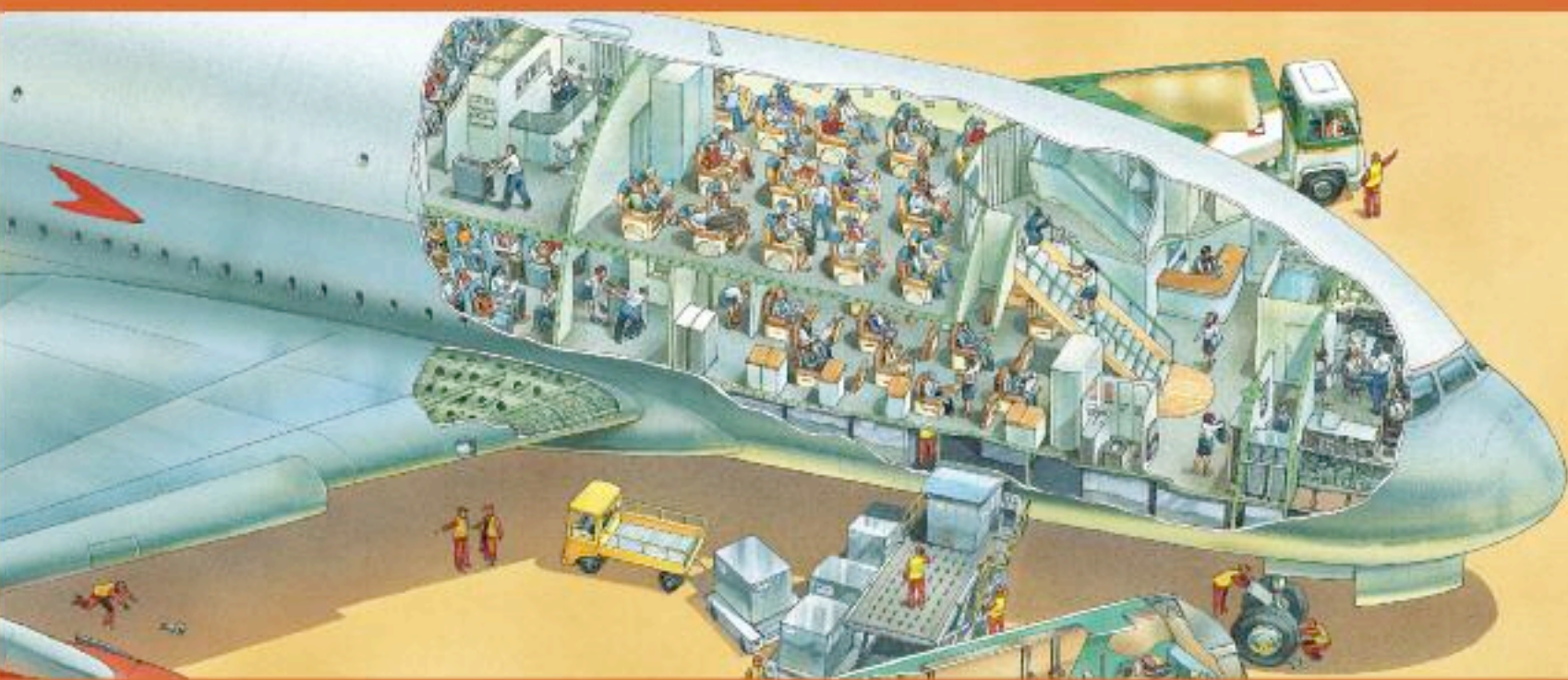


ILLUSTRATED ENCYCLOPEDIA



# TRANSPORT



More than 250 keywords

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# ABOUT THIS BOOK

Each double page contains a brief introduction, explaining the general subject, followed by key words arranged in alphabetical order. To look up a specific word, turn to the index at the back of this book: this will tell you which page to go to. If you want to learn more about a subject, take a look at the factfile or brief history, or follow the arrows to read related entries.



**INTRODUCTION**  
This explains the general subject and provides some basic knowledge.

**BOLD WORDS**  
These highlight useful words that do not have their own entry.

**BRIEF HISTORY/FACTFILE**  
Brief histories give a summary of important dates. Factfiles provide extra information on the subject in easy to read bullet points.

### STORY OF SHIPS

The first boats were made from logs, reeds or animal skins bound together, and propelled by paddles or poles pushed into a river bed. The first sailing boats were built about 6000 years ago. Over the centuries, ships became larger and boatbuilders arranged sails to catch the wind more efficiently. In the 19th century, the first steam-powered ships appeared. By 1920, huge steamships carried most of the world's cargo, but in the mid-20th century, steam began to give way to diesel power.

An early paddle steamer. Its chimney doubles as a mast for its sails.

**Barque** An ocean-going sailing ship used to carry cargo in the 18th century. Despite its large size, it could be operated by a small crew. The largest sailing ship ever was a barque called the *France II*, built in 1911.

**Battleship** A large, armoured ship with guns and missiles. The first steam-powered battleships were built in the 1800s.

**Caravel** A light, fast sailing ship with a deep hull, used to carry cargo. It was developed by the Portuguese in the 15th century.

**Carrack** A broad, ocean-going sailing ship, built in Europe from the 15th century. Carracks had three or four masts, combining square and triangular sails.

**Clipper** A fast, 19th century sailing ship, with a streamlined hull used to carry cargo such as tea and spices.

**Coracle** A traditional one-man fishing boat, with a hull made from reeds or wood. It is paddled with an oar, and is light enough to be easily carried.

**Dhow** A traditional Arab sailing boat, fitted with one or more triangular sails.

**The SS Great Eastern**

**Dugout canoe** A simple boat made from a hollowed-out tree trunk and powered by paddles. Dugouts are the oldest known boats in the world.

**A Native American making a canoe.**

**Barge** A long, flat-bottomed boat used to transport goods along rivers and canals. Early barges were towed by horses on a path beside the water. Modern barges are self-propelled or pulled by tugboats.

**EARLY SAILING SHIPS**

- Greek trireme 480 BC
- 15th century Flemish carrack (right)
- Egyptian warship (left) 1000 BC
- Phoenician ship (left) 800 BC
- Viking longship (left) 1000
- 15th century Chinese junk (right)
- 15th century Portuguese carrack
- 17th century Spanish galleon

The Titanic

**Galleon** A ship with square sails and at least two decks armed with cannons. Galleons were used by Europeans from the 16th to the 18th century for warfare and trade.

The *France II*, the biggest sailing ship ever. Its steel hull was 147 m long.

**Galley** A long, slender ship used by the ancient Greeks and Romans. It was sometimes fitted with sails, but would be rowed into battle to attack enemy ships with a sharp ram on its bow.

**Junk** A traditional Chinese boat with sails stiffened by bamboo poles and a stempost rudder for steering. Its hull is fitted with compartments that strengthen the ship and slow flooding in case of accidents.

**Knarr** A shallow-bottomed sailing ship, used by the Vikings around 1000 years ago. Its hull was made from overlapping, or "clinkered", planks of wood. Knarrs were used for trading and, later, for exploration of the North Atlantic Ocean.

**Longship** A fast, slender ship used to carry Viking warriors into battle. It was powered by both a square sail and oars. Its front was carved into the shape of a dragon's head.

**Paddle steamer** A ship in which a steam engine turned paddle wheels fitted to either side of the hull. The first commercial paddle steamer was built by American Robert Fulton (1765-1815) in 1807.

**SS Great Britain** A passenger steamship designed by English engineer Isambard Kingdom Brunel (1806-1859) in 1843. It was the first iron steamship to be fitted with a screw propeller.

**SS Great Eastern** An iron paddle steamer built by Brunel in 1858. It could carry 4000 passengers and was the largest ship in the world at the time.

**Steamship** A ship with a steam engine that turns paddle wheels or a propeller. Early steamships also had sails as they could not carry enough coal for long voyages and their engines were unreliable.

**Titanic** A steam-powered ocean liner that sank after hitting an iceberg on its maiden voyage in 1912. 1500 people lost their lives.

**Trireme** A warship used by the ancient Greeks, Romans and Phoenicians, powered both by sails and by three rows of oars.

A battleship at port

**A BRIEF HISTORY**

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- c.3500 BC The first sailing boats are built in ancient Egypt.
- c.2700 BC The first triremes are built.
- c.1300 BC Junks are first made in China.
- c.1000 AD The Vikings use knarrs to cross the Atlantic Ocean.
- c.1492 The first carracks are built.
- c.1807 The first commercial paddle steamer is built in America.
- 1809 The first steamship with a screw propeller is built.

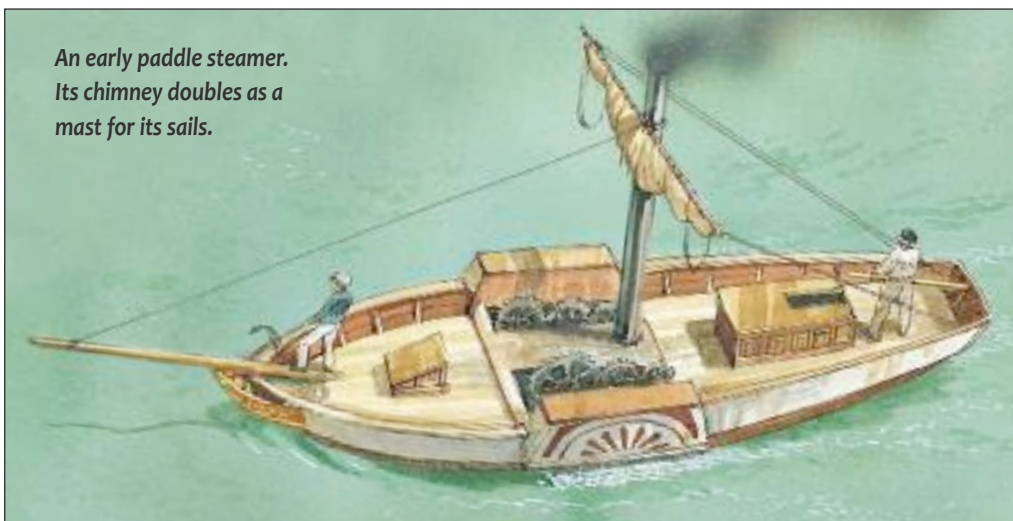
**ARROWS**  
These arrows show you where to look up other words mentioned in the entry. For example, (→ 26) tells you to go forward to page 26 and (← 6) tells you to turn back to page 6.

