley's Comet 18  
 Hall, Virginia 334  
 Halloween 205  
*Hallucigenia* 71  
 halogens 31  
 ham 239  
 hammer throwing 261  
 hamsters 124–5  
 Han Wudi 306  
 hand-pelota 247  
 handaxes 44, 184–5  
 handball 246  
 Hanging Gardens of Babylon 286  
 Hannibal 295  
 Hanoverians 324–5  
 Hanukkah 205  
 hard cheese 230–1  
 Harding, Warren B. 319  
 Hardiwar (India) 182  
 hares 133, 150  
 harlequin sweetlips 98  
 Harley-Davidson motorbikes 58, 59  
 harmony 212  
 harness races 281  
 Harold II, King 325  
 harriers 118  
 Harrison, Benjamin 318  
 Harrison, William Henry 318  
*Harry Potter and the Philosopher's Stone* (Rowling) 221  
 Harvest Festival 204  
 harvesting 52  
 hatchetfish 99  
 hatchlings 115, 117  
 hats 240–1, 242–3  
 Hatshepsut 288  
 haulage vehicles 54  
 hawk-moths 95  
 hawkfish 155  
 hawks 118  
 hay fever 83  
 Hayes, Rutherford B. 319  
 hazardous waste 176  
 heart  
   human 34  
   snakes 110  
 heat 25  
 heatwaves 174  
 heavy horses 138  
 hedgehogs 68, 142  
 heels 37  
 height, horses 139  
 helicopters 61, 62  
 Helios 293  
 hellebores 82  
 helleborines 82  
 helmets  
   Ancient Greek 291  
   Ancient Roman 294  
   medieval European 308–9  
   Mughal 302  
   Ottoman 301  
   Samurai 304  
   Viking 297  
 hemlock 85  
 Henie, Sonja 263  
 Henry III, King 325  
 Henry IV, King 325  
 Henry V, King 325  
 Henry VI, King 324  
 Henry VIII, King 324  
 heptathlon 261  
 Heracles, labours of 293  
 hermit crabs 91, 102, 155  
 herons 116  
 Herrerasaurus 72, 78  
 Herschel, William 19  
 Hesperides, golden apples of 293  
*Heterodontosaurus* 75  
 hibiscus 81  
 hieroglyphs 289  
 high jump 260  
 Hildegard of Bingen 223  
 Himalayan sheepdogs 135  
 Himalayas 13





Himeji Castle (Japan) 219  
 Hindi 206  
 Hinduism 202  
 hinged shells 102–3  
 Hippolyta, belt of 293  
 hippopotamuses 147, 191  
 hippy style 243  
 Hiroshige, Utagawa 305  
 Hiroshima (Japan) 331  
 history 282–335  
   Ancient Americas 298–9  
   Ancient Egyptians 288–9  
   Ancient Greeks 190–3  
   Ancient Rome 294–5  
   British monarchs 324–5  
   castles and fortresses 310–11  
   Cold War 332–3  
   early empires 286–7  
   European empires 322–3  
   exploration 314–15  
   first humans 284–5  
   Imperial China 306–7  
   Imperial Japan 304–5  
   Industrial Revolution 326–7  
   medieval Europe 308–9  
   Ottoman Empire 300–1  
   Renaissance 312–13  
   revolutions 316–17  
   spies 334–5  
   United States 318–21  
   Vikings 296–7  
   World War I and II 328–31  
 Hitler, Adolf 330, 331  
 Ho Chi Minh 316  
 Hobbes, Thomas 223  
 hobbies  
   games 276–7  
   knots 274–5  
   magic 278–9  
   see also sports  
*The Hobbit* (Tolkien) 220  
 hockey 246  
   underwater 266  
 Hodgkin, Dorothy 29  
 hogweed 82  
 Hohenzollern Castle (Germany) 311  
 Holi 205  
 Hollerith, Herman 43  
 hollyhocks 81  
 Holocaust Memorial (Berlin) 331  
 Holy Trinity Church (Slovenia) 308  
*Homeosaurus* 73

homes, electricity 28  
*Homo erectus* 284  
*Homo neanderthalensis* 284  
*Homo sapiens* 284  
 Honda cars 50  
 Honduras, flag 196  
 honey 141  
 Hoover, Herbert 319  
 hoplites 291  
*Hoplopteryx* 70  
 hornbeams 85  
 horncone, Mexican 81  
 hornets 143  
 horse riding 280–1  
 horseball 281  
 horses 133, 138–9  
   cheese 231  
 horseshoe crabs 153  
 horsetail 81  
 hot cross buns 233  
 hot deserts 148  
 hot springs 193  
 Houdini, Harry 279  
 houseflies 93  
 Houses of Parliament (London)  
   218  
 howler monkeys 126  
*Huangosaurus* 74  
 Hubble Space Telescope 17  
 human body 30, 34–41  
 humans, first 284–5  
 Hume, David 222  
 Hummers 51  
 hummingbirds 117  
 humpback whales 122, 130  
*The Hunchback of Notre Dame* (Hugo)  
   221  
 Hungarian pulis 135  
 Hungarian vizslas 134  
 Hungary  
   bread 232  
   flag 197  
   revolution 316, 317  
   Soviet invasion 333  
 hunter-gatherers 285  
 hunting 33  
   birds of prey 118  
   crocodilians 112  
   early civilizations 286  
   first humans 285  
   frogs 105  
   lions 129

meat-eating dinosaurs 77  
 spiders 89  
 hurdles 261  
 hurling 246  
 hurricanes 174, 175  
 huskies 134  
 hyacinths 82  
 Hyades star cluster 20  
*Hybodius* 78, 79  
 hybrid cars 51  
 Hydra 293  
 hydraulics 55  
 hydroelectric power 171, 177  
 hydrogen 30  
 hydrostatic skeletons 133  
 hyenas 146, 147  
*Hypsilophodon* 75  
 hyrachotheium 138

## IJ

*Iberomesornis* 78  
 ibises 116, 145  
 Ibizan hounds 134  
 Ibn-Rushd (Averroes) 223  
*Icaronycteris* 71, 78  
 ice dancing 263  
 ice sheets 194  
 ice skating 263  
 icebergs 194  
 Iceland  
   cheese 230  
   fish 236  
   flag 197  
*Ichthyosaurus* 78  
 icons 202  
 Ieyasu, Tokugawa 304, 305  
 igneous rocks 166  
 iguanas 108–9, 186  
*Iguanodon* 75  
 immune system 35  
 imperialism 322  
 Impressionism 208–9  
 Inca civilization 298, 299  
 incubation, eggs 115  
 Independence Day (USA) 204  
 independence movements 322  
 India 182  
   art 209  
   British rule 322  
   early civilizations 286  
   flag 197  
 food production 199  
 Mughal Empire 302–3  
 space programme 15, 17  
 Indian epics 220  
 Indian Ocean 153, 171  
 Indonesia  
   flag 197  
   food production 199  
   tsunami 163  
 Industrial Revolution 326–7  
 Infrared Astronomical Satellite 19  
 infrared telescopes 18  
 insects 92–3  
   butterflies and moths 94–5  
   desert 149  
   eggs 115  
   forests 143  
   rainforest 144–5  
   savanna 147  
   skeletons 133  
   tree of life 68  
 instruments, musical 210–11  
 insulators 27  
 intelligence agencies 335  
 international instruments 210  
 International Space Station 17  
 international tractors 52–3  
 internet 43, 45  
 Inuits 267, 315  
 inventions 44–5  
   Chinese 306–7  
   Renaissance 312  
 invertebrates 78  
   desert 149  
   forests 143  
   fossils 72–3  
   rainforest 144–5  
   reef 154–5  
   tree of life 68  
 Iolo 161  
 Iraq, flag 197  
 Ireland  
   bread 232  
   flag 197  
   meat 238  
 irises 82  
 Irish setters 134  
 Irish wolfhounds 135  
 iron 326  
*Irritator* 76  
*Isanosaurus* 74  
 Ishtar Gate (Babylon) 286





ISI (Pakistan) 335  
 Islam 202, 309  
   art 208  
 island chains, volcanic 161  
 Israel, flag 197  
 Istanbul (Turkey) 188, 300–1  
 Italy  
   cheese 230  
   flag 197  
   football 248  
   Italian Empire 322  
   pasta 235  
   Renaissance 312–13  
   World War I 328, 329  
   World War II 330–1  
 Ivar the Boneless 297  
 ivory 323  
 Ivory Coast, flag 196  
 Jack Russell terriers 134  
 jackfruit 227  
 Jackson, Andrew 319  
 Jacquard, Joseph 43  
 jaguars 128, 129, 145, 147, 187  
 Jahangir, Emperor 302  
 Jainism 203  
 Jakarta (Indonesia) 180  
 Jamaica, flag 196  
 James I, King 324  
 James Webb Space Telescope  
   19  
*Jane Eyre* (Bronte) 220  
 janissaries 300  
 Jantar Mantar Observatory (Delhi)  
   302  
 Japan  
   art 209  
   cherry blossom 183  
   earthquakes and tsunamis 162,  
   163  
   fish 236  
   flag 197  
   Imperial 304–5  
   Meiji Restoration 317  
   space programme 15, 17  
   World War II 330–1  
 Japanese bobtails 137  
 Jarnsmida Bjorn 297  
 Jason, and the Golden Fleece 293  
 javelin 261  
 jawbones 36  
 jawless fish 99  
 jaws

crocodilians 112  
 sharks 101  
 jays 121  
 Jazz Age, fashion 243  
 jeeps 51  
 Jefferson, Thomas 319  
 jellyfish 133  
 jet stream 72  
 jets (weather) 175  
 Jewel Box cluster 22  
 jewelfish 155  
 jewelled amanitas 87  
 jewellery  
   Ancient Egypt 289  
   Ancient Greece 290  
   early civilizations 209, 287  
   Mughal 303  
   Ottoman 301  
   Viking 296  
 Jews  
   Judaism 203  
   World War II 331  
 Jin Mao Tower (Shanghai) 219  
 jirds 124  
 jitterbug 214  
 jive 215  
 John Deere 52  
 John Dory 98  
 Johnson, Amy 63  
 Johnson, Andrew 319  
 Johnson, Lyndon B. 318  
 joints 37  
 Jolly Roger 197  
 Jordan 182  
   flag 197  
 jousting 309  
 Joyon, Francis 269  
 Judas trees 85  
 judo 272, 273  
 jujitsu 272  
 Julius II, Pope 312  
 jumping 260  
   horse 281  
 jumping spiders 88  
 jungle cat 129  
 junipers 85  
 Juno spacecraft 16  
 Jupiter 12  
   missions to 16  
 Jurassic Period 70  
 Jutland horses 138

## KL

K2 179  
 Kabuki 214  
 Kalahari Desert 191  
 kalaripayit 272  
 kangaroo rats 149  
 kangaroos 147, 148, 193  
 Kangchenjunga 179  
 Kangxi 306  
 Kant, Immanuel 222  
 kapok trees 145  
 Karabakh horses 138  
 karate 272  
 Kastelholm Castle (Finland) 311  
 kayaking 267  
 Kazakhstan, flag 197  
 Kelut (Java) 161  
 kendo 272  
 Kennedy, John F. 318, 332  
*Kentrosaurus* 70, 74  
 Kenya, flag 196  
 Kepler, Johannes 18  
 kestrels 119, 132  
 kettle lakes 171  
 Kevlar 29  
 keyboards 211, 212–13  
 KGB 333  
 Khafra 288  
 Khrushchev, Nikita 332  
 Khufu 288  
 kicking  
   American football 251  
   football 249  
 Kilauea (Hawaii) 160  
 killer whales 130–1  
 Kimetto, Dennis Kipruto 260  
 King Charles spaniels 135  
 king cobra 110, 111  
 Kingcycle 64  
 Kingdoms, Egyptian 289  
 kingdoms, tree of life 69  
 kingfishers 117, 121, 143  
 Kingsley, Mary 315  
 kingsnakes 110–11, 148  
 kinkajou 145  
 kinkalows 137  
 Kiribati  
   fish 236  
   flag 197  
 kirmish formation 294  
 kites 116, 119, 307  
 kitesurfing 267  
 kittens 136  
 kiwis 116, 193  
 Kiyomasa, Kato 304  
 Knabstrup horses 138  
 knifefish 99  
 knights 311  
 Knossos, Palace of (Crete) 218  
 knots 274–5  
 Knox-Johnston, Robin 269  
 koalas 143, 193  
 koi carp 98, 99  
 Komodo dragon 108, 109  
 Konming lanterns 62  
 Korat cats 137  
 Korea 333  
   Korean War 333  
 Kosovo, flag 197  
 Kostelic, Janica 262  
 Krakatau (Indonesia) 161, 163  
 krill 91, 150, 153  
 Krishna 202  
 Kronosaurus 79  
 Kublai Khan 306  
 Kuiper Belt, missions to 17  
 kung fu 272  
 Kurilian bobtails 137  
 Kuwait, flag 197  
 Kyrgyzstan, flag 197  
 kyudo 272  
 labradoodles 135  
 lacrosse 247  
 ladybirds 92, 143  
 Laestrygonians 293  
 Lafayette, James Armistead 334  
 Lagos (Nigeria) 190  
 lagotto romagnolo 134  
 laikas 134  
 Lake Eyre (Australia) 193  
 Lake Huron (Canada/USA) 171  
 Lake Lagoda (Russian Federation)  
   188  
 Lake Michigan (USA) 171  
 Lake Superior (Canada/USA) 171,  
   184  
 Lake Taupo (New Zealand) 161  
 Lake Titicaca (Bolivia/Peru) 186, 187  
 Lake Toba (Sumatra) 161  
 Lake Victoria (Uganda/Kenya/  
   Tanzania) 171, 190  
 Lake Vostok (Russia) 195





lakes 164, 165, 171  
 Laki (Iceland) 161  
 lamb 239  
 Lamborghini cars 51  
 Lancastrians 324–5  
 lancetfish 153  
 land iguanas, Galápagos 186  
 Land Rover cars 51  
 land slugs 96  
 land snails 96  
 land speed record 51  
 landscape, shaping of 164–5  
 language 40, 206–7  
 Laos, flag 197  
 Laperm longhairs 137  
 larch 80  
 Large Magellanic Cloud 22  
*Lariosaurus* 78  
 larvae 93, 133  
 Latin 295  
 Latin American Revolutions 317  
 latitude 178  
 Latvia, flag 197  
 laurels 85  
 lava 160, 161  
 Lavoisier, Antoine 29  
 law, early civilizations 287  
 laws of motion 24  
 leaf frogs 104–5  
 leafy vegetables 228–9  
 Leakey, Louis 33  
 leatherback turtles 123  
 leavened bread 232  
 leaves  
   plants 80  
   trees 84  
 Lebanon, flag 197  
 Lee, Robert E. 321  
*Leedsichthys* 79  
 legless lizards 109  
 legumes 228–9  
 Leif the Lucky 297  
 lemmings 150  
 lemon trees 85  
 lemons 199  
 lemurs 127  
 Lenin, Vladimir Ilyich 316–17  
 Leo constellation 20  
 Leonardo da Vinci 62, 208, 312, 313  
 leopard cats 129  
 leopards 69, 128–9  
 Lepanto, Battle of 300

Lesotho, flag 196  
*Lesothosaurus* 75  
 lettuce 198  
 levitation tricks 279  
 Lhasa apsos 135  
 Lhotse 1 179  
 Liberia, flag 196  
 Libya, flag 196  
 lichens 68, 143  
 Liechtenstein, flag 197  
 life  
   beginning of 70–1  
   on Earth 159  
   essentials for 32  
   tree of 68–9  
 lifecycle  
   butterflies 95  
   crabs 90  
   frogs 104  
   insects 93  
   mushrooms 87  
   turtles 107  
 light 25  
 light bulbs 44  
 lightning 26, 174  
*Liliensternus* 76  
 Lilienthal, Otto 63  
 lilies 81, 82  
 limbic system 40  
 limes 199  
 limestone landscapes 165  
 limpets 102  
 Lincoln, Abraham 319, 320, 321  
 Lindbergh, Charles 63  
 line dancing 214  
 lines, fishing 270  
*The Lion, the Witch and the Wardrobe*  
   (Lewis) 221  
 lionfish 99, 152, 155  
 lions 69, 128, 129, 146–7  
*Liopleurodon* 78  
 literature 220–1  
 Lithuania, flag 197  
*The Little Prince* (Saint-Exupéry) 220  
 liverwort 81  
 lizardfish 98, 152  
 lizards 68, 108–9, 132, 147, 148  
   eggs 115  
 llamas 141  
 loaches 99  
 lobsters 90–1, 133, 237  
 Local Group 10

Locke, John 222  
 locusts 92, 122, 123, 149  
 lodestones 315  
*Loganellia* 71  
 loggerhead sea turtles 106  
 logging 145  
 long jump 260  
 Long Valley Caldera (USA) 161  
 long-distance running 261  
 long-haired cats 136–7  
 longhorn beetles 92, 93  
 longitude 178  
 Lotus Eaters 293  
 Lotus Temple (Delhi) 203  
 Louis XIV, King of France 216, 316  
 Louis XVI, King of France 317  
 L'Ouverture, Toussaint 317  
 lowland rainforest 145  
 Lucas terriers 135  
*Lufengosaurus* 74  
 luge 263  
 Lunar Reconnaissance Orbiter 16–17  
 Lunar Roving Vehicle 15  
 lungs 34  
 lupins 83  
 lurchers 135  
 lures (fishing) 271  
 lutes 313  
 Luther, Martin 312  
 Luxembourg, flag 197  
 lymphatic system 35  
 lynxes 128, 129, 143  
 lycopene 228  
 Lyra constellation 20  
*Lystrosaurus* 78

## MN

M4 globular cluster 22  
 M13 star cluster 20  
 M15 star cluster 20  
 M71 star cluster 20  
 Maalu 1 179  
 Maat Mons (Venus) 12  
 macaques 126–7  
 MacArthur, Ellen 269  
 Macedonia, flag 197  
 Machiavelli, Niccolò 223, 312  
 Machu Picchu (Peru) 298  
 mackerel 98–9  
 McKinley, William 318  
 McLaren 51  
 Madagascar, flag 196  
 Madison, James 319  
 Magellan, Ferdinand 314, 315  
 Magellan spacecraft 17  
 Magellanic clouds 22  
 magic 278–9  
 magma 159, 160  
 magnetic field 158  
 magnetic trains 57  
 magnetism 24, 28  
 magnolias 80, 85  
 magpies 143  
 mahjong 276  
 Mahmud II, Sultan 300  
 Maiasaura 75  
 Maine coons 137  
 maize (corn) 198  
 Malawi, flag 196  
 Malaysia  
   fish 236  
   flag 197  
 Maldives  
   fish 236  
   flag 197  
 Mali, flag 196  
 Mallard 56  
 Malta, flag 197  
*Mamenchisaurus* 74  
 mammals 124–41  
   cats 136–7  
   desert 148  
   dogs 134–5  
   egg-laying 68  
   evolution 78, 79  
   farm animals 140–1  
   forests 142–3  
   horses 138–9  
   monkeys and apes 126–7  
   polar regions 150–1  
   rainforest 144–5  
   rodents 124–5  
   savanna 146–7  
   skeletons 132–3  
   tree of life 68, 69  
   whales and relatives 130–1  
   wild cats 128–9  
 mammoths 71, 73, 79  
 man-made elements 30  
 man-made lakes 171  
 manatees 68  
 mancala 276, 277  
 Manchester terriers 134





- mandarin fish 155  
 Mandarin language 206  
 mandarins 199  
 mandolins 211  
 mandrills 127, 144  
 mango trees 85  
 mangroves 80  
 Manila (Philippines) 180  
 manta rays 101, 153, 154–5  
 mantle  
   Earth 158, 159  
   Moon 14  
 manuscripts, illuminated 208  
 Manx cats 137  
 Mao Zedong 316, 333  
 maples 85, 142  
 maps  
   Africa 190–1  
   age of exploration 314–15  
   animal migration 142–3  
   Antarctica 194–5  
   Asia 182–3  
   climate and weather 172–3  
   Europe 188–9  
   European empires 322–3  
   exploration 314–15  
   food production 198–9  
   North America 184–5  
   Oceania 192–3  
   our physical world 178–9  
   our political world 180–1  
   South America 186–7  
   water on Earth 170–1  
   World War I 328  
   World War II 330  
 maras 125  
 marbles 246  
 Marcos, Ferdinand 317  
 margays 129  
 Mariana Trench 159  
 Marie Antoinette, Queen of France  
   243, 317  
 Mariinsky Theatre (St Petersburg)  
   216  
 marine life  
   oceans 152–3  
   polar regions 150–1  
   see also crustaceans; fish;  
   seashells; whales  
 Mariner spacecraft 16  
 marmosets 126  
 marmots 125  
*Marrella* 71  
 Mars 13, 19, 161  
   missions to 17  
 Marshall Islands, flag 197  
 marsupials 68, 193  
 martens 142  
 Marx, Karl 222  
 Mary I, Queen 324  
 Masai Mara 191  
 Maseratis 50  
 masks, baseball 252  
 mass 24  
 mass dampers 163  
 Massey Ferguson tractors 52–3  
 mastiffs 135  
 Mata Hari 334  
 materials 29  
 mathematics  
   geometry 48–9  
   numbers 46–7  
 matter 11, 25  
   states of 28  
 matzah 233  
 Mauna Loa (Hawaii) 160  
 Mauritania, flag 196  
 Mauritius, flag 196  
 Mawsynram (India) 179  
 May Day 205  
 Maya civilization 298, 299  
 meagres 98  
 mealworms 133  
 meanders 164, 165  
 meat 199, 238–9  
 meat-eating dinosaurs 76–7  
 Mecca 202  
 Medici, Catherine de 216  
 Medici family 312  
 medicine, US Civil War 321  
 medieval period  
   art 208  
   clothing 240, 242  
   Europe 308–9  
 Mediterranean 189  
 Medusa 293  
 meerkats 148  
 megacities 180  
*Megalodon* 78, 79  
 Mehmed II (The Conqueror), Sultan  
   300  
 Meiji, Emperor 317  
 Meiji Restoration 317  
 Melanesia 12  
 melons 226, 227  
 memory 40, 41  
 Mendel, Gregor 33  
 Mendeleev, Dmitri 31  
 menorahs 203  
 men's fashion 240–1  
 Mercalli scale 162, 163  
 Mercedes-Benz cars 50–1  
 Mercury 12  
   missions to 16  
*Merychippus* 138  
 Mesopotamia 286  
 mesosphere 159  
 Mesozoic Era 70–1  
 Messenger spacecraft 16  
 metalloids 31  
 metals 29, 31  
 metalware  
   Ancient Americas 299  
   Vikings 296–7  
 metamorphic rocks 167  
 metamorphosis 95  
 meteors 19  
 Mexico  
   flag 196  
   history 298–9  
   Mexican Revolution 317  
 Mexico City 184  
 M16 (UK) 335  
 mice 124–5, 148  
 Michelangelo 208, 312, 313  
 Micronesia 192  
   flag 197  
 microscopes 45, 315  
 microwave ovens 43  
 Midas, King 293  
 middle-distance running 261  
 midsummer 204–5  
 midwife toads 105  
 migration, animal 122–3  
 military tactics, Roman 294  
 milk 140, 198  
   cheese-making 230, 231  
 Milky Way 11, 19, 22  
 Mill, John Stuart 222  
 millet 198  
 millipedes 133  
 minerals 166–7  
 Ming dynasty 306  
 minims 212  
 mining 145, 327  
   gemstones 169  
 Minis 51  
 minke whales 130  
 minks 142  
*Minmi* 75  
 Minoan civilization 290  
 Minos, King 293  
 Minotaur 293  
*Miohippus* 138  
 Mir space station 17  
 missiles, nuclear 333  
 Mississippi River (USA) 184  
*Mixosaurus* 78  
 mixtures 28  
 moats 310  
 mobile phones 43, 45  
 Moche people 298  
 Moctezuma II 299  
 modern art 209  
*Moeritherium* 79  
 Mohs hardness scale 167  
 Moldova, flag 197  
 mole-rats 125  
 molecules 28  
 molluscs 68, 96–7, 102–3  
 Monaco 181  
   flag 197  
 monarch butterflies 95, 122  
 monarchs, British 324–5  
 Monet, Claude 209  
 Mongolia, flag 197  
 Mongols 305, 306  
 Monitor lizards 108  
 monkey puzzle trees 85  
 monkeys 126–7, 133, 145  
 monocots 82  
*Monolophosaurus* 76  
 Monroe, James 319  
 monsoons 174  
 Mont Saint-Michel (France) 308  
 montane savanna 146  
 Montenegro, flag 197  
 Montgolfier brothers 62  
 Moon 11, 14–15, 19  
   flag 197  
   landings 15, 333  
   missions to 15, 16–17  
 Moon Festival (China) 204  
 moon moths 94, 95  
 Moondog 19  
 moons 11  
 morays 98–9  
*Morganucodon* 70





- Morland, Samuel 42  
 Morocco, flag 196  
 mosaics 208, 209  
*Mosasaurus* 79  
 mosques 202, 208  
 Mossad (Israel) 335  
 mosses 69, 71, 142  
 moths 93, 94–5  
 Moti Masjid (Delhi) 303  
 motion, laws of 24  
 motorbikes 58–9  
 motte and bailey castles 310  
 Mount El'brus (Russian Federation) 188  
 Mount Everest (Nepal) 159, 179, 183  
 flag 197  
 Mount Kilimanjaro (Tanzania) 190, 191  
 Mount McKinley (Alaska) 184  
 Mount Olympus (Greece) 292  
 Mount Pelée (Martinique) 161  
 Mount Tambora (Indonesia) 161  
 Mount Unzen (Japan) 161  
 Mount Vesuvius (Italy) 161  
 Mount Wilhelm (Papua New Guinea) 193  
 mountain bikes 64, 264  
 mountains  
 building 159  
 habitat 159  
 tallest 179  
 movement  
 and the brain 40  
 caterpillar 95  
 frogs 105  
 monkeys and apes 126  
 Mozambique, flag 196  
 MRI scans 41  
 MSS (China) 335  
 Mughal Empire 302–3  
 mulberry trees 85  
 mullets 98  
 multiplication 46  
 mummies 288–9  
 munchkin cats 136  
 Murray-Darling River (Australia) 193  
 muscles 35, 38–9  
 muscular system 35, 39  
 mushrooms 68, 86–7, 143  
 music  
 how music works 212–13  
 Imperial Japan 305  
 medieval Europe 308  
 musical instruments 210–11, 313  
 Renaissance 313  
 musk oxen 151  
 Muslim art 303  
*Muttaborrasaurus* 75  
 Myanmar, flag 197  
 Mycenae 290  
 myths and legends  
 Greek 292–3  
 Imperial China 307  
 naan bread 232  
 Nadi Temple (Fiji) 202  
 Nagasaki (Japan) 331  
 Namibia, flag 196  
 narwhals 131, 151  
 NASA 16–17  
 National Basketball Association (NBA) 254  
 nationalism 322  
 Native Americans, art 208  
 native religions 203  
 NATO 332  
 natterjack toads 105  
 nature 66–155  
 animals 88–141  
 fossils and prehistoric life 72–9  
 fungi 86–7  
 habitats 142–55  
 how life began 70–1  
 plants 80–5  
 tree of life 68–9  
 Nauru 181  
 flag 197  
 nautical charts 268  
 nautilus 97  
 navelworts 83  
 navigation tools 315  
 sailing 268  
 Navratilova, Martina 259  
 Nazca people 298  
 Nazi Party 331  
 NCG 3603 Nebula 22  
 Nebuchadnezzar, King of Babylon 286  
 nebulae 10, 20, 22  
 nectarines 199  
 negative numbers 47  
 Nemean Lion 293  
*Nemegtbaatar* 79  
 Neogene Period 71  
 Nepal 183  
 flag 197  
 Neptune 13  
 missions to 17  
*Neptunea* 71  
 nerves, messages 40  
 nervous system 26, 35, 40  
 netball 246  
 the Netherlands  
 bread 232  
 flag 197  
 nettles 143  
 networks, computer 42  
 neutrons 25, 28  
 Nevado del Ruiz (Colombia) 161  
 new dandies 240  
 New Horizons spacecraft 17  
 New Look fashion 242  
 New Year's Eve 204  
 New Zealand 192, 193  
 flag 197  
 meat 238  
 Newgrange (Ireland) 285  
 Newton, Isaac 18, 25  
 newts 68, 104–5  
 Niagara Falls (Canada/USA) 184  
 Nicaragua 333  
 flag 196  
 revolution 317  
 Nietzsche, Friedrich 222  
 Niger, flag 196  
 Nigeria  
 flag 196  
 food production 199  
 population 190  
 night sky  
 Northern 20–1  
 Southern 22–3  
*Nighthawk* 60–1, 63  
 Nile River 288–9  
 Nimrud (Assyria) 286  
 nitrogen 30  
 Nixon, Richard 318, 332  
 noble gases 31  
 non-flowering plants 80–1  
 non-metals 31  
 Nordic combined 263  
 Norfolk terriers 134  
 Norman cobbs 138  
 Normans 325  
 Norse myths 296  
 North America 184–5  
 flags 196  
 food 224–5  
 population 180, 184  
 size 178  
 North Korea 333  
 flag 197  
 Northern lights 19  
 Norway  
 fish 236  
 fjords 189  
 flag 197  
 Norwegian forest cats 136  
 notes, musical 212–13  
*Nothosaurus* 78  
 nuclear arms race 332  
 nuclear power 27  
 nucleus, atom 25, 28  
 numbers 46–7  
 Roman 295  
 nursery web spiders 88  
*The Nutcracker* 216  
 nuts 199  
 Nyamuragira (Democratic Republic of Congo) 160