**KEY WORDS AND ENTRIES**  
Key words are arranged alphabetically across each double page. Each entry provides a short explanation of what the key word means.

**PAGE NUMBER**  
Page numbers are easy to find at the side of the page.

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The SS Great Eastern

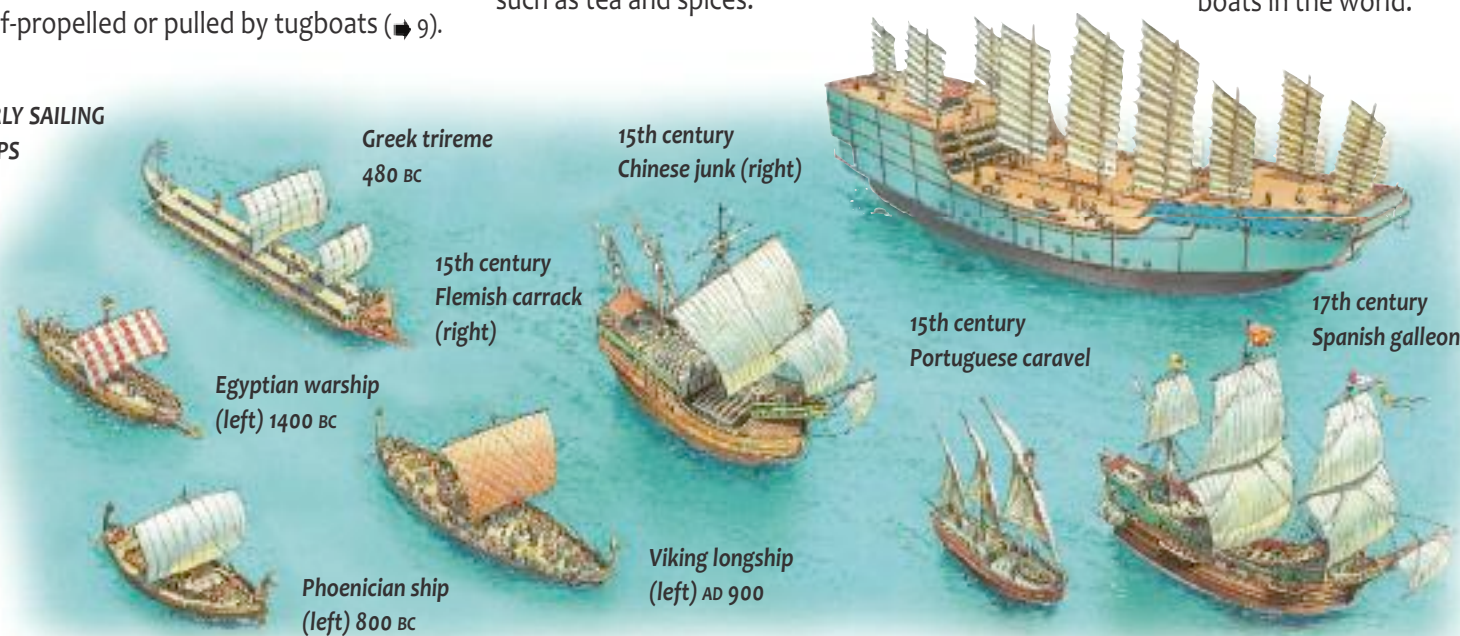
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## EARLY SAILING SHIPS



Greek trireme 480 BC

15th century Chinese junk (right)

15th century Flemish carrack (right)

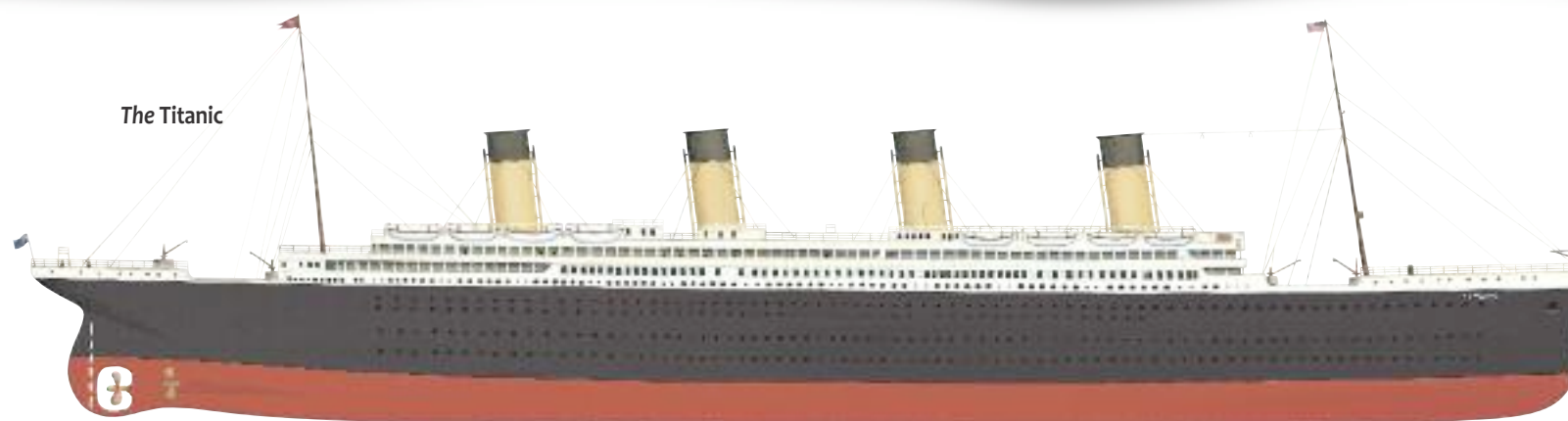
15th century Portuguese caravel

17th century Spanish galleon

Egyptian warship (left) 1400 BC

Phoenician ship (left) 800 BC

Viking longship (left) AD 900



The Titanic

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The France II, the biggest sailing ship ever. Its steel hull was 147 m long.

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A battleship in port

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- ★ 1839 The first steamship with a screw propeller (♣9) is built.

**Titanic** A steam-powered ocean liner that sank after hitting an iceberg on its maiden voyage in 1912. 1500 people lost their lives.

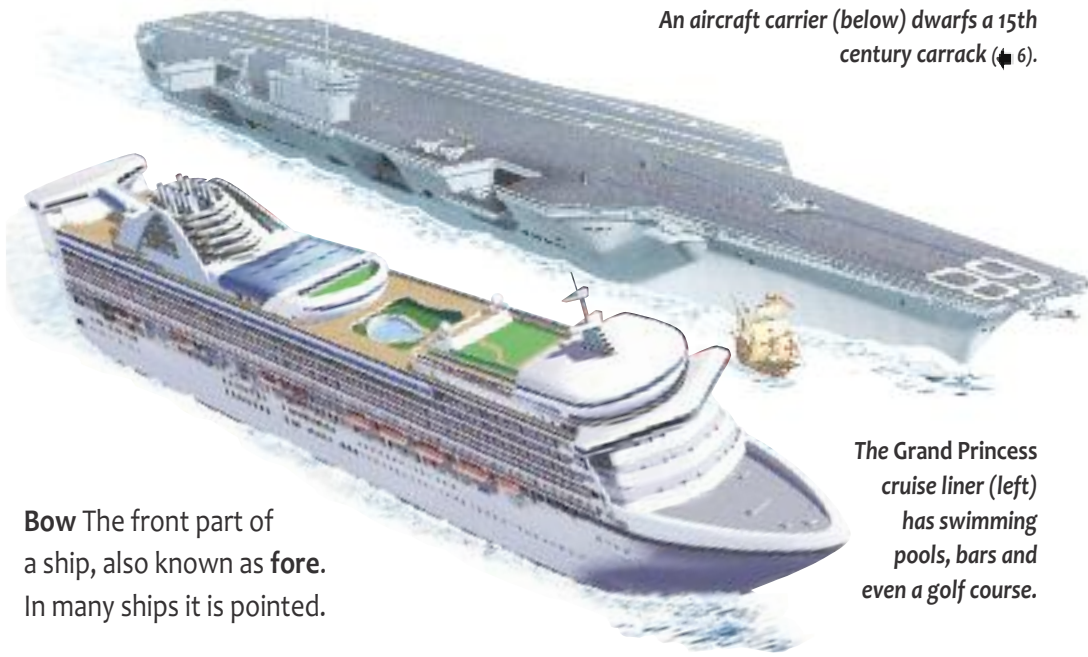
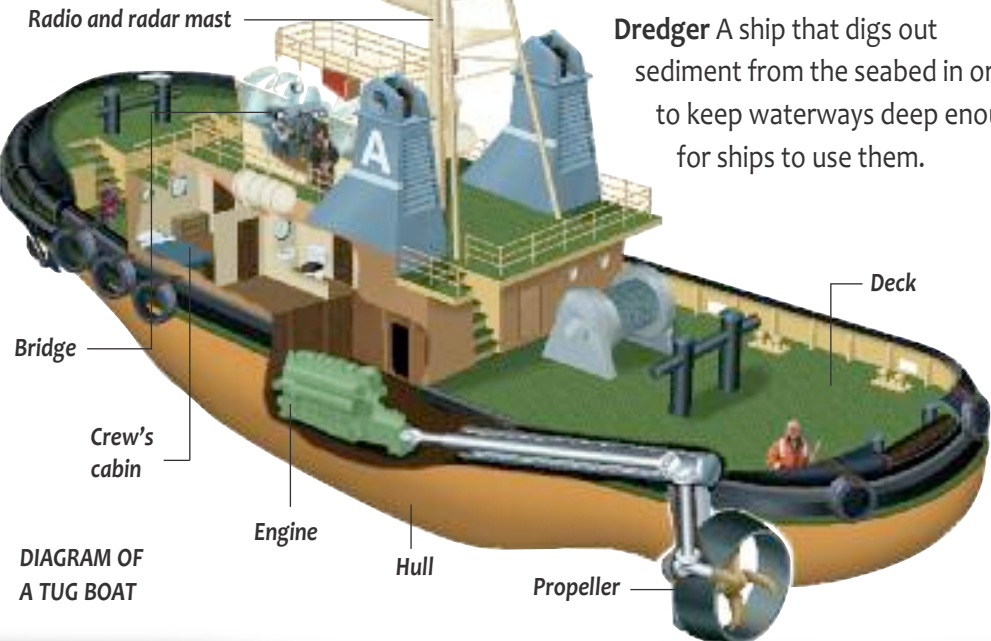
**Trireme** A warship used by the ancient Greeks, Romans and Phoenicians, powered both by sails and by three rows of oars.