## O

- oaks 85, 142  
 oats 198  
 Obama, Barack 319  
 oboes 210  
 obsessive-compulsive disorder (OCD) 41  
 obtuse angles 48  
 ocean racing 269  
 Oceania  
 flags 197  
 food 225  
 population 180, 193  
 size 178  
 oceans 152–3, 158  
 acidity 176  
 ocean floor 170  
 sizes 171  
 temperatures 170  
 ocelot 129  
 ocicats 137  
 octaves 213  
 October Revolution (Russia) 316–17  
 octopuses 68, 97, 152–3  
*The Odyssey* 293  
*Of Mice and Men* (Steinbeck) 220  
 off-road bikes 64





off-road vehicles 51  
 Offa 324  
 Ohm, Georg Simon 27  
 oil lamps 291  
 Okavango Delta 191  
 Okayama Castle (Japan) 311  
 oleanders 81  
 olives 199  
 Olmec people 298, 299  
 Olympic Games 290  
   cycling 265  
 Olympus Mons (Mars) 13, 161  
 Oman, flag 197  
 Omega Centauri cluster 22  
 onagers 139  
 Onyx River 195  
*Opabinia* 78  
 opals 168, 169  
*Ophiacodon* 71, 78  
 optical telescopes 18  
 Orange Revolution (Ukraine)  
   317  
 oranges 199  
 orangutans 126, 183  
 orb formation 294  
 orbits  
   Earth 178  
   Moon 14  
   planets 13  
 orcas 150, 151, 155, 194  
 orchestras 210  
 orchids 82, 83, 144, 185  
 order (classification of life) 69  
 Ordovician Period 71  
 organic gemstones 169  
 organisms, single-cell 69  
 Organization of African Unity 322  
 organs 34  
 oriental cats 137  
 Orion Nebula 20  
*Ornithocheirus* 78  
 ornithopods 75  
*Ornithosuchus* 78  
 Osman I (Gazi), Sultan 300  
 ospreys 118  
 ostriches 116, 121, 149  
 otters 142  
 Ottoman Empire 300–1  
   World War I 328, 329  
 overgrazing 146  
 owls 116, 119, 132, 149  
 oxbow lakes 164

oxygen 30, 32, 80, 84  
 oystercatchers 117  
 oysters 68, 97, 236, 237

## PQ

paces, horse 281  
 pachisi 277  
 Pacific islands 192–3  
 Pacific Ocean 153, 171  
 paddlefish 99  
 pages 311  
 painted lady butterflies 95  
 painted sun spiders 89  
*Pakicetus* 131  
 Pakistan, flag 197  
 Palaeozoic Era 70–1  
 Palau, flag 197  
 Paleogene Period 71  
 Palio Horserace (Siena) 204  
 palm oil 198  
 Palmieri, Luigi 163  
 Panama, flag 196  
 pandas 33, 143  
 Pandora's jar 293  
 pandoro bread 233  
 panettone 233  
 Pangea 178  
 pansies 81  
 panther chameleons 109  
 Panthera 69, 73  
 paper 221, 307  
 Papua New Guinea, flag 197  
 Paracelsus 312  
 Paraguay, flag 196  
 parallelograms 48, 49  
 Parasaurolophus 75  
 parental care  
   crocodilians 112  
   midwife toads 105  
   monkeys and apes 126  
 Paris (France) 189  
 parrotfish 98, 155  
 parrots 117, 144  
   feathers 120  
 Parthenon (Athens) 209, 219, 290  
 partridges 116, 239  
 paso doble 215  
 Pascal, Blaise 42  
 pasque flowers 151  
 Passchendaele 328  
 passenger planes 61

passing  
   American football 251  
   basketball 255  
   football 249  
 Passover 205  
 pasta 234–5  
 Pasteur, Louis 33  
 patience 277  
 patu digua spiders 89  
 Pauling, Linus 29  
 Peace Memorial (Hiroshima) 331  
 peaches 199  
 peacock butterflies 94  
 peacocks 116  
   feathers 120  
 peanuts 199  
 pearls 169  
 peas 198  
 pedals, bicycle 64  
 Peel, Edward 271  
 Pegasus 293  
 pegmatites 166  
 pelargoniums 83  
 pelicans 116, 189  
 pellets, owl 119  
 Pembrokeshire Welsh corgis 135  
 Penguin paperbacks 220  
 penguins 116, 132, 150, 151, 194  
 penny farthings 65  
*Pentaceras* 74  
 peppers 199  
 percentages 47  
 perception 41  
 perch 99  
 Percheron horses 138  
 perching birds 117  
   feathers 121  
 percussion instruments 211  
 Periodic Table 30–1  
 Permian Period 70–1  
 Persephone 293  
 Perseus constellation 20  
 Persian cats 137  
 perspective 313  
 Peru 186, 187  
   flag 196  
   history 286, 298–9  
   pasta 235  
 Peruvian Inca Orchid 134  
 pesticides 176  
*Peteinosaurus* 78  
 Petra (Jordan) 182

petrification 73  
 pharaoh hounds 134  
 pharaohs 288  
 phases, of Moon 15  
 pheasants 116, 120, 239  
 Philippines  
   flag 197  
   Yellow Revolution 317  
*Philoceratops* 73  
 philosophers 222–3  
   Greek 291  
*Phioma* 79  
 Phoenicians 314  
 photosynthesis 80  
 phylum (classification of life)  
   69  
 physics 24–5  
 phytoplankton 150  
 pi 49  
 pianos 211  
   keyboard 212–13  
 piccolos 210  
 pick-up trucks 54  
 pick-up sticks 276  
 Pierce, Franklin 318  
 Piero della Francesca 313  
 pigeons 117, 121, 132, 239  
 pigs 141, 199  
 pikas 150  
 pill woodlice 91  
 pillars, formation of 165  
 pilot whales 131  
 pines 80, 143  
 Pioneer spacecraft 16, 17  
 piranhas 99, 144  
 pirate flags 197  
 pistol shrimps 90  
 pit fruit 226–7  
 pitch (music) 212–13  
 pitcher plants 81, 145  
 pitches, football 248  
 pitta bread 232  
 Pixiebob longhairs 137  
 pizza 232  
*Placerias* 78  
*Placodus* 78  
 plaice 98  
 planets 11, 12–13  
   size of 13  
 plant-eating dinosaurs 74–5  
 Plantagenets 325  
 plantains 199





- plants 33, 159  
 desert 148, 149  
 forests 142–3  
 fossils 72  
 fruit 226–7  
 growth of 80  
 how life began 70–1  
 polar regions 151  
 rainforest 144–5  
 savanna 147  
 tree of life 69  
 trees 84–5  
 vegetables 228–9
- plasma sphere 27
- plastics 29, 44
- plate boundaries 159, 162
- Plateosaurus* 70, 73, 75
- platform shoes 241
- Plato 223, 291
- platypuses 193
- platysma 38
- Pleiades star cluster 20
- Pliohippus* 79, 138
- Plioplatecarpus* 79
- ploughs 45, 52, 286
- plovers 151
- Pluto 19
- pod vegetables 228–9
- podengos 134
- pointe shoes 216, 217
- poison  
 frogs 105, 145  
 mushrooms 87  
 plants 81  
 rainforest animals 145  
 scorpions 88  
 snakes 111  
 spiders 89
- poison-dart frogs 104, 105, 144, 145
- Poisson d'Avril (France) 205
- Poitevin horses 138
- poker 277
- Poland  
 bread 232  
 flag 197  
 food production 199  
 Solidarity 317  
 World War II 330
- polar bears 151
- Polar cell 173
- polar regions 158  
 exploration 315
- Polaris 19, 21
- pole vault 260
- polecats 142
- police vehicles 55
- Polk, James K. 318
- pollination 83
- Pollock, Jackson 209
- pollution 176
- polo 247, 281
- Polo, Marco 314
- polygons 48
- Polynesia 192
- Pompeii 209
- Pompidou Centre (Paris) 218
- ponies 139
- pony of the Americas 139
- poodles 135
- pool 247
- poppies 81, 151
- population  
 Africa 180, 190  
 Antarctica 195  
 Asia 180, 183  
 Europe 180, 188  
 North America 180, 184  
 Oceania 180, 193  
 South America 180, 186
- porcupine fish 99, 154
- porcupines 125
- pork 238
- porpoises 131
- Porsche cars 50–1
- Portugal  
 Carnation Revolution 316  
 fish 236  
 flag 197  
 Portuguese Empire 322  
 tsunami 163
- Poseidon 293
- positive numbers 47
- Post Impressionism 209
- potatoes 198
- pottery *see* ceramics
- poultry 239
- power stations 27
- powers 46
- prairie dogs 125
- prawns 91
- prayer flags 202
- Pre-Cambrian Era 70
- precious stones 168–9
- precipitation 173
- prediction tricks 279
- prehistoric animals 78–9  
*see also* dinosaurs
- prehistoric art 208
- prehistoric man 284–5
- preserved meats 239
- presidents, US 318–19
- pretzels 233
- prickly pears 148
- Pride and Prejudice* (Austen) 221
- primary feathers 120
- primates 68, 126–7
- prime numbers 47
- printing presses 221, 312
- processor chips 42
- production tricks 279
- programming languages 42
- Prometheus 293
- prosauropods 74
- protists 33, 69, 159
- Protoceratops* 75
- protons 25, 28
- Protostega* 70
- Protosuchus* 79
- Przewalski's horses 139
- pseudoscorpions 89
- Psittacosaurus* 75
- ptarmigans 151
- Pterodactyl* 70
- Pterodaustro* 78
- pterosaurs 70
- Ptolemy 18
- puff adders 111
- puffballs 86
- pufferfish 98
- puffins 117, 151
- pugs 135
- pumas 129
- pumpernickel 232
- punishments  
 from the gods 292  
 medieval European 309
- punk style 241, 243
- pupae 93
- Purim 205
- pygmy owls 119
- pyramids  
 Chichen Itza 185  
 Egyptian 190, 288  
 Giza 190  
 square 49
- pyroclastic flows 161
- Pythagoras 222, 291
- Pythagoras's theorem 49
- pythons 110–11, 146–7
- Qatar, flag 197
- Qatrania Castle (Jordan) 311
- Qin Shi Huang 306
- quadrilaterals 48
- quails 116, 141, 239
- Quant, Mary 242
- quantum physics 25
- quarks 25
- quartz 166  
 gems 168–9
- Quaternary Period 71
- quavers 212
- Queen Alexandra's birdwings 94, 95
- quince trees 85
- quipu* 296
- Qu'ran 202

## R

- rabbits 141
- raccoons 142
- racing cars 51
- racket sports 256–7
- racketts 313
- racquetball 247, 257
- radio communications 44
- radio telescopes 18
- radio waves 25
- radios, spies 334
- radius 36, 48
- rafflesia 83, 144
- raft spiders 89
- Ragdoll cats 137
- Ragnar 297
- raids, Viking 296
- railways  
 birth of 326, 327  
 US Civil War 320
- rain, non-aqueous 175
- rainfall 171, 173, 179
- rainforest 144–5  
 Amazon 187  
 Costa Rica 185
- raising aces trick 279
- Raleigh, Sir Walter 315
- Ramadan 204
- Ramses II 288
- Range Rover cars 51
- rapeseed 198





- rapids 164  
 raptors 118–19  
 rare earth metals 31  
 rats 124–5  
 ratsnakes 111  
 rattlesnakes 110–11, 149  
 rauschpfeife 313  
 RAW (India) 335  
 ray-finned fish 68  
 rays 68, 101, 153, 154–5  
 Reagan, Ronald 319, 332  
 real tennis 246, 257  
 Realism, art 208  
 rebecs 313  
 recorders 313  
 recording devices 334  
 rectangles 48, 49  
 recycling 177  
 redshanks 117  
 redwoods 84  
 reef fish 154–5  
 reels, fishing 270  
 reflecting telescopes 18  
 Reflection nebula 20  
 reflective symmetry 49  
 reflex angles 48  
 refracting telescopes 18  
 refrigerators 44  
 reindeer 150–1  
 Reinsch, Gabriele 260  
 relay running 261  
 religion  
   Ancient Americas 299  
   Ancient Egypt 289  
   Ancient Greece 291  
   early civilizations 287  
   Imperial China 307  
   Imperial Japan 304  
   medieval Europe 309  
   world religions 202–3  
 remora fish 153  
 Renaissance 312–13  
   art 208  
   fashion 242  
 renewable energy 177  
 Renoir, Pierre-Auguste 208  
 reproductive system 35  
 reptiles 106–13  
   crocodiles and alligators 112–13  
   desert 148  
   lizards 108–9  
   prehistoric 78, 79  
 rainforest 144–5  
 savanna 146–7  
 skeletons 132  
 snakes 110–11  
 tree of life 68  
 turtles and tortoises 106–7  
 reservoirs 171  
 respiratory system 35  
 restoration tricks 279  
 revolutions 316–17  
*Rhabdodon* 75  
*Rhamphorynchus* 78  
 rhinoceroses 68, 79, 147  
 Rhodesian ridgebacks 135  
 rhomboids 38  
 rhombuses 48, 49  
 rhythm 212–13  
 Rialto Bridge (Venice) 313  
 rice 198  
 Richard I (The Lionheart), King 309, 325  
 Richard III, King 324  
 Richter scale 163  
 riding gear 280  
 rifles 321  
 right angles 48  
 right whales 130–1  
 rigs, fishing 270  
 rings, planetary 12–13  
 Rio Carnival (Brazil) 204  
 rituals 299  
 river bank, rainforest 144–5  
 river dolphins 131  
 rivers 159, 171  
   landscape formation 164, 165  
 road bikes 65, 265  
 road racing 265  
 roads, Roman 295  
 Roaring Forties 172  
 Roaring Twenties, clothing 240, 243  
*Robertia* 78  
 robins 117, 142  
 robots 43  
 rock art  
   Aboriginal 192  
   prehistoric 208, 285  
 rock cycle 167  
*Rocket*, Stephenson's 57, 326  
 rockling 98  
 rocks 166–7  
 Rococo  
   art 208  
   clothing 241  
 rodents 68, 124–5  
 rodeo 281  
 Rodin, Auguste 209  
 rods, fishing 270  
 roe, fish 237  
 Rollo 297  
 rolls, bread 232–3  
 Romania, flag 197  
 Rome, Ancient 286, 294–5  
   art 209  
   clothing 240  
   flag 196  
   trade 314  
 Rome (Italy) 189, 313  
*Romeo and Juliet* (Shakespeare) 221  
 Romulus and Remus 295  
 rooks 121  
 Roosevelt, Franklin D. 319  
 Roosevelt, Theodore 318, 330  
 root vegetables 228–9  
 roots, plant 80  
 ropes, knots 274–5  
 rosary peas 81  
 Rosenberg, Julius and Ethel 334  
 roses 83  
 Rosetta spacecraft 16  
 Rosette nebula 22  
 rotational symmetry 49  
 Rotorua (New Zealand) 193  
*Rotularia* 71  
 round fish 236–7  
 rounders 247  
 Rousseau, Jean-Jacques 222  
 Route du Rhum 269  
 rowans 85  
 rowing 267  
 royal grammas 98  
 Royal Opera House (London) 216  
 rubies 169  
 Rubik's cube 277  
 rudders, ship's 306  
 rugby 247  
 rumba 215  
 rummy 277  
 runes 296  
 running 260  
 Russia  
   area 181, 183, 188  
   earthquake 162  
   flag 197  
   food production 199  
   population 188  
   space programme 15  
   World War I 328, 329  
   see also Soviet Union  
 Russian black terriers 134  
 Russian blue cats 137  
 Russian toy dogs 135  
 Rutherford, Ernest 25  
 Rwanda, flag 196  
 rye 198

## S

- sacred dance 214  
 sacrifices 299  
 saddles 280  
 safety bicycles 65  
 Sagrada Familia (Barcelona) 218  
 Sahara Desert 190  
 sailing 268–9  
 St Basil's Cathedral (Moscow) 219  
 St Bernards 135  
 St Demetrios of Thessaloniki  
   (Bulgaria) 308  
 St Elmo's fire 175  
 St Kitts & Nevis, flag 196  
 St Patrick's Day 205  
 St Peter's Basilica (Rome) 202, 313  
 St Vincent & the Grenadines, flag  
   196  
 salamanders 68, 104, 132  
 salame 239  
 Salar de Uyuni (Bolivia) 187  
 salmon, Atlantic 122  
 salsa 215  
 salt pans 187  
 salt water 170  
   fishing 270  
*Saltasaurus* 74  
 salted fish 236  
 saltwater crocodiles 112  
 saltwater fish 98–9  
 salukis 135  
 Salyut space station 16  
 samba 215  
 Samburu people 11  
 Samoa, flag 197  
 samoyeds 134  
 Samurai warriors 304–5  
 San Marino 181  
   flag 197  
 sand cats 129  
 sand dunes 148





- sand spits 164  
sanshou 272  
Santa Maria (Guatemala) 161  
São Paulo (Brazil) 186  
São Tomé & Príncipe, flag 196  
sapphires 168–9  
Sargassum fish 99  
sartorius 38  
Sartre, Jean-Paul 223  
sashimi 236  
satellites 45, 173, 333  
Saturn 12, 19  
    missions to 17  
satyrs 292  
Saudi Arabia, flag 197  
Saumur Castle (France) 311  
*Sauropelta* 75  
sauropods 74  
sausages 238, 239  
savanna 146–7  
Savannah cats 137  
Saxe-Coburg-Gotha 325  
scent hounds 135  
schools (fish) 153  
science 10–41  
    biology 32–41  
    chemistry 28–31  
    physics 24–7  
    Renaissance 312  
    scientific journeys 315  
    space 10–23  
scops owls 119  
scorpionfish 98  
scorpions 68, 88–9, 144, 149  
Scott, Robert Falcon 194, 315  
Scottish fold cats 137  
Scottish terriers 134  
screech owls 119  
*Scutosaurus* 70  
Scylla 293  
sea beets 83  
sea birds 117, 121  
sea bream 98–9  
sea fans 154–5  
sea level, rising 176  
sea lions 152  
sea scorpions 98  
sea slaters 91  
sea slugs 96–7, 155  
sea snails  
    fossils 72  
    shells 102–3  
sea sponges 68, 155  
sea squirts 154  
sea urchins 133, 237  
seadragons 98  
seahorses 98, 99, 152, 155  
seals 150, 151, 152, 194  
seashells 102–3  
seasons 172  
    polar 150  
    trees 84  
secondary feathers 121  
secret agents 334  
secret compartments 335  
secretary birds 119  
sectors 48  
sediment 164  
sedimentary rocks 166–7  
seeds  
    dispersal 80  
    food 199  
    fossils 72  
    fruit 83, 226, 227  
    germination 80  
    planting 52  
    vegetables 228  
segments 48  
seismology 162, 163  
Selim I (The Grim), Sultan 300  
Selkirk rex cats 137  
semaphore 197  
semi-precious stones 168–9  
semibreves 212  
semiquavers 212  
semitones 213  
Senegal, flag 196  
senet 277  
senses 40  
    sharks 101  
Seoul (South Korea) 180  
sepak takraw 246  
sequences, number 46  
Serbia, flag 197  
Serengeti 146  
    migration 123  
servals 128, 146  
SETI project 19  
*Seven Little Australians* (Turner) 220  
sewage 176  
sextants 44, 315  
Seychelles  
    fish 236  
    flag 196  
Shackleton, Ernest 194, 315  
Shah Jahan, Emperor 302, 303  
Shakespeare, William 221  
shamanism 203  
Shang dynasty 306  
sharks 68, 98, 100–1  
    coral reefs 154–5  
    oceans 152, 153  
    polar regions 151  
sharps (music) 213  
sheep 140–1, 239, 311  
    cheese 231  
sheepdogs 135  
shellfish 237  
shells  
    crustaceans 90–1  
    seashells 102–3  
    snails 96, 97, 102–3  
    turtles and tortoises 106  
Shetland ponies 139  
shield volcanoes 160  
shields  
    Ancient Greek 291  
    Ottoman 301  
    Roman 294  
    Viking 297  
Shinto 203, 304  
ships  
    ancient explorers 314  
    Ancient Greek 291  
    US Civil War 320  
    Viking 296  
    World War I 329  
    World War II 331  
shire horses 138  
shoals 153  
shock waves (earthquakes) 162  
shoes  
    ballet 216, 217  
    dancing 215  
    Imperial China 307  
    men's fashions 240–1  
    women's fashions 242–3  
Shoguns 304  
*Shonisaurus* 78  
shopping, online 43  
short-haired cats 136–7  
shot put 247, 261  
shrimps 90–1, 153, 154  
Shunosaurus 74  
shuttlecocks 257  
siamang 127  
Siamese cats 136  
Siamese fighting fish 99  
Siberian cats 136  
Siberian huskies 134  
Siddhartha Gautama 223  
sidecars 58–9  
siege weapons 311  
Sierra Leone, flag 196  
Sierra Negra (Galápagos) 160  
sifakas 127  
sight hounds 135  
sign language 207  
signals  
    with flags 197  
    officials' (basketball) 255  
    referee's (American football) 251  
Sikhism 203  
silk 306  
Silk Road 307  
Silurian Period 71  
silver birch 85  
*Simosuchus* 78  
Sinclair C5 64  
Singapore, flag 197  
Singapura cats 137  
singing dogs, New Guinea 134  
*Sinosauropteryx* 76  
Sirens 293  
Sisyphus 292  
skates 101  
skating 263  
skeletal system 35, 37  
skeletons  
    animal 132–3  
    human 36–7  
    squirrel 124  
ski jumping 263  
skiing 262–3  
skin 34  
skinks 109  
skuas 151  
skulls  
    dinosaurs 75, 77  
    human 36  
skunk cabbage, Western 83  
skunks 142  
Skylab 16  
skylarks 117  
skyscrapers  
    earthquakes 163  
    tallest 219  
slalom 262





- slavery 323  
sledges 315  
sleight of hand 279  
sliding sports 263  
Slocum, Joshua 269  
Slovakia, flag 197  
Slovenia, flag 197  
slugs 96–7  
  eggs 115  
Smalls, Robert 321  
smart casual clothing 240  
Smilodon 79  
smoked fish 236  
snailfish 153  
snails 68, 96–7  
  eggs 115  
snakes 68, 110–11, 132, 146–7, 148  
  eggs 115  
  rainforest 144–5  
snakes and ladders 276  
snapdragons 83  
snappers 98  
snooker 247  
snowboarding 262  
Snowshoe cats 137  
snowstorms 174  
snowy owls 119, 150  
social networking 43  
society  
  Imperial Japan 304  
  Roman 295  
  Viking 296  
Socrates 223, 291  
soft cheese 230  
soft coral 155  
softball 247  
software 42  
Soho spacecraft 16  
Solar Impulse 263  
solar power 27, 177  
Solar System 11, 12–13  
soldiers  
  US Civil War 320–1  
  World War I 329  
  World War II 330  
soles 98  
Solidarity 317  
solitaire 276  
Solomon Islands, flag 197  
solutions 28  
Somali cats 137  
Somalia, flag 196  
sombo 272  
Somme, Battle of the 328  
Song dynasty 306  
sorghum 198  
Sorraia ponies 139  
sorrel 143  
Sotomayor, Javier 260  
sound barrier 61  
sound waves 25  
South Africa, flag 196  
South America 186–7  
  ancient civilizations 298–9  
  flags 196  
  food 224  
  population 180, 186  
  size 178  
  Spanish, Portuguese empires 322  
South Atlantic Race 269  
South Korea 333  
  flag 197  
South Pole 194  
  flag 197  
South Sudan, flag 196  
Southern lights 19  
Southern Ocean 153, 171  
Soviet Union  
  Cold War 332–3  
  space programme 15, 16–17  
  World War II 330–1  
  *see also* Russia  
soya beans 198  
space 10–11  
  exploration 16–17, 314  
  Northern skies 20–1  
  Southern skies 22–3  
  volcanoes in 161  
Space Race 15, 333  
space walks 333  
Spain  
  flag 197  
  food production 198  
  football 248  
  meat 238  
  Spanish Civil War 316  
  Spanish Empire 322  
spaniels 134–5  
Spanish language 206  
Spanish water dogs 134  
sparrowhawks 143  
spears 44  
species 69  
speed  
  leopards 129  
  trains 57  
speed skating 263  
sperm whales 130–1, 152  
sphagnum 81  
*Sphenosuchus* 79  
spheres 49  
Sphinx (Egypt) 190, 218, 289  
Sphynx cats 137  
spices 323  
spider crabs 90  
spider flowers, Brazilian 83  
spider monkeys 145  
spiders 68, 88–9, 133, 149  
spiderworts 82  
spies 334–5  
spinach 198  
spine 36  
spinning machines 327  
*Spinosaurus* 76  
spiral staircases 310  
spitz dogs 134  
sponges 68, 71, 153  
spore trees 85  
spores 86, 87  
sporting dance 215  
sports  
  American football 250–1  
  athletics 260–1  
  ball sports 246–7  
  baseball 252–3  
  basketball 254–5  
  combat sports 272–3  
  cycling 264–5  
  fishing 270–1  
  football 248–9  
  horse sports 281  
  racket sports 256–7  
  sailing 268–9  
  tennis 258–9  
  water sports 266–7  
  winter sports 262–3  
sports bikes 58–9  
spotlight loosejaws 152  
sprinting 261  
sprites 175  
spruce 85  
Sputnik 1 16, 333  
squared numbers 46  
squares 48, 49  
squash 246, 256  
squid 68, 97, 150, 153, 237  
squires 311  
squirrel monkeys 126  
squirrelfish 98  
squirrels 124–5, 133  
SR-71 Blackbird 62–3  
Sri Lanka, flag 197  
stacks, formation of 165  
stag beetles 92, 143  
staghorn coral 155  
*Stagonolepis* 78  
stalactites 165  
stalagmites 165  
Stalin, Joseph 332  
standard bikes 58  
star clusters 20, 22  
star forts 310  
starlings 121, 132  
stars 10  
  Northern skies 20–1  
  Southern skies 22–3  
static electricity 26  
staves (music) 212–13  
stealth fighters 60–1, 63  
steam engines 44–5, 56, 320, 326, 327  
steeplechase 281  
stegosaurus 74  
*Stegosaurus* 74, 75  
stellar neighbourhood 11  
stem vegetables 228, 229  
*Stenacanthus* 71  
Stephenson, George 326, 327  
Stephenson, Robert 57, 326  
stilt fishermen 271  
stingrays 101  
stink lilies 83  
stollen 233  
stonefish 98, 153  
Stonehenge (England) 18, 204–5, 285  
stonemasons 311  
storks 116, 121  
stratosphere 159  
stratovolcanoes 160  
street dance 215  
strike aircraft 60–1  
string instruments 211  
string trick, magic 279  
*Struthiomimus* 73, 76  
Stuarts 324  
stunts, motorbike 58  
stupas 202





*Styracosaurus* 74  
 subtraction 46  
*Suchomimus* 76  
 suckerfish 271  
 Sudan, flag 196  
 Suez Crisis 322  
 Suffolk Punch horses 138  
 sugar beet 198  
 sugar cane 198, 323  
 Suleiman I (The Magnificent), Sultan 300, 301  
 Sultan Ahmed Mosque (Istanbul) 300–1  
 sultans, Ottoman 300–1  
 Sumatra, earthquakes and tsunamis 162, 163  
 Sumba ponies 139  
 Sumer 286  
 sumo wrestling 272, 273  
 Sun 12, 19  
   distance of planets from 12–13  
   missions to 16–17  
 Sun Yat-sen 317  
 sundog 19  
 sunfish 99  
 sunflower seeds 198  
 sunlit zone, ocean 152–3  
 sunspots 19, 175  
 supercars 50–1  
 superclusters 10  
 supercomputers 42  
 supersonic flight 60, 61, 62  
 supervolcanoes 161  
 surface area 49  
 surfing 192, 267  
 surgeon fish 99, 154  
 Suriname, flag 196  
 Surrealism 209  
 surveillance cameras 43  
 sushi 236  
 suspension tricks 279  
 suspensions 28  
 swallows 117  
   migration 122  
 swallowtail butterflies 94, 95, 143  
*Swan Lake* 216  
 swans 117  
   feathers 121  
 Swaziland, flag 196  
 Sweden  
   flag 197  
   pasta-eating 235  
 sweet peas 83

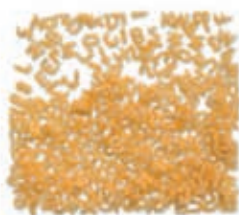
sweet potatoes 198  
 swifts 117  
 swimming 266  
 Swinging Sixties 242  
 switches 26  
 Switzerland  
   cheese 230  
   flag 197  
   pasta-eating 235  
 Sydney (Australia) 193  
 Sydney Opera House 192, 218  
 symbols  
   numerical 46  
   religious 202–3  
 synaesthesia 41  
 synchronized swimming 266  
 synthetic fibres 29  
 Syria, flag 197  
 Syrian ponies 139

**T**

table tennis 246, 256  
 table top games 276–7  
 tack, horse 280  
 tacking (sailing) 269  
 tackle, fishing 270  
 tackling (football) 249  
 tadpoles 104  
 taekwondo 272  
 Taft, William H. 318  
 taichu calendar 307  
 tail feathers 120  
 tails  
   cats 136  
   dinosaurs 75  
   lizards 109  
   monkeys 126  
 taipan, Australian 111  
 Taiwan, flag 197  
 Taj Mahal (Agra, India) 182, 218, 303  
 Tajikistan, flag 197  
 Takatsuna, Sasaki 304  
 talons 118  
 tamarins 126  
 tandem cycles 65  
 Tang dynasty 306  
 tangerines 199  
 tango 215  
 tangrams 49  
 tankers 54  
 tanks 329, 331