# SHIPS & SUBMARINES

**S**hips are large vessels that carry passengers and cargo across the sea. Boats are smaller vessels designed for use on rivers and canals or in coastal waters. Submarines are vessels that can travel underwater. Many ships and boats are powered by a diesel engine (▶ 16), which drives a propeller. Different types of vessel are categorized by the jobs they do. They include: merchant ships, such as dredgers and cargo ships, military ships and fishing and leisure craft.

**Aircraft carrier** A large military ship with a main deck that serves as a runway from which aircraft take off and land. Aircraft are kept in hangars below deck.

**Ballast tank** A compartment low in a ship's hull that can be filled with water, or emptied. A ship may fill its ballast tank to make it sit lower in the water and so stabilize it. In a submarine, ballast tanks are filled with water to make it dive or emptied to make it surface.



The Grand Princess cruise liner (left) has swimming pools, bars and even a golf course.

**Bow** The front part of a ship, also known as **fore**. In many ships it is pointed.

**Bridge** A room high up on a ship, from where the crew steer and control the ship.

**Cargo ship** A large ship, also known as a **freighter**, that transports cargo.

**Catamaran** A boat with two hulls, connected by one or more decks. Some catamarans are fitted with sails and used for racing. Larger models have diesel engines and are used as high-speed ferries.

**Container ship** A ship that carries cargo in large metal boxes called containers. These are loaded and unloaded using cranes, or rolled on and off in port.

**Cruise ship** A large passenger ship designed for holiday cruising.

**Deck** The horizontal floor of a ship.

**Dredger** A ship that digs out sediment from the seabed in order to keep waterways deep enough for ships to use them.



**Hull** The part of a ship that sits in the water. Inside the hull are decks and vertical walls called **bulkheads**.

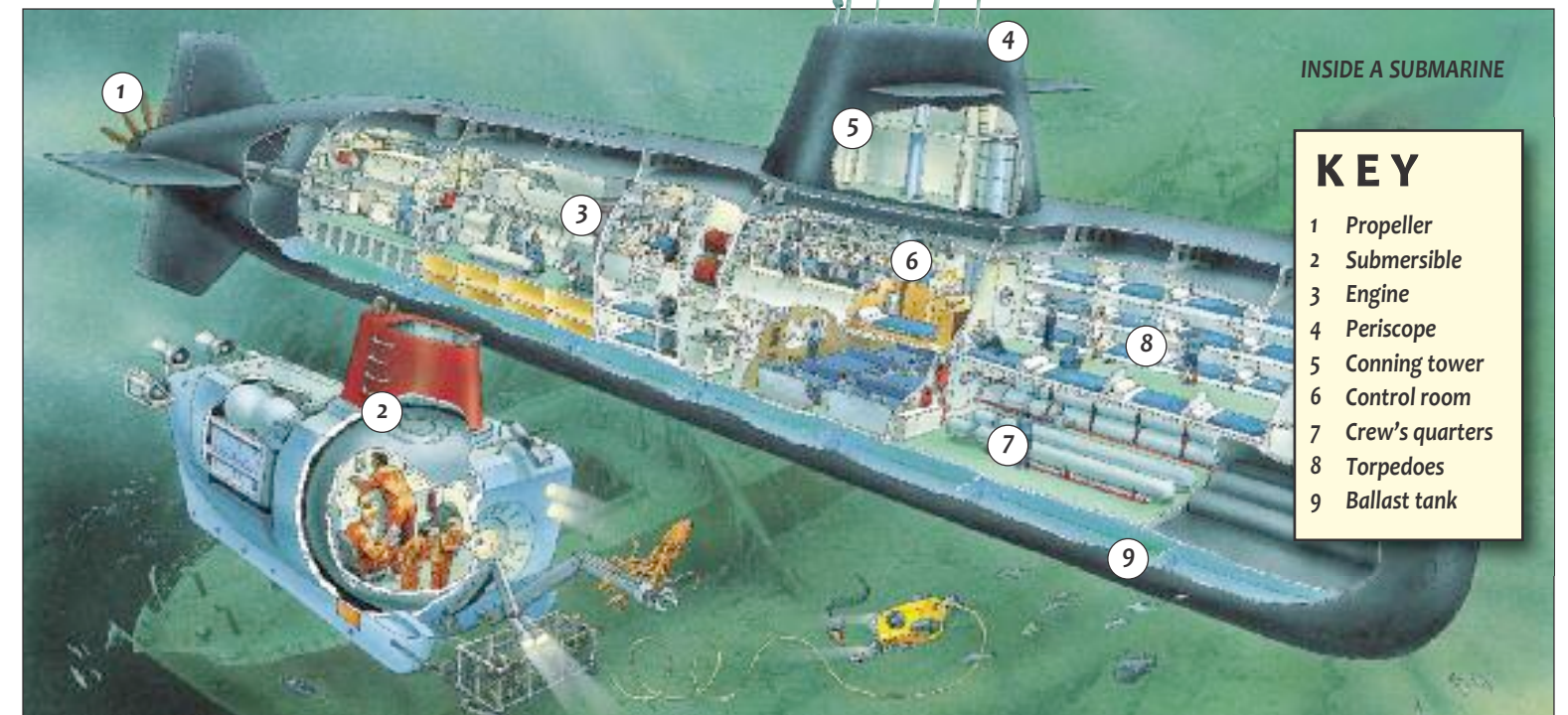
**Hydrofoil** A speedboat with wing-like structures that generate lift (▶ 20) as the boat moves forward. This raises the hull out of the water, reducing its drag.

**Hydroplane** A fast, streamlined boat. Two projections push the hull out of the water so that only the propeller is submerged. A hydroplane called the **Spirit of Australia** holds the water speed record of 511 km/h.

**Keel** A beam along the bottom of a ship's hull, running from bow to stern.

**Ferry** A vessel that takes cars and people across short stretches of water.

**Hovercraft** A vessel that moves above the water on a cushion of air. Fans blow air into a "skirt" beneath the ship, where it collects and inflates to lift the boat off the water.



**Lifeboat** A small craft kept on a larger vessel in case of emergencies, or a ship launched from land to rescue other ships.

**Ocean liner** A large vessel used for ocean crossings. Liners are built to withstand rough seas and provide luxury quarters.

**Periscope** A device that uses mirrors to see around corners. Periscopes are used on submarines so that the crew can see above the water without having to surface.

**Port** The left-hand side of a ship when facing the ship's bow (front).

**Powerboat** A fast boat with a sharp bow and powerful engine. The hull skims the water at high speeds.

**Rudder** A hinged, blade-like structure, mounted underwater at a ship's stern. When it turns, the force of water pushing against it changes the ship's direction.

**Sailing ship** A vessel powered by sheets of cloth, angled in order to catch the wind to carry the ship forward. The sails are fitted on one or more tall structures called **masts**.

**Screw propeller** A device formed of curved, rotating blades. As the blades spin, water is sucked in around them and pushed backwards. This drives a vessel forwards.

**Starboard** The right-hand side of a ship when facing the ship's bow (front).

**Stern** The rear of a ship, also known as **aft**.

**Submarine** A ship that travels underwater. Submarines use ballast tanks to dive or surface. Large, ocean-going submarines are nuclear-powered, but smaller submarines have electric motors, powered by batteries. On the surface, diesel engines take over.



**Submersible** A miniature submarine, used for research in the ocean depths or to carry out underwater repairs.

**Tanker** A large ship designed to transport liquids such as oil or chemicals. The largest tankers are up to 450 m long.

**Trawler** A boat that drags large fishing nets behind it.

**Tugboat** A small, powerful boat used to push or pull large ships and manoeuvre them in and out of ports.

**Yacht** A sailing boat used for pleasure or sport. Large yachts are often furnished with luxurious living quarters.

## FACTFILE

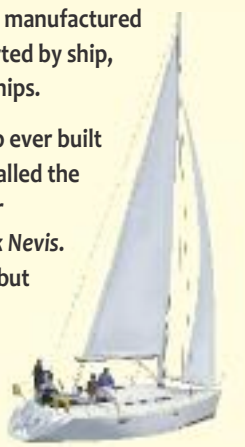
★ The first successful submarine, the **Turtle**, was developed in America in 1775 for use against British ships in the American War of Independence

★ Large container ships can carry up to 15,000 container boxes at once.