Tantalus 292  
 Tanzania, flag 196  
 Taoism 203  
 taolu 272  
 tapestries 208  
 tapirs 68  
 tarantulas 89, 133, 149  
 Tasmanian devils 193  
 Tay Ninh Temple (Vietnam) 203  
 tea 323  
 technology 42–65  
   computers 42–3  
   inventions 44–5  
   vehicles 50–65  
 tectonic plates 159, 162  
 tegu lizards 109  
 telegraphs 321, 327  
 telephones 44, 327  
 teleportation tricks 279  
 telescopes 18, 315  
 television 44  
 Telford, Thomas 327  
*Temnodontosaurus* 78  
 temperate deciduous forests 142  
 temperate dry forests 142  
 temperatures  
   extreme 179  
   water 170  
 Temple of Heaven (Beijing) 219  
 tempo 213  
 tendons 39  
 tennis 246, 256, 258–9  
*Tentosaurus* 75  
 Teotihuacan 298  
*Teratornis* 78  
 Tereshkova, Valentina 333  
 termites 147  
 terns 122, 123  
 Terracotta Army 306  
 terrapins 107  
 terriers 134  
 Tesla, Nikola 27  
 testudo 294  
 Tet Trung Thu (Vietnam) 204  
 tetras 99  
 Thai boxing 272  
 Thai ridgebacks 135  
 Thai water dragon 109  
 Thailand, flag 197  
 Thales “the Wise” 222  
 Thanksgiving (USA) 205  
 theatre, Imperial Japan 305

*Thecodontosaurus* 73  
 theodolites 312  
*Therizinosaurus* 76  
 thermosphere 159  
 theropods 76–7  
 Theseus 293  
 Thiepval (France) 328  
 Thirties, fashion 240, 242  
 Thomas Aquinas 223  
 thorny devils 148  
 thoroughbred horses 138  
 thoughts 40  
 throwing 260  
 thunderstorms 174  
*Thylacosmilus* 71  
 tidal energy 171, 177  
 tidal surges 171  
 Tiffanie cats 137  
 tiger sharks 100, 154  
 tigers 69, 128, 129, 133  
 Tikal 298  
*Tiktaalik* 71  
 tilapia 99  
 Tillandsia 81  
 time signatures 212  
 time zones 180  
 tissue 34  
*Titanosaurus* 75  
 Titans 292  
 Titian 208  
 tits 142  
*To Kill a Mockingbird* (Lee) 221  
 toads 68, 104–5, 147  
 toes 37  
 Togo, flag 196  
 Tokyo (Japan) 180, 183  
 Toltec people 298, 299  
 Tomato Battle (Spain) 204  
 tomatoes 199  
 Tomb of Humayun (Delhi) 303  
 Tomb of Safdarjung (Delhi) 303  
 Tomba, Alberto 262  
 tones (music) 213  
 Tonga, flag 197  
 tongues  
   cats 136  
   frogs 105  
   snakes forked 110  
 Tonkinese cats 137  
 tools  
   early 284–5  
   early civilizations 286





- magicians 278  
 monkeys and apes 126  
 navigation 315  
 toothed whales 130  
 topaz 169  
 Topkapı Palace (Istanbul) 300  
 Torah 203  
 tornadoes 174, 175  
 tortilla 232  
 tortoises 106–7, 132, 147, 148, 186  
   eggs 115  
 tortures 309  
 Torvill, Jayne 263  
 totem poles 208  
 toucans 116, 144  
   feathers 120  
 Tour de France 265  
 tourer motorbikes 58  
 towns, rise of the new 327  
 Toyota cars 50, 51  
 track bikes 65, 265  
 tracks  
   athletics 260  
   cycling 264–5  
   sliding sports 263  
 tractors 52–3  
 trade  
   Ancient Egypt 314  
   Ancient Rome 314  
   European empires 323  
 trains 56–7  
 Trakai Island Castle (Lithuania) 308  
 transformation, magic 279  
 transition metals 31  
 transport  
   aircraft 60–3  
   bicycles 64–5  
   cars 50–1  
   motorbikes 58–9  
   trains 56–7  
 transporters 54  
 trapdoor spiders 88  
 trapeziums 48, 49  
 treasure, Viking 296–7  
 treble clef 212  
 trebuchets 311  
 tree ferns 850  
 tree frogs 104, 144, 185  
 tree of life 68–9  
 tree rings 84  
 trees 84–5  
   *see also* forests
- treesnakes 111  
 trenches 328–9  
 Trevithick, Richard 56, 57, 326, 327  
 triangles 48, 49  
 Triassic Period 70  
*Triceratops* 73, 74, 75  
 tricks  
   magic 278–9  
   of the mind 41  
 trilobites 70–1, 72  
 Trinidad & Tobago, flag 196  
 triple jump 260  
 triremes 291  
 triticale 198  
 Triton 161  
 Trojan Horse 290, 293  
 trombones 210  
 tropical storms 175  
 troposphere 159  
 trotting 281  
 trout 99  
 trucks 54–5  
   Antarctica 195  
 Truman, Harry S. 319, 333  
 trumpetfish 98–9  
 trumpets 210  
 tsetse flies 147  
 tsoureke 233  
 tsunamis 163  
 tubas 210  
 tubers 229  
 tucuxi dolphins 130  
 Tudors 324  
 tughras 300  
 tulip trees 80  
 tulips 81  
 tunas 271  
 tuning forks 25  
 Tunisia  
   flag 196  
   pasta-eating 235  
*Tuojiangosaurus* 72  
 turacos 116  
 turbot 98  
 Turkey 300  
   bread 232  
   flag 197  
 turkeys 116, 120, 141, 239  
 Turkish Angoras 137  
 Turkish Vans 136  
 Turkmenistan, flag 197  
 turnips 199  
 turpentine trees 85  
 turtles 68, 106–7, 132, 144, 155  
   eggs 115  
   migration 123  
 tusk shells 103  
 tuskfish 98  
 Tutankhamun 288  
 Tuthmosis III 288  
 Tuvalu 181  
   flag 197  
 twilight zone, ocean 152–3  
 twist 214  
 twisters 175  
 Tyler, John 318  
*Tyrannosaurus rex* 72–3, 76, 77
- UV**  
 Uganda, flag 196  
 Uintatherium 71, 79  
 ukeleles 211  
 Ukraine  
   flag 197  
   food production 199  
   Orange Revolution 317  
 Ulama 299  
 ultraviolet 25  
 ultraviolet telescopes 18  
 Uluru (Australia) 192  
 umpires  
   baseball 252  
   tennis 258  
 underground railways 57  
 understorey, rainforest 144–5  
 underwater hockey 266  
 Underworld 292, 293  
 unicycles 65  
 uniforms  
   US Civil War 320  
   Vietnam War 333  
   World War I 329  
 Unionists (US Civil War) 320–1  
 United Arab Emirates, flag 197  
 United Kingdom  
   British Empire 322  
   flag 197  
   monarchs 324–5  
   World War I 328  
   World War II 330–1  
 United States 184–5  
   American Revolution 317  
   area 181  
 Cold War 332–3  
 European empires 322  
 flag 196  
 food production 198  
 meat 238  
 pasta 235  
 population 184  
 presidents 318–19  
 space programme 15, 16–17  
 tornadoes 174  
 US Civil War 320–1  
 World War I 328, 329  
 World War II 330–1  
 Universe 10–11  
 Ur (Mesopotamia) 208, 286  
 Uranus 13, 19  
 urinary system 35  
 Ursa Major 19  
 Uruguay  
   flag 196  
   football 248  
   meat 238  
 Uruk 286  
 Uzbekistan, flag 197  
 Valles Caldera (New Mexico) 161  
 valleys, glaciated 164  
 Van Buren, Martin 319  
 Van Gogh, Vincent 209  
 vanishing tricks 279  
 Vanuatu, flag 197  
 vaquitas 131  
 Vargas, Getulio 316  
 Vatican City 181  
   flag 197  
*Vegavis* 70  
 vegetables 198–9, 228–9  
 vehicles  
   aircraft 60–3  
   bicycles 64–5  
   motorbikes 58–9  
   tractors 52–3  
   trains 56–7  
   trucks and diggers 54–5  
 Velocar 64–5  
 velocipedes 65  
*Velociraptor* 76  
 velodromes 265  
 Velux 5 Oceans (yacht race) 269  
 Venezuela 186  
   flag 196  
 Venice (Italy) 313  
   Carnival 205





venison 239  
 Venus 12, 19, 161  
   missions to 17  
 Venus figurines 285  
 Venus flytraps 81  
 Verdun, Battle of 328  
 Versailles (France) 216  
 vertebrates  
   fossils 73  
   tree of life 68  
 Vesalius, Andreas 312  
 vexillology 196  
 Victoria, Queen 325  
 Victoria Falls (Zambia/Zimbabwe) 191  
 Victorian period, fashion 243  
 Vietnam  
   August Revolution 316  
   flag 197  
   Vietnam War 333  
 Vikings 296–7, 314  
 Vinson Massif 195  
 violas 211  
 violins 25, 211  
 viperfish 152  
 vipers 110–11, 145  
 Virgin Galactic 17  
 vitamins, vegetables 228  
 volcanoes 70, 160–1, 167  
   oceanic 170  
 voles 124–5  
 Volga River (Russian Federation) 188  
 Volkswagen cars 50  
 volleyball 246  
 Volta, Alessandro 27, 327  
 voltage 27  
 Voltaire 222  
 volume 49  
 Volvo Ocean Race 269  
 Voyager spacecraft 16, 17  
*Vulcanodon* 74  
 vultures 118, 146–7, 149

## WXYZ

wading birds 117  
   feathers 121  
*Wai Khru Ram Muay* 215  
 wake robins 143  
 wakeboarding 267  
 walking, horses 281  
 walruses 151  
   migration 122

waltzes 215  
 wandering spiders, Brazilian 89, 145  
 wands, magic 278  
 warblers 117  
 warfare *see* arms and armour  
 warriors  
   Ancient Greek 291  
   Ancient Rome 294  
   Aztec 299  
   early civilizations 287  
   Mongol 306  
 Warsaw Pact 332  
 Washington, George 318  
 wasps 93, 143, 149  
 waste 176–7  
 water  
   on Earth 170–1  
   and habitat loss 146  
   and life 32  
   molecule 28  
 water buffaloes, cheese 231  
 water cycle 171  
 water erosion 165  
 water hemlocks 81  
 water lilies 80  
 water polo 247, 266  
 water power 171  
 water spiders 88  
 water sports 266–7  
 water to ice trick 278  
 waterfalls, formation of 164  
 watermelons 199  
 water-skiing 267  
 Watt, James 327  
 weapons *see* arms and armour  
 weather 172–3  
   extreme 174–5, 176  
   record-breaking 173  
 weather balloons 173  
 weathering 167  
 webs, spider 89  
 weight 24  
 weights (fishing) 270  
 Welbike scooter 59  
 Wellingtonia 85  
 Welsh mountain ponies 139  
 West Highland white terriers 134  
 Western Pygmy Blue butterflies 94, 95  
 Western Wall (Jerusalem) 203  
 wetlands 159  
 whale sharks 100, 155

whales 68, 130–1, 152, 194  
   migration 122  
   polar regions 150–1  
 wheat 198  
 wheaten terriers 134  
 Wheatstone, Charles 327  
 wheel, invention of 45, 287  
 whelks 97, 102, 237  
 whip spiders 89  
 whiskers, cats 136  
 White Nights Festival (St Petersburg) 205  
 white water rafting 267  
 Whitney, Eli 327  
 wild ass, African 139  
 wild boars 143  
 wild cats 128–9  
 wild dogs, African 147  
 wildebeest 122, 123, 146, 191  
 wildlife *see* animals  
 William IV, King 325  
 William the Conqueror 309  
 Williams, Serena 259  
 Willoughby, Hugh 315  
 willows 85, 151  
 Wilson, Woodrow 319  
 wind 173  
   katabatic 175  
   sailing 269  
 wind displays 268  
 wind erosion 164, 165  
 wind power 177  
 Windcheetah bicycles 64–5  
 Windsors 325  
 windsurfing 267  
 wings  
   birds 116, 118, 120, 121  
   insect 92  
 winter sports 262–3  
 winter's bark 80  
 Wittgenstein, Ludwig 223  
*Wiwaxia* 78  
 wolf spiders 88  
 Wollstonecraft, Mary 222  
 wolverines 151  
 wolves 133, 134, 143, 151  
   dire 79  
   maned 147  
 women's fashion 242–3  
 wood 29, 177  
 woodcocks 120  
 wooded savanna 146

woodpeckers 143, 149  
   feathers 120  
 woodwind instruments 210  
 wool 140  
 working dogs 135  
 world records, athletics 260  
 World Series baseball 253  
 World War I 328–9  
 World War II 330–1  
 World Wide Web 45  
 wrentits 117  
 wrestling 272  
 Wright brothers 63  
 writing  
   Chinese 306  
   early civilizations 287  
   Greek 291  
   Maya 296  
   music 212  
 Wu Zetian 306  
 X-ray telescopes 18  
 X-rays 25  
*Xenophora* 71  
 Xinhai Revolution 317  
 xylophones 211  
 yachts 268–9  
 yams 199  
 Yangtze River (China) 183  
 yeasts 69  
 Yellow Revolution (Philippines) 318  
 Yellowstone Caldera (USA) 161  
 Yellowstone National Park (USA) 185  
 Yemen, flag 197  
 yews 80, 85  
 ylang ylang 85  
 Yongle 306  
 Yoritomo, Minamoto 304, 305  
 Yorkists 324  
 Yorkshire terriers 134  
 Yoshisada, Nitta 304  
 Ypres, Battle of 328  
 Zambia, flag 196  
 Zapata, Emiliano 317  
 Zapotec people 298  
 zebras 139, 146, 191  
 Zeppelin, Ferdinand, Graf von 63  
 Zhou dynasty 306  
 Ziggurat (Ur) 286  
 Zimbabwe, flag 196  
 Zoroastrianism 203  
 Zuse, Konrad 43





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Tractor Works (c/Thieman, ftr/Moline); Rabtrak (c/YTO 180, crb/Felderman, fcrb/Soils 20); Derek Mellor (tc); Paul Rackham (bc, cra, fcrb/International T-20); Happy Old Iron, Marc Geerkens (crb/Georges Vidal); Robin Simons (fcr); Paul Holmes (fcr); Piet Verschelde (fbr). **53 Dorling Kinderley:** James Coward (ca); Daniel Ward (ftl, tl, cla, fcr/McDonald Imperial); Roger and Fran Desborough (tc, fcrb, fclb); The Shuttleworth Collection (tr); Andrew Farnham (fcla/Massey-Harris); Mary and Brian Snelgar (cra); Lister Wilder (c); Robert Crawford (ftr); Happy Old Iron, Marc Geerkens (fcr/Pavesi America); Paul Rackham (fcla/Titan, fcr, fbl, clb, bc); Henry Flashman (bl); Richard Mason (fbr/Doe Triple-D); David Wakefield (fbr/JCB). **54-55 Fotolia:** Yahia Loukkal (b). **54 Dorling Kinderley:** DaimlerChrysler AG (fcl, clb). **Fotolia:** Masek (bl). **55 Dorling Kinderley:** James River Equipment (clb, crb); Yorkshire Air Museum (cl); James Rivers (br). **56-57 Dorling Kinderley:** Railroad Museum of Pennsylvania (S12 Switcher); Ribble Steam Railway / Science Museum Group (Deltic). **56 Dorling Kinderley:** Didcot Railway Centre (c/King Edward II, br/GWR Hall Class); Virginia Museum of Transportation (tr/Whitcomb, bc/VGN Class SA No. 4); The National Railway Museum, York / Science Museum Group (clb/Rocket, bl/Wren, bl/Ner Clas XL No 66); Ffestiniog & Welsh Highland Railways (clb/Taliesin, cb/Merddin Emrys); National Railway Museum, York (crb/LB & SCR B1 Class, bl/Mallard); Ribble Steam Railway / Science Museum Group (bc/Hardst Austerity); Harzer Schmalspurbahnen (br/DR Class 99.7376). **57 Dorling Kinderley:** DB Schenker (cb/BR Class 92); Musee de Chemin de Fer, Mulhouse (tl/Bugatti Railcar); Harzer Schmalspurbahnen (tl/DR Class Kö, tc/GHE T1); Railroad Museum of Pennsylvania (tr/Type NWZ, cla/Conrail No.2233, c/No. 800, c/PRR Class GG1); Didcot Railway Centre (tl/BR Class 08); Ribble Steam Railway / Science Museum Group (tc/BR Class 05, ca/D9500 Class 14, cra/Sentinel, cl/0-4-0); Virginia Museum of Transportation (tr/Norfolk and Western 41, ca/N&W EMD GP9 Class); Eisenbahnfreunde Traditionsbahnbetriebswerk Stassfurt (cra/DR V15, cla/DR V60, cl/DR E04, clb/DR Class 243, br/Shunter); Hitachi Rail Europe (cb/Javelin); The Science Museum, London (bl/Puffing Billy). **Dreamstime.com:** Mamahoooba (crb/Maglev). **58 Dorling Kinderley:** Charlie Garratt (clb); Nigel Cocks (cra); The National Motorcycle Museum (cl, cl/Triumph Trophy TR6, c/Royal Enfield, clb/Ivy Three, fbl); Phil Crosby and Peter Mather (c); Micheal Penn (bl); Peter Hodson (bc). **58-59 Dorling Kinderley:** The National Motorcycle Museum (ca); Wayne MacGowan (c). **59 Dorling Kinderley:** Charlie Garratt (cl); The National Motorcycle Museum (tc, cr, cb, bc); Brian Chapman and Chris Illman (tc/Weslake, fcrb/Mighty Mouse); Motorcycle Heritage Museum, Westerville, Ohio (tr, clb); George Manning (cla, ca, crb); Neil Mort, West Motorcycle (ca/Ducati); Justin Watson (cr/Honda); David Jones (cr/Moto guzzi); Ian Bull (br); National Motor Museum, Beauieu (fcrb, bl). **60 Dorling Kinderley:** Tony Agar (ca/Mosquito); Sari Salis Aviation (tc/DVII); Royal Airforce Museum, London (Hendon) (tc/FW 190, tr/ME262, tl/Pup, tc/Bulldog, ca/Spitfire, cla/S.E.5A, cla/Dolphin, cl/Vimy); Brooklands Museum (tl/Camel); Gatwick Aviation Museum (tc/P-38, c/B-25, c/Vulcan, clb/Wellington); Midlands Air Museum (tr/F-86); Commemorative Air Force, Mesa, Arizona (cla/Nieuport 17, clb/B-17); Paul Ford (cla/Dr 1); RAF Museum, Cosford (ca/Mustang); Planes of Fame Air Museum, Chino, California (ca/A6M Zero, ca/Yak-9); Yorkshire Air Museum (cra/Hawker Hunter); Matthew Boddington (cl/B.E.2c); RAF Battle of Britain Memorial Flight (c/Lancaster); Keith Warrington, Sutton Coldfield Model Makers Society (cl/JU87B); Pima Air and Space Museum, Tucson, Arizona (cb/B-58A). **60-61 Dorling Kinderley:** Royal International Air Tattoo 2011 (B-52). **61 Dorling Kinderley:** Royal Airforce Museum, London (Hendon) (cla/F-35 Lightning); Pima Air and Space Museum, Tucson, Arizona (tl/Tomcat); John Wilkes, Model Exhibition, Telford (tl/Harrier); Dave Gait (tc/Douglas DC3); Nationaal Luchtvaart Themapark Aviodome (tc/F27 Friendship); Brooklands Museum (tc/Concorde); Flugausstellung (tc/L-1049, ca/Comet 4C); Golden Apple Operations Ltd (ca/Stearman); The Real Aeroplane Company (cra/J/1N Autocrat, c/Pitts 51S); Philip Powell (cra/F177RG Cardinal); Richard Seeley (c/Gipsy Moth); Hamblin Jet, Luton Airport (cr/Learjet 45); The Shuttleworth Collection (c/JetRanger); RAF Boulmer, Northumberland (cr/Sea King); Fleet Air Arm Museum (cb/Westland Wessex, crb/Westland Lynx). **Dreamstime.com:** Patrick Allen / Ratmandude (cb/Bell UH-1); Wayne Mckown / Mckown (cl/B2); Darkmonk (cra/Airbus A380); Ivan Cholakov / ICholakov (crb/Black Hawk). **U.S. Air Force:** Senior Master Sgt. Joy Josephson (cl/A-10 Thunderbolt II). **62 Dorling Kinderley:** Brooklands Museum (bl); City of Norwich Aviation Museum (cl); Flugausstellung (fclb). **NASA:** U.S Air Force (clb); (br). **The Library of Congress, Washington DC:** (cr). **63 Dorling Kinderley:** Nationaal Luchtvaart Themapark Aviodome (tr); Roy Palmer (clb). **Dreamstime.com:** Darkmonk (br). **The Library of Congress, Washington DC:** (cb). **U.S. Air Force:** (cr, crb, bl). **64 Dorling Kinderley:** Trek UK Ltd (ca). **65 Dorling Kinderley:** National Cycle Collection (tl, tc, tr, cra, cla); (tr/Swift safety bicycle). **66 Dorling Kinderley:** The Natural History Museum, London (ca, cb). **67 Dorling Kinderley:** Natural History Museum, London (cra); Mike Read (cla). **Dreamstime.com:** Jeff Grabert / Jgrabert (cra/margay). **Fotolia:** Eric Isselee (ca). **68 Dorling Kinderley:** Natural History Museum, London (fcl); Neil Fletcher (ftr); Booth



Museum of Natural History, Brighton (bl). **Dreamstime.com:** Cammeraydave (cla/Snail); Musat Christian (fcla). **Fotolia:** HandmadePictures (tr); Karl Bolf (cla). **69 Dorling Kinderksley:** Mark Hamblin (bl). **70 Dorling Kinderksley:** The Natural History Museum, London (cla/Dicroidium, c/Hexagonocaulon, crb); Swedish Museum of Natural History (cra, cra/Tubicaulis). **Fotolia:** Beboy (tc). **71 Dorling Kinderksley:** The Natural History Museum, London (cla, ca/Cooksonia, cr, clb); Swedish Museum of Natural History (fcra, fcr); Oxford Museum of Natural History (cl). **72 Dorling Kinderksley:** Instituto Fundacion Miguel Lillo, Argentina (bl); The Natural History Museum, London (cla/Lepidodendron, fclb); Natural History Museum, London (fcla, ca, fcl, c/Cretaceous Cone, clb, bc, cra/Bryozoan, fcra, cra/Lithostrotion coral, crb/Lace Coral); Oxford Museum of Natural History (cb). **72-73 Dorling Kinderksley:** Senckenberg Gesellschaft Fuer Naturforschugn Museum (bl). **73 Dorling Kinderksley:** 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). **75 Dorling Kinderksley:** Jon Hughes (cla/Titanosaurus, bc). **78 Dorling Kinderksley:** Jon Hughes and Russell Gooday (cra, cr, bc/Placodus, br/Lariosaur); Jon Hughes (cla, cla/Peteinosaurus, c, clb, bc, bc/Mixosaurus, fcrb/Liopleurodon, br/Ichthyosaurus, br/Temnodontosaurus, fbr/Geosaurus); Peter Minister and Andrew Kerr (fcla, cl); (cra, fcrb, bc/Shonisaurus). **79 Alamy Images:** Elvele Images Ltd (tr). **Dorling Kinderksley:** Jon Hughes and Russell Gooday (cla, cla/Sphenosuchus, ca, fcr, clb); Natural History Museum, London (tc); Jon Hughes / Bedrock Studios (cr, bl/Kronosaurus); Jon Hughes (cra, fclb, bl, 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 Kinderksley:** Chris Gibson (cb). **90 Dorling Kinderksley:** Linda Pitkin (fcrb/Aesop). **91 Dorling Kinderksley:** Linda Pitkin (fcl/Porcelain, cl/Hermit crab, clb/slipper, clb/marble, cb/squat, bl, bc); Linda Pitkin / lindapitkin.net (cl/Panamic); Jerry Young (cra/Pill). **Dreamstime.com:** Olga Demchishina / Olygsha (fclb/Mantis). **92 Alamy Images:** Brand X Pictures / Brian Hagiwara (cl/June). **Dorling Kinderksley:** 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 Kinderksley:** Forrest L. Mitchell / James Laswel (cla/Clubtail, 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 (cra/damsel); Oxford University Museum of Natural History (fclb). **Dreamstime.com:** Ryszard Laskowski / Ryszard (tl/Army ants). **94-95 Dorling Kinderksley:** The Natural History Museum, London (All Images). **96 Dorling Kinderksley:** Linda Pitkin (tc/varicose, ca/annae, ca/Headshield, fr/Spanish, ftr/elegans). **Dreamstime.com:** Jannekespr (cr/tipped). **NOAA:** Estuarine Research Reserve Collection (cra). **96-97 Dorling Kinderksley:** Linda Pitkin (tl). **97 Dorling Kinderksley:** Linda Pitkin (tc/hare, ca/Variable Neon, crb/Bigfin); Richard Ling (cra/Cuttlefish). **Dreamstime.com:** Selahattin Ünsal Karhan (c/Trumpet). **98 Dorling Kinderksley:** 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:** Andytid (tl/Turbot); Lunamarina (ca/Bluefish); Eric Isselee / Isselee (cr); Asther Lau Choon Siew / Pufferfishy (fclb/Gurnard). **Fotolia:** uwimages (cb/anemone). **98-99 Dorling Kinderksley:** Terry Goss (cb). **99 Dorling Kinderksley:** Frank Greenaway (ftr); Linda Pitkin (cl); Jerry Young (tl, ca/Catfish). **Dreamstime.com:** Stefan Hermans / Perrush (tr/goldfish); Peter Leahy / Pipehorse (ftr/trumpet); Stephan Pietzko / Pilens (fcrb/Burbot); Tonny Wu (cb). **100 Dorling Kinderksley:** Linda Pitkin (cra); Brian Pitkin (cla). **101 Dorling Kinderksley:** Dr. Peter M Forster (cra). **Dreamstime.com:** Greg Amptman (fbr); Dongfan Wang / Tbgac (cr); Yobro10 (cra/Southern stingray). **104 Dorling Kinderksley:** Dr. Peter Janzen (cla, cla/leaf frog, cla/Splendid leaf frog); Peter Janzen (ca, cra); Twan Leenders (c, clb, clb/Red). **105 Dorling Kinderksley:** Twan Leenders (ftr, fcra, ca, cr); Jan Van Der Voort (fcl); Ignacio De la Riva (cl). **Dreamstime.com:** Kamunan Suthongsa (fcrb). **106 Dorling Kinderksley:** James H. Harding (tr/Blanding); Twan Leenders (cla); Jerry Young (fcla, c/Red-legged, crb/hinge); Jan Van Der Voort (cra/Spur-thighed); The Natural History Museum, London (br). **Dreamstime.com:** Amwu (cb/Elongated); Torsten Kuenzlen / Kuenzlen (tc/Loggerhead); Am Wu / Amwu (cra). **107 Dorling Kinderksley:** Twan Leenders (cra/Terrapin); Jerry Young (fcl, bc/Kinixys). **Dreamstime.com:** Amwu (fcra). **Getty Images:** Photographer's Choice RF / Peter Pinnock (bc). **108 Dorling Kinderksley:** Twan Leenders (cb). **Dreamstime.com:** Amwu (clb). **108-109 Dorling Kinderksley:** Andy and Gill Swash (cb). **109 Dorling Kinderksley:** Twan Leenders (cra, crb/Percival's Legless Skink, fcrb). **Dreamstime.com:** Iulian Gherghel (bc). **Fotolia:** Eric Isselee (fcra). **111 Dorling Kinderksley:** 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 Kinderksley:** Jerry Young (fcr/dwarf). **Dreamstime.com:** Lukas Blazek (t); Nico Smit / Ecophoto (fcrb); Ediverivo (cl).