★ About 90% of all manufactured goods are transported by ship, mostly container ships.

★ The longest ship ever built was an oil tanker called the **Seawise Giant**, later renamed the **Knock Nevis**. It was 458 m long, but was scrapped in December 2009.

Racing yacht



# STEAM TRAINS

**A** train is a vehicle, consisting of a locomotive and carriages, that runs on guide rails called a railway. The first trains were invented almost 200 years ago and driven by steam-powered locomotives, which use the energy produced by pressurized steam. Before the invention of trains, the fastest people could move across land was on horseback. The development of the railways enabled people and heavy goods to be transported more quickly and easily.

**“Big Boy” locomotives** A class of steam locomotives built in the US in the 1940s. At 40 m long and 600,000 kg, they were the largest, heaviest and most powerful steam locomotives ever.



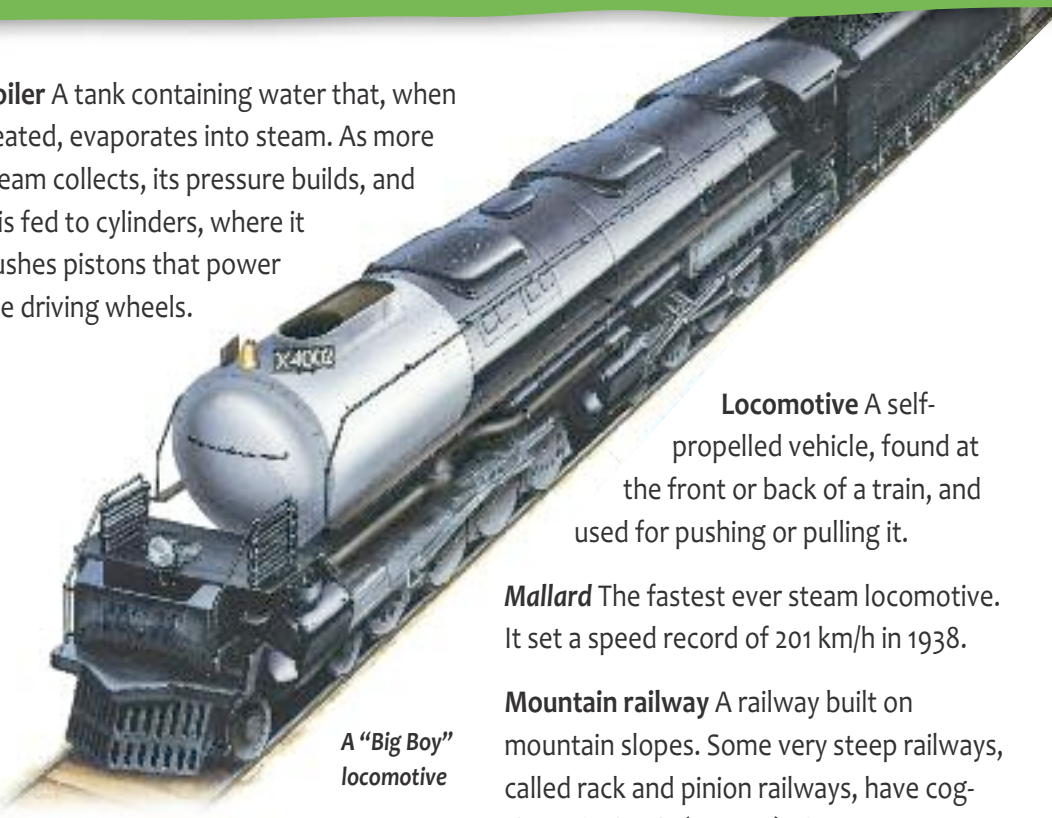
Trevithick's locomotive (above)  
Stephenson's Rocket (below)



A typical late-19th-century American locomotive (below), with a pilot at the front.



**Boiler** A tank containing water that, when heated, evaporates into steam. As more steam collects, its pressure builds, and it is fed to cylinders, where it pushes pistons that power the driving wheels.



A “Big Boy” locomotive

**Chimney** A tall, hollow column at the front of a steam locomotive. It sends smoke from the engine and steam from the cylinders into the air above the train.

**Driving wheels** The wheels that drive a locomotive along. The sliding motion of pistons in the engine moves the wheels around via a system of connecting rods.

**Firebox** An area where coal is burned to heat the boiler. A person known as a stoker or fireman, supplied the firebox with coal.

**Gauge** The distance between the two rails making up a railway track.

**Locomotive** A self-propelled vehicle, found at the front or back of a train, and used for pushing or pulling it.

**Mallard** The fastest ever steam locomotive. It set a speed record of 201 km/h in 1938.

**Mountain railway** A railway built on mountain slopes. Some very steep railways, called rack and pinion railways, have cog-shaped wheels (pinions), that grip on to a toothed rail (rack) between the tracks.



A locomotive filling up with water at a water tower.

**Narrow-gauge railway** A railway with a gauge of less than 1.5 m. Narrow-gauge railways can have tighter bends than standard-gauge railways, for example around mountain slopes, and can fit through narrow tunnels, such as in mines.

**Pilot** A device, also known as a “cowcatcher”, mounted on the front of a locomotive and used to clear objects from the track.

**Rocket** The steam locomotive built by George Stephenson. In 1829 it won a competition for the best steam locomotive. It travelled at speeds of 47 km/h. Its design was used for all later steam locomotives.

**Signal** A device beside a railway line that shows train drivers whether the track ahead is clear. Early signals used mechanical arms. Modern signals are mostly controlled by computers.

**Stephenson, George (1781–1848)** British engineer who built the first public railway line to use steam locomotives. The gauge he used is now the “standard gauge”, used in 60% of the world’s railways.



Firemen on a steam locomotive keep the firebox supplied with fuel.

**Stockton and Darlington Railway**

The first steam passenger railway, which opened in England in 1825. Its trains were powered by the Rocket steam locomotive.



The Darjeeling Himalayan Railway, a narrow-gauge railway still powered by steam locomotives today.

**Stoker** A machine used to supply an engine’s firebox with coal. Some could deliver as much as 22,000 kg an hour.

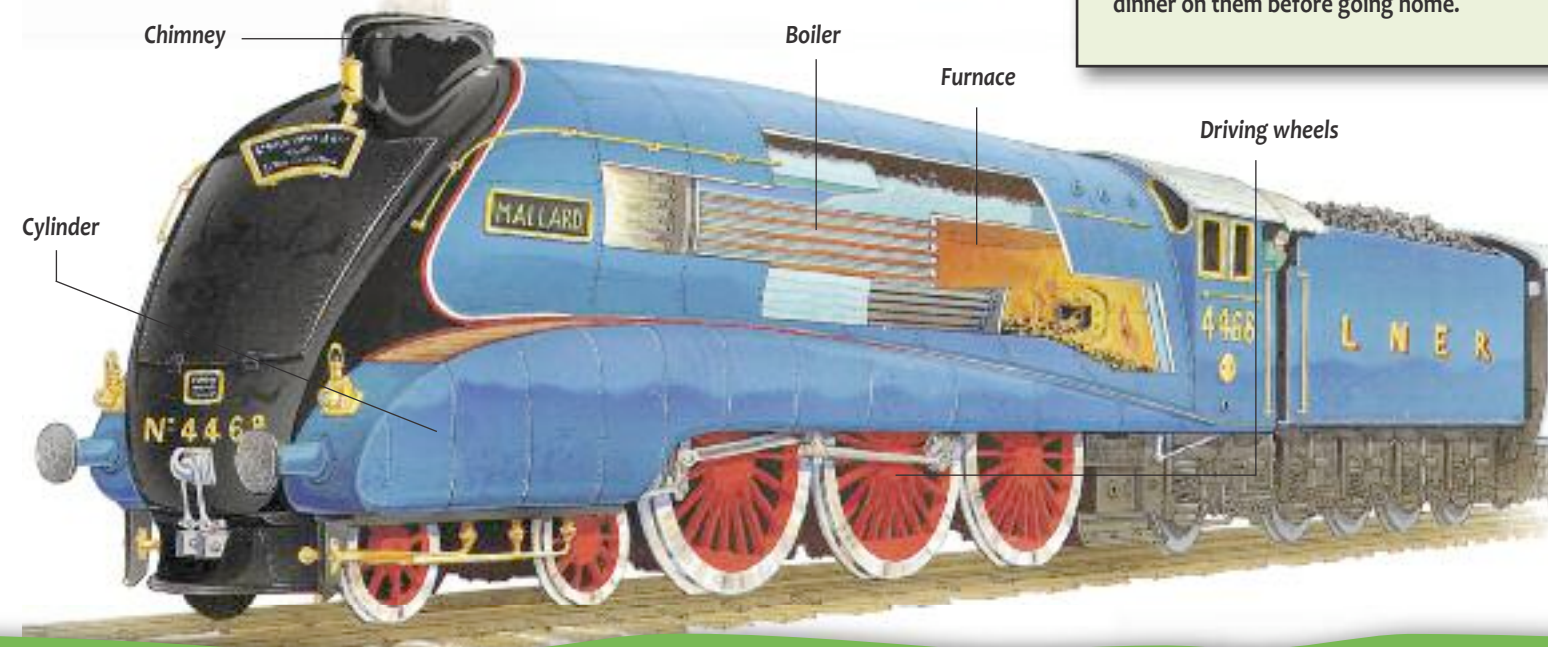
**Trevithick, Richard (1771-1833)** English engineer who built the first locomotive powered by a steam engine in 1804. Trevithick’s locomotive was used to haul trucks at an ironworks. It could pull up to 10,000 kg of iron.