**114-115 Dorling Kinderksley:** The Natural History Museum, London (All Images). **116 Dorling Kinderksley:** Greg and Yvonne Dean (cb); E. J. Peiker (fcra); The National Birds of Prey Centre, Gloucestershire (cra); Jari Peltomaki (cla, clb); Markus Varesvuo (cla); Brian E. Small (cra, cl/runner, br); Barry Hughes (cl); Roger Tidman (bc, fbr). **Getty Images:** Frank Krahrmer / Photographer's Choice RF (fbl). **117 Dorling Kinderksley:** Mike Danzenbake (cl/swift); The Natural History Museum, London (cra); E.J. Peiker (c, cr); Andy and Gill Swash (fcl); Mike Danzenbaker (cl/LUCIFER); Mike Read (c/tody); Tomi Muukkonen (clb); Markus Varesvuo (cra, fbl); Garth McElroy (cra/duck); Melvin Grey (bl, clb/gallinule); Chris Gomersall Photography (cra/puffin); Brian E. Small (br, br/warbler, fbr); Mike Lane (br/skylark). **118 Dorling Kinderksley:** Chris Gomersall (fcr); The National Birds of Prey Centre, Gloucestershire (c, fcr/Harris hawk, cb/egyptian); Hanne and Jens Erikson (cra); Melvin Grey (br). **Dreamstime.com:** Isselee (c/Bald Eagle). **119 Dorling Kinderksley:** 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 (cra). **120 123RF.com:** mycteria (cra). **Dorling Kinderksley:** The Natural History Museum, London (cla); Evgeniya Moroz (cl/peacock). **Dreamstime.com:** Iakov Filimonov (bl); Irisangel (br). **121 Dorling Kinderksley:** Barnabas Kinderksley (bc). **Dreamstime.com:** David Medina claesson (br); Vtorous (fcr); Smileus (bl); Kruglik (bl/bluebird); Picstudio (br/kingfisher). **122 Dorling Kinderksley:** The Natural History Museum, London (cla). **123 Dreamstime.com:** Torsten Kuenzlen / Kuenzlen (cra). **Fotolia:** Chrispo (cr). **124 Dorling Kinderksley:** Greg and Yvonne Dean (cb/Sun); Exmoor Zoo, Devon (fcra). **Fotolia:** Eric Isselee (cra). **124-124 Dorling Kinderksley:** The Marwell Zoological Park, Winchester (tl). **125 Dorling Kinderksley:** The Booth Museum of Natural History, Brighton (fcr/Hopi); Rebecca Dean (fcl/african); E. J. Peiker (c/harrisii); Drusillas Zoo, Alfriston, West Sussex (fbr). **Dreamstime.com:** Per Björkdahl (cra/lemming); Eduard Kyslynsky (cra); Dule964 (cra/Dormouse); Martha Marks (fcrb/prairie). **126 Dorling Kinderksley:** 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 Kinderksley:** Andy and Gill Swash (ca/Toque); Jerry Young (ftr). **Dreamstime.com:** Lin Joe Yin / Joeyin (fcl/Gibbon). **Fotolia:** Eric Isselee (cl/Pileated Gibbon). **128 Dorling Kinderksley:** Prof. Marcio Motta (cr); Wildlife Heritage Foundation, Kent, UK (br). **Dreamstime.com:** Rafael Angel Irusta Machin / Broker (ca); Isselee (b). **129 Dorling Kinderksley:** Berlin Zoo (cr); Wildlife Heritage Foundation, Kent, UK (c, cl, bl, cb); Blackpool Zoo, Lancashire, UK (cra). **Dreamstime.com:** Jeff Grabert / Jgrabert (cra); Outdoorsman (cra/Canadian lynx). **Fotolia:** Shchpikova Elena (br). **131 Dorling Kinderksley:** The Tank Museum (cl). **132 Dorling Kinderksley:** The Natural History Museum, London (cla, cl, cra/tortoise, c, cb, cb/Crow); Booth Museum of Natural History, Brighton (cra, fbr). **133 Dorling Kinderksley:** The Natural History Museum, London (tr, fcrb, crb). **Fotolia:** giuliano2022 (tc/Rhinocer). **134 Dorling Kinderksley:** Jerry Young (tr). **136 Dreamstime.com:** Ekaterina Cherkashina / Katerinache (cra/Munchkin). **137 Dreamstime.com:** Eric Isselee / Isselee (clb/persian). **138 Dorling Kinderksley:** Haras National de Saint Lo, France (cl/Clay/Norman Cob). **Dreamstime.com:** Isselee (br). **139 Fotolia:** Jan Will (bl/Zebra). **140 Dorling Kinderksley:** Barleylands Farm Museum and Animal Centre, Billericay (tr, ca, fcra); South of England Rare Breeds Centre, Ashford, Kent (cla, br); Cotswold Farm Park, Gloucestershire (cra). **Fotolia:** Eric Isselee (clb). **140-141 Dorling Kinderksley:** Barleylands Farm Museum and Animal Centre, Billericay (c). **141 Dorling Kinderksley:** 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 Kinderksley:** Jerry Young (fcra). **Dreamstime.com:** Inga Nielsen (ca); Svehlik21 (cra). **143 Alamy Images:** Photofrenetic (fclb). **Dorling Kinderksley:** Cotswold Wildlife Park (fcl); Andy and Gill Swash (c/Coyote); Jerry Young (c, cl/Mandarin Duck); E. J. Peiker (cb); Natural History Museum, London (cra). **Dreamstime.com:** Anton Kozyrev (br); Urospeteko (fcla); Jnhuz (clb); Ijacky (bl). **Fotolia:** Eric Isselee (ca). **144 Dorling Kinderksley:** Natural History Museum, London (tr); Jerry Young (ca/Red Eyed Tree Frog). **Dreamstime.com:** Eric Isselee (cra); Isselee (cb); Kira Kaplinski / Kkaplin (clb). **145 Alamy Images:** Life on White (clb). **Dorling Kinderksley:** Natural History Museum, London (ca, ca/Tawny Rajah, cl); Jerry Young (ftr, cla/Black spider monkey, cl/Nymph, cb); Twan Leenders (cr). **Fotolia:** Eric Isselee (cla). **146 Dreamstime.com:** Anankml (tr); Ryszard Laskowski (c). **Fotolia:** Andreas Altenburger / arxxx (cra). **146-147 Dorling Kinderksley:** Jerry Young (bc). **147 Dorling Kinderksley:** Cotswold Wildlife Park (cra). **Fotolia:** Shchpikova Elena (clb). **148 Dorling Kinderksley:** Jerry Young (ca, cr). **Dreamstime.com:** Smelme (ftr); Stefan Gottschild (br). **Fotolia:** Steve Lovegrove (fcrb). **149 Dorling Kinderksley:** E. J. Peiker (cla). **150 Corbis:** (cra). **Getty Images:** Sandy Carey, Photodisc / Alan (br). **150-151 Dreamstime.com:** Steven Oehlenschläger (bc). **151 Dorling Kinderksley:** Drusillas Zoo, Alfriston, West Sussex (bc); Jerry Young (tl). **Dreamstime.com:** Achim Baqué (cra/leopard seal); Helen Panphilova /

Gazprom (cla); Vladimir Seliverstov / Vladsilver (fcr); Isselee (bl). **Fotolia:** Stefan Zeitz / Lux (cb). **Getty Images:** Joel Sartore (tc); Purestock (cra/Harp Seal). **152 Dorling Kinderksley:** Linda Pitkin (tr, ca/cuttlefish, tr/seahorse, c). **152-153 Dorling Kinderksley:** Rick Hibpsman (bl). **153 Dorling Kinderksley:** 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 (c); Teguh Tirtaputra / Teguhirtira (cb); Dejan Sarman / Dejan750 (cra). **154 Dorling Kinderksley:** Linda Pitkin / lindapitkin.net (br). **Dreamstime.com:** Carol Buchanan (cra). **154-155 Dorling Kinderksley:** Dr. Peter M Forster (c). **155 Alamy Images:** Martin Strmiska (br). **Dorling Kinderksley:** The Goldfish Bowl (cra/Jewelfish). **Dreamstime.com:** Eric Isselee (clb/Hermit crab); Krzysztof Odziomek / Crisod (tc); Tazdevilgreg (c/Corral Trout). **156 Dorling Kinderksley:** Natural History Museum, London (cra, cb). **157 Dorling Kinderksley:** Planetary Visions Ltd (cra). **Dreamstime.com:** Dan Breckwoldt / Danbreckwoldt (cla). **Fotolia:** Mark Higgins (cra/kangaroo). **Getty Images:** Dene Myles (ca). **158 Dreamstime.com:** Staphy (bc). **159 Dreamstime.com:** Yury Tarasov / Sportfoto (bc). **Fotolia:** Galyna Andrushko (bc/peak). **160 Dreamstime.com:** Jason Yoder / Jasonry00 (br). **161 Dorling Kinderksley:** Museo Archeologico Nazionale di Napoli (br); NASA (bc/Volcano erupting on Io). **165 Dreamstime.com:** Vera Golovina (br). **166 Dorling Kinderksley:** The Natural History Museum, London (cl/magnetite, fclb/Hornblende, bc/Corundum, fbr); The Science Museum, London (cla/Pumice). **167 Dorling Kinderksley:** The Natural History Museum, London (cb/Proustite); The Oxford University Museum of Natural History (cl/diamond). **168-169 Dorling Kinderksley:** The Natural History Museum, London (All images). **169 Dreamstime.com:** Leon Rafael / Lrafael. **172-173 Dorling Kinderksley:** Planetary Visions Ltd (c). **173 Dreamstime.com:** Jeremy Richards (cra). **NASA:** (bc, br); (fbr). **174 Corbis:** Warren Faidley (fcra). **Dreamstime.com:** Amnemcova (cra/Snow storm); Sergey Galushko / Galdzer (cla); Gina1111 (ca); Victor Zastol' skiy / Vicnt (cra/Tornado); Dexitner (cl/Heatwave); Ollrig (cl/Drought); Anizza (c); Antares614 (cra/Hailstorm). **NOAA:** Carrie Smith / NOAA Central Library (ftr). **U.S. Geological Survey:** (ca/flood); Seth Munson (fcl). **176 Alamy Images:** Travelib Africa (clb). **177 Alamy Images:** Hugh Threlfall (cra). **Dorling Kinderksley:** Dr. Peter Janzen (ca/frog). **Fotolia:** Scanrail (cra/global). **182 Dorling Kinderksley:** Barnabas Kinderksley (cla). **183 Dreamstime.com:** Byjeng (cra). **185 Dorling Kinderksley:** Jerry Young (ftr). **186 Corbis:** DLILLC (bc). **Dreamstime.com:** Misha Shiyanyov / Kertis (cl). **187 Dorling Kinderksley:** Philip Dowell (tr/Jaguar). **Dreamstime.com:** Chrishowey (bc). **190 Dreamstime.com:** Jeremy Richards (clb). **191 Fotolia:** Eric Isselee (clb). **PunchStock:** Digital Vision (cr). **193 Dreamstime.com:** Dmitry Pichugin / Dmitryp (br); Callan Chesser / Ewanchesser (tc); Bin Zhou / Dropu (bc). **Fotolia:** Mark Higgins (cra); Eric Isselee (tr). **194 Dorling Kinderksley:** The Royal Geographical Society, London (cla); The National Maritime Museum, London (clb). **Dreamstime.com:** Staphy (bl, bc). **195 Dorling Kinderksley:** Alan Burger (cra/sea); Arctic Trucks / Gisti Jonsson (tc). **Dreamstime.com:** Xavier Marchant / Xaviermarchant (cr); Jan Martin Will / Freezingpictures (tr/Adelie penguin). **Getty Images:** Dene Myles (cra); David Tipling / Digital Vision (tr). **198 Alamy Images:** Hugh Threlfall (cb). **Dreamstime.com:** Elena Elisseeva (cl/solar); Igor Marx (cl); Mafoto (cb/Triticate); Mateno (clb). **199 Dorling Kinderksley:** Odds Farm Park, High Wycombe, Bucks (clb/pig). **200 Dorling Kinderksley:** Blandford Fashion Museum (ca/Straw hat); Musee du Louvre, Paris (ca/Mona Lisa). **Dreamstime.com:** Anky10 (clb); Vtupinamba (ca); Goncharuk Maksym (cr). **201 Dorling Kinderksley:** Barnabas Kinderksley (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). **202 Dorling Kinderksley:** Barnabas Kinderksley (cra); Stephen Oliver (bc). **Dreamstime.com:** Murali Nath / Muralinath (fcr); Silentiger (fcl). **203 Dorling Kinderksley:** Central London Ghurdwara (cb); The Zoroastrian Trust Funds of Europe (cr); Pitt Rivers Museum, University of Oxford (bc); Barnabas Kinderksley (bl). **204 Dorling Kinderksley:** Barnabas Kinderksley (bl). **Dreamstime.com:** Gino Santa Maria (tr); Patrick Poendl (cb). **Fotolia:** Anatolii (cl). **205 Dreamstime.com:** Jamen Percy (tc); Sergey Tsvirov (c); Laura Stone (cr). **208 Dorling Kinderksley:** Andy Crawford (bl, bl/Star-shaped pendant); University Museum of Archaeology and Anthropology, Cambridge (tc, tr); National Museum of Wales (tc/Stone-Age painting); Musee National du Moyen-Age Thermes de Cluny (cl); Museum of the Order of St John, London (ca); The American Museum of Natural History (fcr); 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 (fcl); Steve Estvanik (c). **209 Dorling Kinderksley:** The University of Aberdeen (cla); University of Pennsylvania Museum of Archaeology and Anthropology (ftr, tc, tc/Ancient Egypt Shabti); Ure Museum of Greek Archaeology, University of Reading (tr); Durham University Oriental Museum (ca, ca/Mummy mask, cl, c, c/Buddha); Wallace Collection, London (c/Ornate Elephant); Villa Giulia and Beniculturali (cr). **Dreamstime.com:** Rolfimages (bc/Expression). **210 Dorling Kinderksley:** The Bate Collection (cl/Clarinet, cr/Bugle); The Powell-Cotton Museum, Kent (bc).