**Water tower** A large container from which steam locomotives could refill their water, which was lost constantly as steam. Water towers were positioned beside tracks, at stopping places and depots.

## FACTFILE

- ★ The steepest mountain railway in the world is in Switzerland. At its steepest point it has a gradient of 48%.
- ★ It takes at least three hours for a steam locomotive to build up enough pressure to drive its wheels and so start moving.
- ★ The earliest passenger steam trains were converted horse-drawn carriages. Rich passengers sat in relative comfort inside the carriages. Poorer passengers sat outside on the top of the carriages and would be covered in smoke.
- ★ At the end of a hard day shovelling coal into a firebox, steam engine crews would often polish their shovels and cook their dinner on them before going home.

MALLARD



Cylinder

Chimney

Boiler

Furnace

Driving wheels

# MODERN TRAINS

There are two main types of modern locomotive: electric and diesel-electric. The fastest trains, such as the French TGV, are electrically powered. Many large cities now have networks of electric trains which run underground, linking up different areas of the city. Trains usually run on double rails on the ground, but some specialized trains, such as maglevs and monorails, have specially designed tracks.



A funicular railway

**Bogie** A structure fitted beneath a carriage, wagon or locomotive, to which two or three pairs of wheels are attached. It absorbs shocks and helps the train to turn corners.

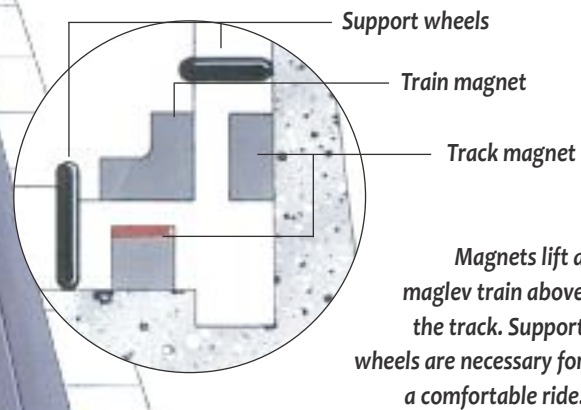
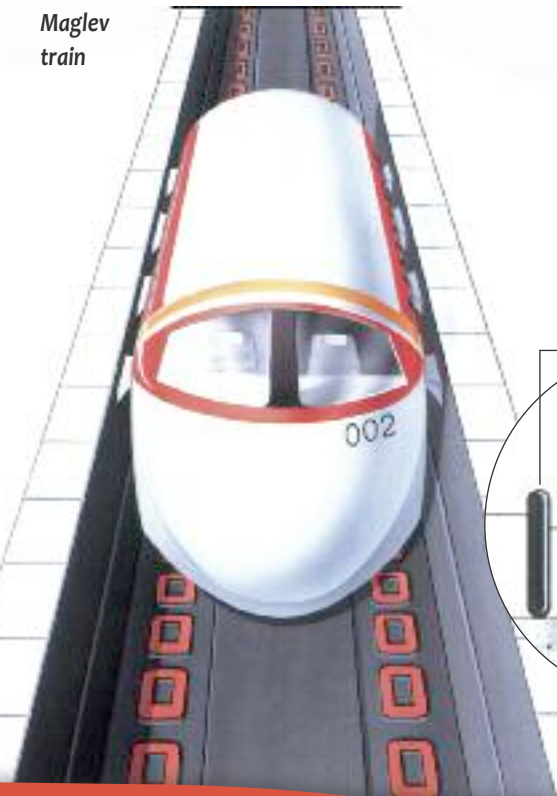
**Diesel-electric locomotive** A modern train in which the wheels are driven by electric motors, but the electricity is generated by a diesel engine. Because it provides its own power, it can run on any track.

**Electric locomotive** A modern train in which the wheels are moved by electric motors, usually one for each pair of wheels. Electricity is provided by overhead cables or an electrified third rail.

**Freight train** A line of goods wagons pulled by a locomotive on a railway line. Freight trains can carry large amounts of cargo long distances overland. This is cheaper than moving goods by road or air.

**Funicular railway** A railway that ascends a steep slope. Carriages are connected to a cable that runs up and down the slope. Ascending carriages are pulled up by the weight of the descending carriages, as the cable winds around a pulley at either end of the line.

Maglev train



**Intercity-Express (ICE)** The high-speed, electric-powered train service that runs through Germany and its neighbouring countries. Streamlined ICE trains travel at speeds of up to 300 km/h, stopping only at major cities.

**Maglev train** A type of train that moves by magnetic levitation. Powerful magnets fixed to the track push away from those fixed to the train in such a way that the train continually moves forwards while being suspended above the track. Because there is little friction, maglevs can reach very high speeds.



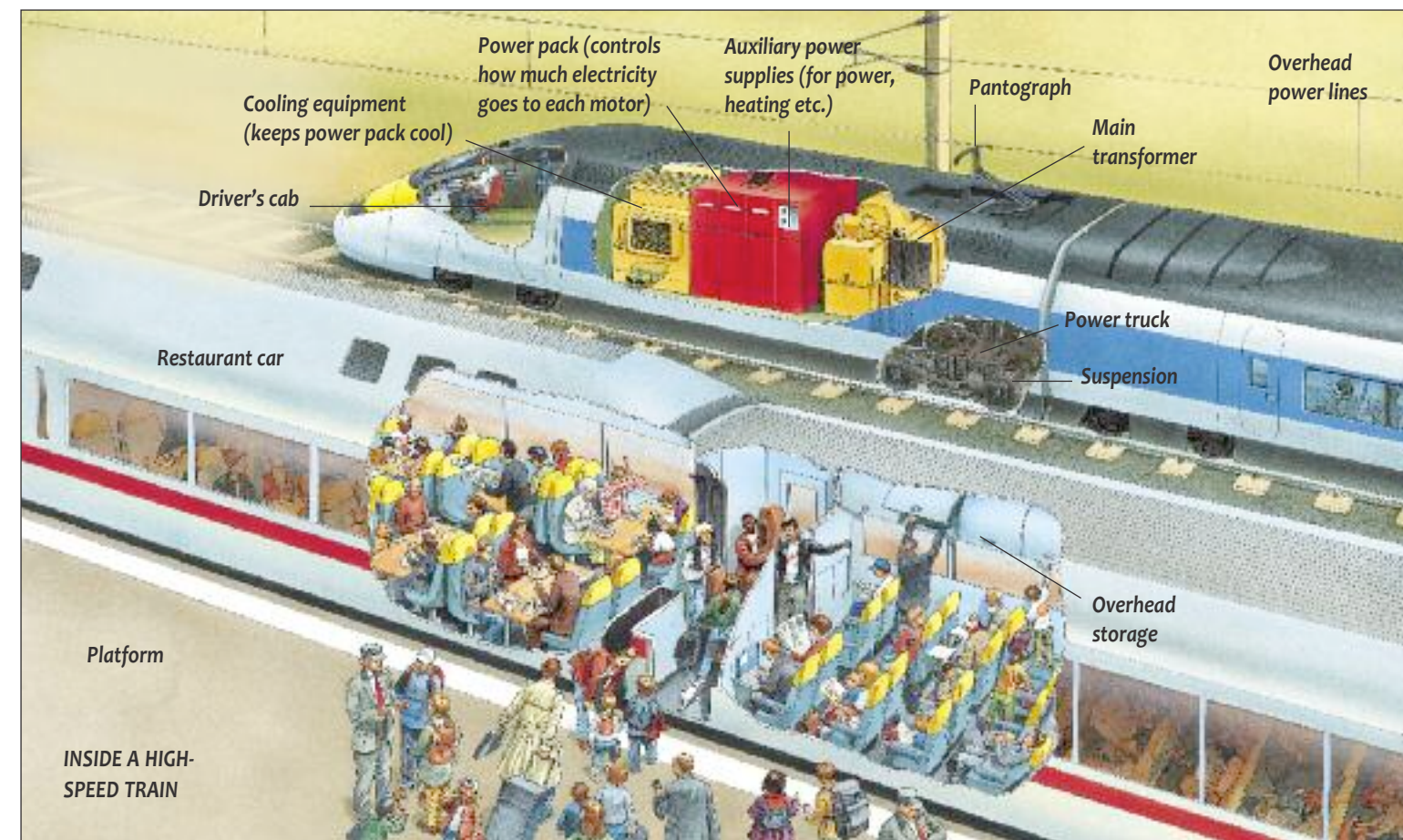
The Wuppertal Schwebebahn, the world's first electric-powered suspended monorail.

**Monorail** A kind of train that runs on a single rail, either above the track as in a normal train, or suspended beneath the rail, from a bridge or other structure. Almost all monorails are powered by an electric rail.

**Orient Express** A long-distance passenger rail service, originally travelling from Paris to Istanbul. It started service in 1883, offering passengers first class luxury. It still travels part of the route today.



The Trans-Siberian Express



**Pantograph** A device on a locomotive that collects electricity from overhead cables in order to power its motor. Electronic circuits control the flow of electricity to the motors.