**211 Dorling Kinderley:** The Bate Collection (c/Viol); The Royal Academy of Music (fcl, c). **Dreamstime.com:** Karam Miri (cb). **Getty Images:** Stockbyte (crb/Ukulele). **214 Dorling Kinderley:** Andy Crawford (cl, c). **Dreamstime.com:** Afxhome (cla); Hongqi Zhang (aka Michael Zhang) (cra). **215 Dorling Kinderley:** Blandford Fashion Museum (cra/tango shoes). **Dreamstime.com:** Anky10 (fcr); Goran Bogicevic (cra); Stable400 (fcr); Derek Tenhues / Derektenhues (fcr/Bathroom); Samotrebizan (cra/samba, fcr/cha cha); Viorel Sima (cr). **216 Dorling Kinderley:** 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); The Royal Ballet School (ca). **Dreamstime.com:** Jackq (fcr). **218 Dorling Kinderley:** Lydia Evans / Rough Guides (crb); Pompidou Centre (br). **Dreamstime.com:** Chrisharvey (cr); Sergii Figurnyi / Bloodua (tc); Konstantin32 (cl). **219 Dorling Kinderley:** Demetrio Carrasco / Rough Guides (fcr); Photos By Chris Christoforou / Rough Guides (tl); Tim Draper / Rough Guides (ftr, bl). **Dreamstime.com:** Yykkaa (bc). **220 Dorling Kinderley:** Pennsylvania Museum of Archaeology and Anthropology (ca). **221 Fotolia:** Derya Celik (ca). **225 Dreamstime.com:** Vtupinamba (cla). **iStockphoto.com:** Vasko Miokovic (cra). **226 Getty Images:** Creativ Studio Heinemann (fcl/Black currants). **226–227 Dreamstime.com:** Goncharuk Maksym (c). **227 Getty Images:** Foodcollection (c/Damson). **229 Getty Images:** felipedupouy.com / Photodisc (bl). **230 Dorling Kinderley:** Westcombe Dairy (ftl, tl, tc). **231 Dreamstime.com:** Malgorzata Kistryn (tl). **Fotolia:** Eric Isselee (bl). **232 Dorling Kinderley:** Barnabas Kinderley (cb/Mantou). **234 Dreamstime.com:** Bert Folsom (crb). **236 Dreamstime.com:** Deepcameo (c). **237 Dorling Kinderley:** The Natural History Museum, London (clb/sea urchin). **240 Dorling Kinderley:** 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). **241 Dorling Kinderley:** Banbury Museum (tr/waistcoat, fcr); Blandford Fashion Museum (tc, fcl, fcl/swim cap); Central Saint Martins (c, c/Jacket, c/Cloak, cr). **Dreamstime.com:** Verkoka (br). **Getty Images:** Photodisc (bc). **242 Dorling Kinderley:** 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). **243 Dorling Kinderley:** 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:** Georgii Dolgikh / Gdolgikh (fbr/lady); Toxawww (tbl). **246 Dorling Kinderley:** Stephen Oliver (br). **Dreamstime.com:** John Kasawa (bl); Mikumistock (cl). **Fotolia:** Gudellaphoto (c). **247 Dreamstime.com:** Dmitry Grushin (tr); Olaf Speier (ftl). **Getty Images:** Burazin / Photographer's Choice RF (bl). **250 Getty Images:** Burazin / Photographer's Choice RF (ca). **258 Dorling Kinderley:** Stephen Oliver (crb). **264 Dreamstime.com:** Vladimir Ovchinnikov (br). **270 Dorling Kinderley:** Leeda Fishing Tackle, UK (cla, ca). **271 Dorling Kinderley:** Leeda Fishing Tackle, UK (crb/Deer Hopper). **Dreamstime.com:** Nataliya Evmenenko (ftr); Bidouze Stéphane (tr). **279 Dorling Kinderley:** Davenport's Magic Kingdom (fcr). **280 Dorling Kinderley:** Pegasus Stables, Newmarket (c); W&H Gidden Ltd (cr). **282 Dorling Kinderley:** The Board of Trustees of the Royal Armouries (cb); Vikings of Middle England (cla); University of Pennsylvania Museum of Archaeology and Anthropology (ca, fcr, clb); The Tank Museum (crb); Durham University Oriental Museum (cb/fan, cb/Glass bowl). **Dreamstime.com:** Ks2008q (ca/coin). **283 Dorling Kinderley:** Anthony Barton Collection (cb/lute); The National Railway Museum, York / Science Museum Group (ca); The Tank Museum (ca/tank); Egyptian Museum, Cairo (cra); Eden Camp Museum, Yorkshire (cb); Whipple Museum of History of Science, Cambridge (cla); Natural History Museum, London (fcr); Durham University Oriental Museum (shoes). **284 Dorling Kinderley:** Natural History Museum, London (crb, bc, br); Oxford Museum of Natural History (cb); Pitt Rivers Museum, University of Oxford (ftr, tr, cr); The Science Museum, London (fcr). **285 Dorling Kinderley:** Pennsylvania Museum of Archaeology and Anthropology (tc/Clovis projectile point); National Museum of Wales (bl); Natural History Museum, London (tc/Harpoon, tc/Manmade barbed tool, bc/Venus' Figurine); The Museum of London (tc/Adze head, ca, c); University Museum of Archaeology and Anthropology, Cambridge (cb, cb/piece of Bone, bc, br). **286 Dorling Kinderley:** Durham University Oriental Museum (cb); University of Pennsylvania Museum of Archaeology and Anthropology (cb, br). **287 Dorling Kinderley:** The University of Aberdeen (tr); The Science Museum, London (cla); University of Pennsylvania Museum of Archaeology and Anthropology (tc, tc/Silver bowl, ftr, ca, ca/scorpions= design cup, ca/Cylinder seal, cra, bc, cr, cr/Necklace, bc/Bead belt, br). **288 Dorling Kinderley:** Egyptian Museum, Cairo (tr); University of Pennsylvania Museum of Archaeology and Anthropology (crb); Durham University Oriental Museum (fbl/left, fbl/right, bl, bc). **289 Dorling Kinderley:** The University of Aberdeen (crb/necklace); Wellcome Institute / Science

Museum, London (cra/oilment slab); University of Pennsylvania Museum of Archaeology and Anthropology (cra/bead collar, cr/cat); Newcastle Great Northern Museum, Hancock (cr/arrowheads, b); Durham University Oriental Museum (cr/girl, crb, cb/amulet); Ure Museum of Greek Archaeology, University of Reading (c); Ashmolean Museum, Oxford (clb/earring, cb/rings). **290 Dorling Kinderley:** 4hoplites (bl/Stove); Geoff Garvey / Rough Guides (tl); The University of Aberdeen (cl/Athenian Coin, c/Alexandrian Coin); National Archaeological Museum, Athens (cl/Knossos Coin); Newcastle Great Northern Museum, Hancock (clb/Plate, cb/Earring); Wellcome Institute / Science Museum, London (clb/Pot); Ure Museum of Greek Archaeology, University of Reading (clb/Jug, bc); University of Pennsylvania Museum of Archaeology and Anthropology (fbl/Powder Box). **291 Dorling Kinderley:** 4hoplites (c, cr, crb, cb, bc, br); Hellenic Maritime Museum (ftl); Canterbury City Council, Museums and Galleries (tl); Mark Thomas / Rough Guides (bl). **294 Dorling Kinderley:** Angels Fancy Dress (r); Ermine Street Guard (fcl, fclb, cl/Scabbard, cl/Gladius, c). **295 Dorling Kinderley:** The University of Aberdeen (fcr/Coin); Newcastle Great Northern Museum, Hancock (tc/Colander); Stephen Oliver (tc/Flask); University of Pennsylvania Museum of Archaeology and Anthropology (tr/Ring); Canterbury City Council, Museums and Galleries (tr/Bottle). **296 Dorling Kinderley:** Danish National Museum (cb); Vikings of Middle England (ca). **297 Dorling Kinderley:** Andy Crawford (br); The Universitets Oldsaksamling, Oslo (tr); Vikings of Middle England (clb, ca, cb, cb/dagger, cr, bl, bl/arrows, bc, fbr). **298 Dorling Kinderley:** Sarah Cummins / Rough Guides (cb); Roger D'Olivere Mapp / Rough Guides (clb); Tim Draper / Rough Guides (crb). **299 Dorling Kinderley:** 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). **301 Dorling Kinderley:** 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 Ariturk (cl). **302 Dorling Kinderley:** 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); The English Civil War Society (cb); Canterbury City Council, Museums and Galleries (cb/handgrip, cb/Gauntlet Sword, crb/Firangi); Durham University Oriental Museum (br). **303 Dorling Kinderley:** The City Palace Museum, Jaipur (br); Durham University Oriental Museum (cb, bc/Khanjar, bc/pendant, bc/Jade). **304 Dorling Kinderley:** Maidstone Museum and Bentliff Art Gallery (tr); Durham University Oriental Museum (cl, clb, bl). **305 Dorling Kinderley:** Courtesy of Durham University Oriental Museum (tc, tc/screen fan, ca/Wrestler's netsuke, ca/bowl); Durham University Oriental Museum (fcl, cl, cl/Spear, ca, ca/Cast iron kettles, ca/Incense burner, tr, crb, br, fbr). **306 Dorling Kinderley:** Tim Draper / Rough Guides (ca/City); Durham University Oriental Museum (tl/Beaker, cla/Pot, clb/Horse, clb/Vase, bl/Plate). **Getty Images:** Ingo Jezierski / Photodisc (ca/Army). **306–307 Dorling Kinderley:** Tim Draper / Rough Guides. **307 Dorling Kinderley:** Durham University Oriental Museum (cb/Puzzle, crb/Pendants, fbl/Bottle, fbl/Caddy, bl/Bowl, bc/Teapot, br); The Science Museum, London (cl/Earthquake Detector, c); University of Pennsylvania Museum of Archaeology and Anthropology (clb/Camel). **308 Dorling Kinderley:** 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). **309 Dorling Kinderley:** Royal Armouries, Leeds (ca); 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). **311 Dorling Kinderley:** The Board of Trustees of the Royal Armouries (cla); Cotswold Farm Park, Gloucestershire (clb, crb, bc); The Order of the Black Prince (cl, bl). **312 Dorling Kinderley:** 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). **313 Dorling Kinderley:** 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). **314 Dorling Kinderley:** National Maritime Museum, London (cr/longship, cr, fclb, clb). **315 Dorling Kinderley:** Natural History Museum, London (cra/drawing, cra); National Maritime Museum, London (ftl, tl, tc, cla, cla/Telescope, fcr, cr, br); The Science Museum, London (ca/ meter panel); The Royal Geographical Society, London (crb); Royal Geographical Society, London (fcrb). **316 Dorling Kinderley:** Canterbury City Council, Museums and Galleries (ca); Maidstone Museum and Bentliff Art Gallery (tc); Stephen Oliver (br). **Dreamstime.com:** Ismael Tato Rodriguez (cl). **317 Alamy Images:** D. Hurst (cla). **Dreamstime.com:** Piet Hagenaars (tc); Ks2008q (cra); Patricia Hofmeester (bc). **320 Dorling Kinderley:** US Army Heritage and Education Center -

Military History Institute (fclb, br/revolver); Civil War Library and Museum, Philadelphia (c/Union Infantryman); Gettysburg National Military Park, PA (c/confederate); Southern Skirmish Association (c/canteen, cb, crb/Knife and fork, fcrb, br); C. Paul Loane Collection (crb). **321 Dorling Kinderley:** Gettysburg National Military Park, PA (crb, bc, bc/Spencer Carbine); Southern Skirmish Association (fcl, cl, fcl/Rope, cl/Cap). **322 Alamy Images:** D. Hurst (cl). **Dorling Kinderley:** National Maritime Museum, London (fcla). **Dreamstime.com:** Hecke01 (clb). **326 Dorling Kinderley:** The National Railway Museum, York / Science Museum Group (bl); The Science Museum, London (br). **Dreamstime.com:** Timothy Large (cr). **327 Dorling Kinderley:** Norfolk Rural Life Museum and Union Farm (bl); The Science Museum, London (fcr, cra, fcrb, cb, br, fbr); Whipple Museum of History of Science, Cambridge (cr); Maidstone Museum and Bentliff Art Gallery (crb); Museum of English Rural Life, The University of Reading (clb/Seed Drill). **Dreamstime.com:** Graham White (tr). **328 Dorling Kinderley:** Royal Green Jackets Museum, Winchester (cla); Jean-Pierre Verney (cl, fcrb); Imperial War Museum, London (clb); John Pearce (crb). **329 Dorling Kinderley:** Board of Trustees of the Royal Armouries (cl); Fleet Air Arm Museum (tc, ca); Imperial War Museum, London (ca/British Mark V Tank, c, clb); Jean-Pierre Verney (cla, cla/helmet and goggles, tr, ftr, fcr, cr/Italy, fcr, fcl, ca/French 'Hairbrush' grenade, ca/hand grenades, ca/Rod club nail, clb/Carcano, bl, fcrb, c/Beretta automatic pistol); Jean-Pierre Verney Collection (cra); Birmingham Pals (clb/Lee Enfield rifle); Imperial War Museum (c/German gas shell); The Tank Museum (cb, cr, br, cb/Luger pistol); The Combined Military Services Museum (CMSM) (c/Glisenti Pistol). **330 Dorling Kinderley:** Royal Air Force Museum, London (Hendon) (cr, cr/Messerschmitt Bf 110, c/Supermarine Spitfire Mk24); The Wardrobe Museum, Salisbury (tl); Eden Camp Museum, Yorkshire (tr); Keith Warrington, Sutton Coldfield Model Makers Society (c); Musee de l'Air et de l'Espace / Le Bourget (fcr); Gatwick Aviation Museum (cr/Bell P-39-D Airacobra, cb/German Heinkel HE 111, crb/Handley Page Halifax III); The Combined Military Services Museum (CMSM) (cb, fcrb, cb/Vickers Mark IV machine gun); Fort Nelson (crb). **331 Dorling Kinderley:** RAF Museum, Cosford (tc); The Wardrobe Museum, Salisbury (tl, cla); Brabury Science Museum, Los Alamos (tr); Gatwick Aviation Museum (ftl); Royal Armouries (cl). **332 Dorling Kinderley:** The Tank Museum (c, c/M2 Half Track, cl, cr/Churchill tank, clb, cb/Panzerkampfwagen II, clb/Panzerkampfwagen III, cb/Ps Kpfw VI Ausf B Tiger II); Fleet Air Arm Museum (cb, cb/HMS Agincourt, bc, br, bc/USS); Scale Model World (crb, bl). **332 Dorling Kinderley:** Fleet Air Arm Museum (cra). **333 Dorling Kinderley:** Board of Trustees of the Royal Armouries (cb/M16); Ukraine State Aviation Museum (ca); Flugausstellung (c); Tim Parker (cb); Ministry of Defense Pattern Room, Nottingham (cb/jacket); Vietnam Rolling Thunder (clb, cb/tunic, cb/trousers, bc). **NASA:** (tc). **334 Alamy Images:** Andrew Twort (cr). **Dorling Kinderley:** H Keith Melton Collection (fcl, c, cr/Mezon, fcr, clb, bl, bc/M-94, crb, br/Handkerchief, br/letter removal device); Imperial War Museum, London (bc, cb/Morse code key, fbr). **Dreamstime.com:** Kittiwut Ittikunlasate (cb). **The Library of Congress, Washington DC:** (tc). **335 Dorling Kinderley:** H Keith Melton Collection (ca/coin, cra, fcl, cl, c, c/sleeve gun, fclb, cb, cb/Tear gas pen, crb, fbl, bl, bc/Surreptitious entry kit, cla); RAF Museum, Hendon (ca); Imperial War Museum, London (bc). **336 Dorling Kinderley:** University of Pennsylvania Museum of Archaeology and Anthropology (br). **337 Dorling Kinderley:** Natural History Museum, London (br). **Dreamstime.com:** Jeff Grabert / Jgrabert (bc). **338 Dorling Kinderley:** Forrest L. Mitchell / James Laswel (bl); Egyptian Museum, Cairo (bc); Jerry Young (br). **339 Dorling Kinderley:** Natural History Museum, London (br); Paul Rackham (fbl); Linda Pitkin (fbr). **340 Dorling Kinderley:** Twan Leenders (fbl); The Shuttleworth Collection (fbr). **341 Dorling Kinderley:** The Natural History Museum, London (fbl); Scanrail (bl). **342 Dreamstime.com:** Andyliid. **343 Dreamstime.com:** The Natural History Museum, London (br). **345 Dorling Kinderley:** The Natural History Museum, London (fbl); Jari Peltomaki (bc); Motorcycle Heritage Museum, Westerville, Ohio (fbr). **346 Dorling Kinderley:** University of Pennsylvania Museum of Archaeology and Anthropology (fbr). **Fotolia:** Jan Will (bc). **347 Dorling Kinderley:** Linda Pitkin (br). **348 Dorling Kinderley:** Linda Pitkin (bc/lobster); Stephen Oliver (bc). **349 Alamy Images:** Paul Fleet (fbr). **Dreamstime.com:** Vtupinamba (br). **351 Dorling Kinderley:** Durham University Oriental Museum (bc, bc/Hilt). **352 Dorling Kinderley:** The Natural History Museum, London (bc); The Real Aeroplane Company (fbl). **Dreamstime.com:** Karam Miri (br). **353 Dorling Kinderley:** Durham University Oriental Museum (bl). **354 Dorling Kinderley:** Greg and Yvonne Dean (br). **NASA:** Boris Rabin (bc). **355 Dorling Kinderley:** Durham University Oriental Museum (bc/gold amulet). **Fotolia:** Eric Isselee (bc, fbr). **Getty Images:** felipedupouy.com / Photodisc (br). **356 Dorling Kinderley:** Brooklands Museum (fbr); Natural History Museum, London (bl). **357 Dreamstime.com:** Kamnuan Suthongsa (br). **NASA:** (fbr)

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