Rapid transit train



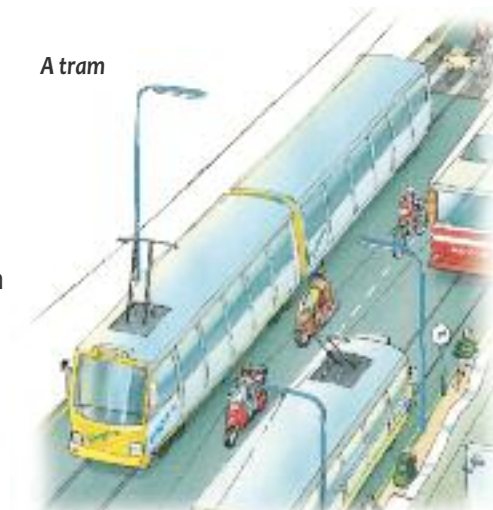
**Passenger train** A line of railway carriages, or cars, designed to carry passengers. Passenger trains have seats, luggage storage areas, lavatories and cafés.

**Rapid transit** A passenger train, also known as an underground or subway, that links up areas of a city. Trains often travel beneath the streets in the city centre but above ground in the suburbs. All underground trains are powered by electricity.

**Shinkansen** A Japanese high-speed train, also known as the "bullet" train, that travels at speeds of up to 300 km/h. Carriages are pressurized in such a way that passengers feel no difference when the train enters tunnels at high speed.

**Shunter** A small locomotive used to push other trains around, for example to move them from one track to another.

**Train à Grande Vitesse (TGV)** France's high-speed, electric-powered locomotive. It holds the record speed for the fastest wheeled train of 575 km/h.



A tram

**Tram** An electric rail vehicle that runs on tracks on city streets.

**Trans-Siberian Express** The longest train service in the world, travelling 9297 km from Moscow to Vladivostok. The journey takes nearly eight days.

## FACTFILE

★ There are more than 1,187,000 km of railway line across the world. If they were placed end-to-end, they would circle Earth more than 30 times.

★ The heaviest train ever was a freight train built in Australia in 2001. It was 7.3 km long and weighed 95,000,000 kg.

★ The longest straight stretch of railway in the world is in the Nullarob plain in southern Australia. It is 478 km long.

★ The largest railway station in the world is Grand Central Terminal in New York, which has 44 platforms. Over 5 million people pass through Grand Central Terminal station every day.



# STORY OF CARS

People used carts pulled by horses or other animals for more than 5000 years before the first self-propelled vehicles, steam-powered carriages, were built. The age of the car really started with the development of the internal combustion engine (▶16) in the late 19th century. Early cars were difficult to operate and were individually hand-built, which made them very expensive. The introduction of cheap, mass-produced cars in the early 20th century quickly made motoring a popular activity.



Cugnot's steam carriage

**Anderson, Mary (1856-1953)** American inventor who invented the windscreen wiper in 1903.

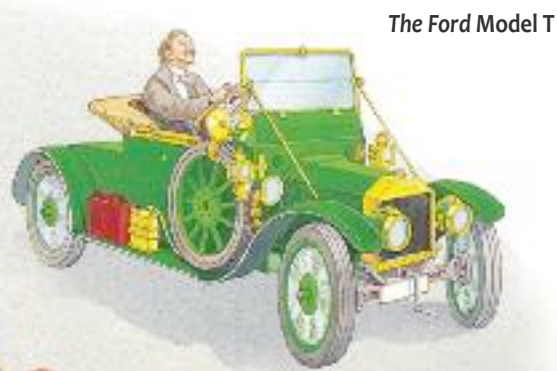
**Automatic gearbox** A gearbox (▶16) that changes gears automatically, according to the speed of the car. The first mass-produced passenger car to have one was the Oldsmobile Hydromatic, built in 1938.

**Benz, Karl (1844-1929)** German engineer who built the first petrol-driven car in 1885. Benz and Gottlieb Daimler began manufacturing and selling cars in the 1890s.

**Boneshaker** The first popular bicycle, built by Frenchman Pierre Michaux in 1861. In 1870, Englishman James Starley designed a version of it called the **Penny Farthing**, named after its enormous front wheel.



The Motorwagen



The Ford Model T



The Mercedes 35hp



The Volkswagen "Beetle"

## Cugnot's steam carriage

The first self-propelled vehicle, a steam car built by Nicolas Cugnot in 1769. It used the energy in pressurized steam to push sliding pistons in an engine. These moved its wheels round via connecting rods.

**Daimler, Gottlieb (1834-1900)** German engineer who built the first motorcycle and, together with Wilhelm Maybach, developed the first petrol-driven engine.

**Daimler Reitwagen** The first motorcycle, a petrol engine attached to a wooden-framed bicycle. It was built by Gottlieb Daimler and Wilhelm Maybach in 1885.

**Deisel, Rudolf (1858-1913)** German inventor who developed the **diesel engine**, an internal combustion engine (▶16) that uses pressure to heat and ignite fuel.

**Electric car** A car fitted with batteries that power an electric motor. It is "refuelled" by recharging its batteries. The first electric car was built in 1881.

**Ford Model T** The first inexpensive, mass-produced car. Large numbers were assembled on a production line by a team of workers, each adding a different part. It was produced from 1908 to 1927.

**Formula One** A motor racing competition that started in 1947, following on from the Grand Prix. The cars used are the most technologically advanced in the world.

**Grand Prix** An international motor racing competition that began on the streets of France in 1901. The Grand Prix encouraged technological advances in cars.



An early bicycle with no pedals



Penny Farthing (right)



Modern racing bicycle (left)



Daimler Reitwagen motorcycle



1930s fire service motorcycle (left)



Modern motorcycle

**Kettering, Charles (1876-1958)** American inventor who developed electric ignition for petrol engines, suspension (▶17) and four-wheeled brakes.

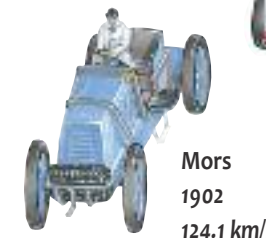
**Hybrid car** A car powered by both an internal combustion engine and an electric motor. The first hybrid was built in 1900.

**Macmillan, Kirkpatrick (1812-1878)** Scottish blacksmith who invented the first pedal-powered bicycle in 1839.

**Mercedes 35 hp** The first "modern car", built in 1901 by the Daimler company. It was the first car to include a powerful petrol engine, tyres, gears and a steering wheel.

## PAST LAND SPEED RECORD HOLDERS

**La Jamais Contente**  
1899  
105.9 km/h



**Mors**  
1902  
124.1 km/h



**Blitzen Benz**  
1909  
202.7 km/h



**Blue flame**  
1970  
1014.5 km/h

**Motorwagen** The first car designed to be powered by a motor (unlike earlier cars, which were modified bicycles or carriages). The three-wheeled vehicle was built by Karl Benz in 1885.

**Otto, Nikolaus (1832-1891)** German inventor who built the first four-stroke engine (▶17) in 1876.

**Panhard et Levassor** The world's first car manufacturer. The French company was formed by René Panhard and Emile Levassor in 1890. They built the first car with its engine at its front and the first car with a steering wheel instead of a stick.

**Puffing Devil** The first steam powered road vehicle, built by English engineer Richard Trevithick (▶11) in 1801.

**Pyréolophore** The first internal combustion engine (▶17), built in 1807 by French brothers Claude and Nicéphore Niépce.

**Spirit of America** The first jet-propelled car, built in 1962. It had a long, streamlined body and three wheels.

**Starley, John (1854-1901)** English inventor who designed the first modern bicycle. The bicycle, built in 1885, had a diamond-shaped frame and a chain-driven back wheel powered by pedals.

**Steam car** A car powered by the force of pressurized steam. Steam cars were popular in the 1800s before the invention of the internal combustion engine. Few were built after the 1920s.

## A BRIEF HISTORY

- ★ 1769 The first self-propelled vehicle, the Cugnot steam carriage, is built.
- ★ 1817 The first bicycle is constructed.
- ★ 1839 The first pedal bicycle is built.
- ★ 1881 The first electric powered car is built.
- ★ 1885 The first petrol-driven car is built.
- ★ 1895 The first car with hollow rubber tyres is built.
- ★ 1908 The first affordable car, the Ford Model T, is built.
- ★ 1965 The first jet-propelled car, the Spirit of America, is built.

- ★ 1997 The Thrust SSC becomes the first car to break the sound barrier.



Thrust SSC

**Thrust SSC** A vehicle powered by two jet engines. In 1997, it travelled at 1227.7 km/h, becoming the first land vehicle to travel faster than the speed of sound.



A modern electric vehicle

**Trouvé, Gustave (1839-1902)** French electrical engineer who built the first electric powered car in 1881.

**Volkswagen "Beetle"** An affordable car produced in Germany between 1938 and 2003. Its name means "people's car". It was the best- and longest-selling car ever.

# PARTS OF A CAR

All modern cars have similar features. Wheels and suspension allow the car to roll smoothly. Power from the engine is transferred to the wheels by the gears. The fuel and exhaust systems supply fuel to the engine and carry away waste gases. The electrical system supplies electricity to the engine's spark plugs, lights and other electrical equipment. All the car's parts are supported by a rigid body shell, which also protects the driver and passengers.

**Accelerator** The pedal at a driver's feet that adjusts a car's speed by controlling the amount of fuel that enters the engine.

**Alternator** A device powered by a car's engine, that produces electrical power for the car.

**Battery** The power source that enables a car to start. It contains plates of lead immersed in acid and produces the strong current needed to turn the starter motor.

**Camshaft** A rotating device in a car's engine that opens and closes its valves, letting air and fuel in and exhaust gases out.

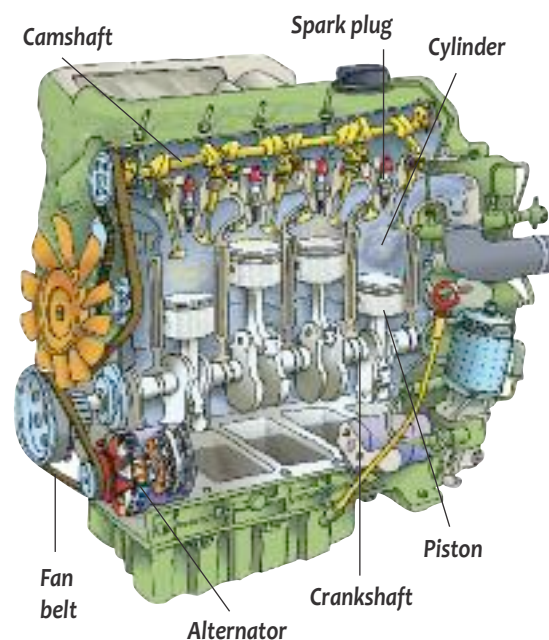
**Crankshaft** A device that turns the up-and-down movement of pistons into rotating motion. Via the gears, this motion turns the wheels of the car.

**Cylinder** The engine part inside which the pistons move up and down. The more cylinders there are inside a car's engine, the more power the car has.

**Dashboard** A panel in front of the driver's seat with dials that show fuel levels and speed as well as controls for headlights, heating and windscreen wipers.

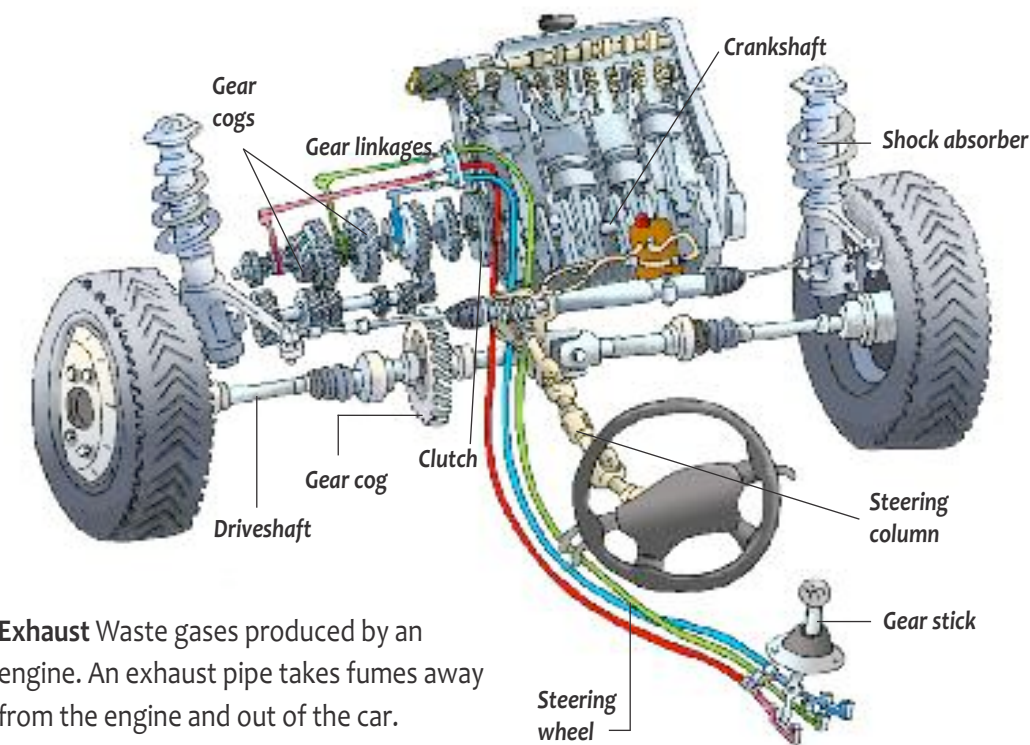
**Diesel engine** A type of internal combustion engine that uses heat caused by compression to ignite its fuel (diesel oil). It does not need a spark to ignite the fuel.

**Disc brakes** A combination of pads and discs on the inside of a car's wheels. When the driver pushes the brake pedal, the pads grip the discs, slowing the wheels down. The force of the driver's foot increases pressure on fluid inside the brake cylinders which, in turn, forces pistons to push the brake pads against the disc.



A piston engine with four cylinders

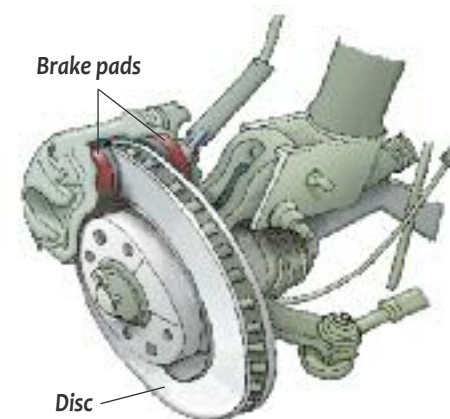
**Drum brakes** A system in which pads, called "shoes", are pushed against a drum in a car's wheel to slow it down. Drum brakes are used on the rear wheels of older cars and on all hand brakes.



**Exhaust** Waste gases produced by an engine. An exhaust pipe takes fumes away from the engine and out of the car.

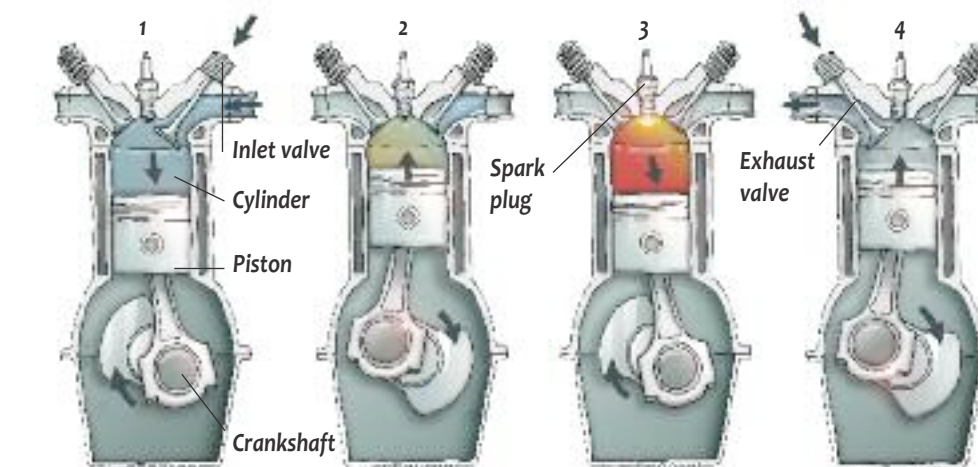
**Gears** A set of cogs that link the engine to the wheels. In a low gear, the wheels turn much slower than the crankshaft, producing more power at slow speeds. To change gear, the driver first pushes the **clutch**, which disconnects the gears from the engine, before moving the gear stick.

**Hand brake** A lever that operates the rear brakes, used when a car is stationary.



**Internal combustion engine** An engine that converts energy from fuel into movement. Fuel and air are ignited inside cylinders, causing repeated explosions that drive pistons. The pistons turn the crankshaft, which powers the wheels. Most engines work on a **four-stroke cycle** (see diagram).

**Pedals** A set of pedals at a driver's feet, pressed in order to change gear (clutch), brake (brake), or accelerate (accelerator).



**Petrol engine** A type of internal combustion engine that uses electricity to create a spark and ignite petrol fuel.

**Piston** A can-shaped part that moves up and down inside an engine's cylinders.

**Radiator** A device that keeps a car's engine cool. Water is pumped around channels where it is heated by the engine. The hot water then carries heat from the engine to the radiator, where it is lost to the air.

**Spark plug** An electrical device that ignites the fuel inside the cylinders of an engine.

**Steering wheel** A wheel used to steer a car. It is connected to the wheels by a column attached to a rack and pinion. The pinion (a cog) connects with the rack (a toothed bar) shifting it left or right.

## FACTFILE

★ Engine power is often measured in units called "horsepower", originally used to compare the pulling power of a steam engine to that of a cart horse. A typical modern car has a horsepower of 125 to 200.

★ There are approximately 100 m of electrical wiring inside most cars.

★ There are more than 600 million passenger cars in the world, a figure that increases every day.

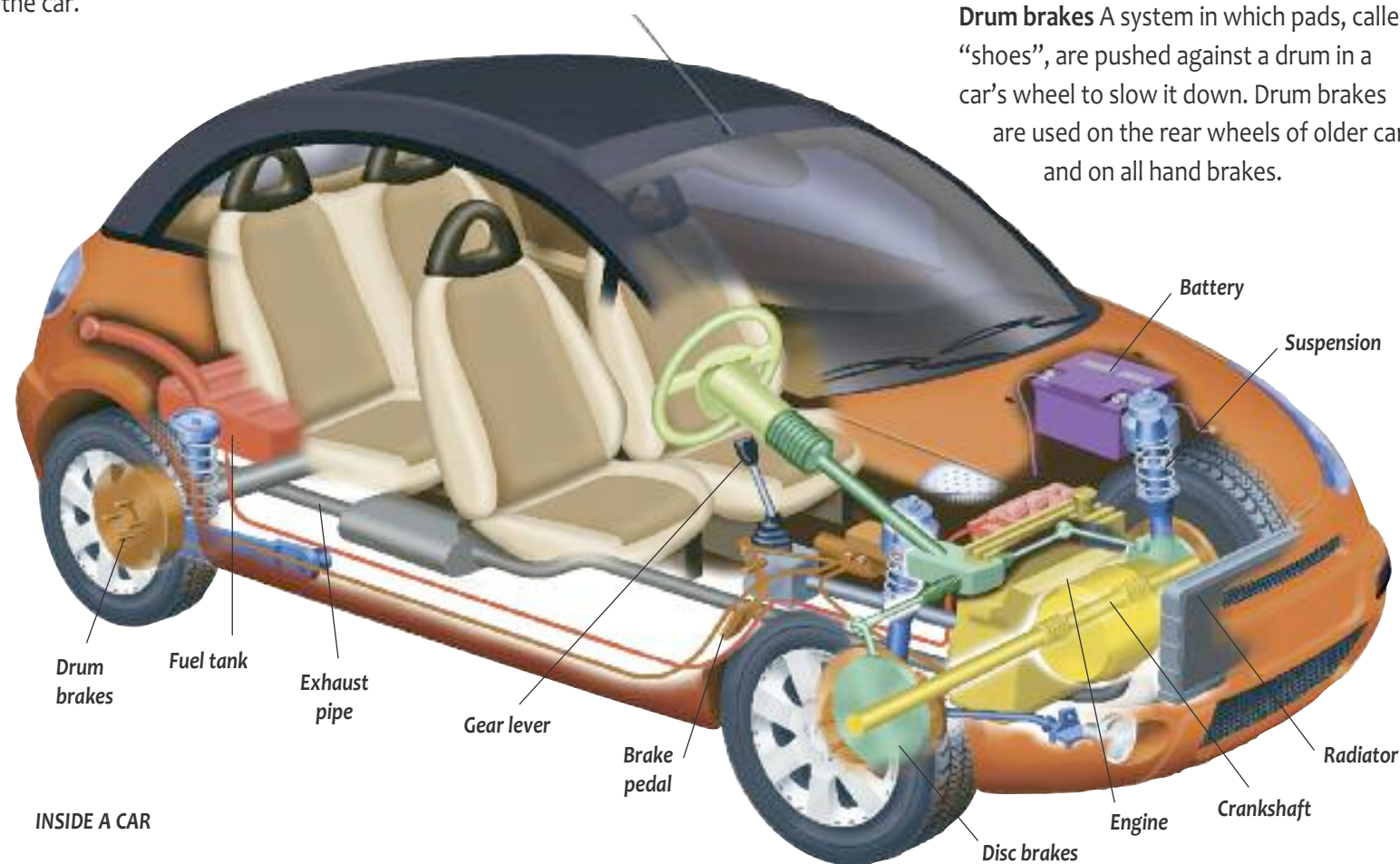
★ In 1916, 55% of the cars in the world were Ford's Model Ts (▲ 15).

★ A number of features that are now standard in road cars, were originally developed to improve the performance of racing cars. These include: navigation computers, anti-lock brakes to prevent skidding, and air bags to protect the driver and passengers in an accident.

**Suspension** A system of springs and shock absorbers attached to the wheels to ensure a car rolls smoothly. Springs take the force of jolts, while shock absorbers dampen the movement of the springs.

**Tyre** A covering around a wheel made of cords and wires encased in rubber, and filled with compressed air.

**FOUR-STROKE CYCLE:** 1 The inlet valve opens to allow fuel and air into the cylinder. 2 The air and fuel is squeezed into the top of the cylinder. 3 A spark ignites the pressurized fuel-air mix, forcing the piston down. 4 The exhaust opens to let out waste gases.



INSIDE A CAR

# STORY OF FLIGHT

The first manned flight took place in 1783 in a hot-air balloon. It took another 120 years before the Wright brothers made the first controlled, powered flight in an aeroplane. After this, aviation technology made rapid advances. In the 1920s, the first passenger airlines were formed, enabling people to travel quickly all over the world. Since the end of World War II, and the invention of jet aircraft, millions of people travel long distances each year by jet airliner.

**Airship** A streamlined balloon filled with lighter-than-air gases such as helium, powered by engines and steered by a rudder. Airships were used for passenger flights until the 1940s.

**Autogyro** An aircraft designed by Spanish engineer Juan de la Cierva in 1923. Rotor blades above the cockpit turned by themselves in the airflow caused by forward motion and lifted the machine.

**Bell X-1** The first aircraft to fly faster than the speed of sound: 1299 km/h. The rocket-powered Bell X-1 made this record in 1947.

**Biplane** An aircraft with two pairs of wings, widely used before the 1940s.

**Blériot XI** The plane in which Frenchman Louis Blériot (1872–1936) crossed the English channel in 1909, the first journey over the sea in a heavier-than-air machine.



The Montgolfier balloon

**Concorde** The first and only type of airliner ever to travel faster than sound. It was first introduced in 1969, making transatlantic crossings in half the time of other airliners. It went out of service in 2003 after a crash in 2000.

**De Havilland Comet** The first commercial jet airliner. It made its first flight in 1949.

**Farman Goliath** A converted First World War bomber that was one of the first commercial passenger airliners.

**Focke DR.I** A German fighter plane, built in 1917. It was the first plane to carry a device that allowed its gun to fire forward without hitting the plane's propeller.

**Glider** An unpowered aeroplane. The early development of gliders proved that people could fly and steer heavier-than-air machines. Today, gliders are mainly used for sports.



Otto Lilienthal in a glider.

**Heinkel He-178** The first turbojet (✈️) powered aircraft. It first flew in 1939.

**Hot-air balloon** A balloon filled with air heated by burners. It rises because the heated air is less dense than the surrounding air. Releasing hot air from the balloon makes it descend. Passengers travel in a gondola beneath the balloon. Hot-air balloons cannot be steered.



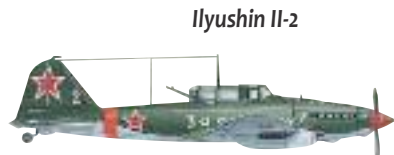
Blériot XI



Martin B-10 bomber



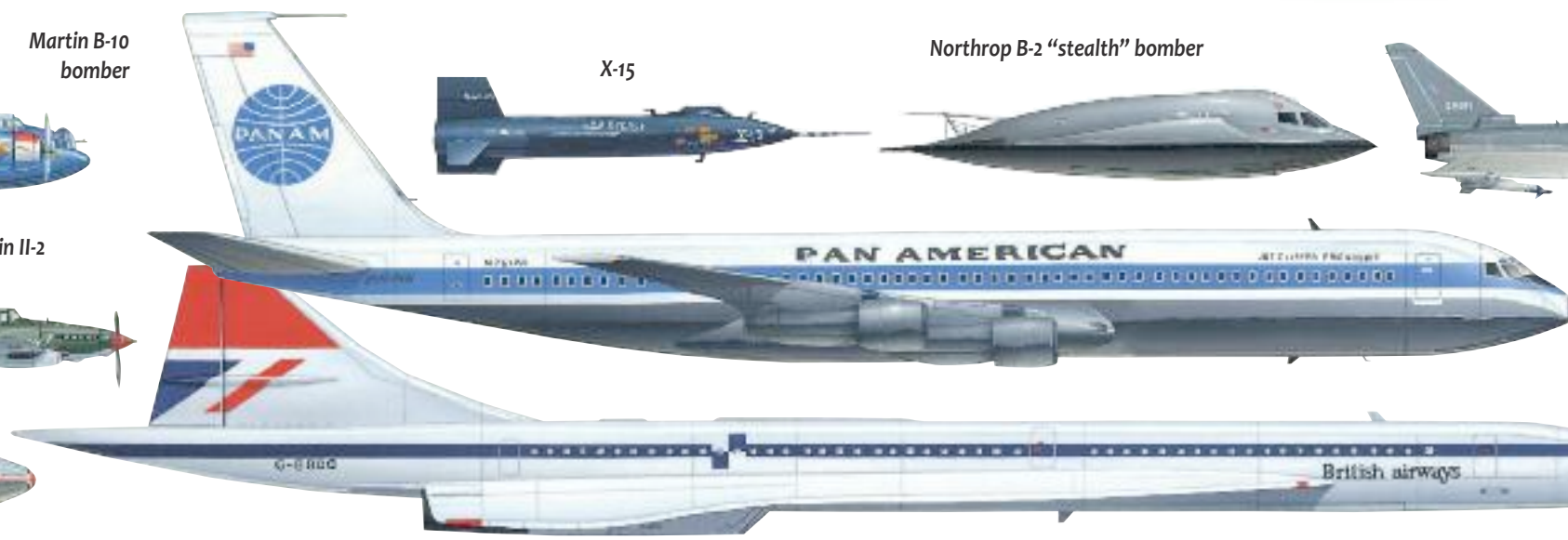
Farman Goliath



Ilyushin Il-2



Douglas DC-3 Dakota



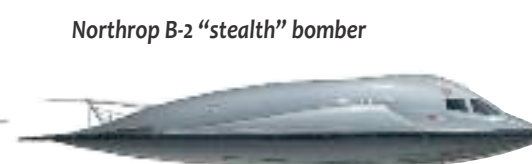
Boeing 707 (left)



BAC/Aérospatiale Concorde (left)



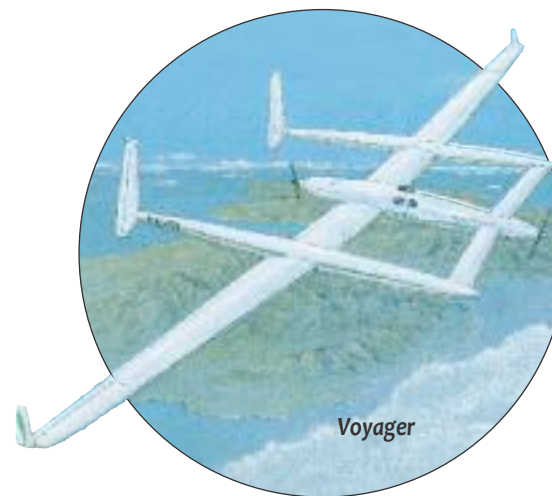
X-1



Northrop B-2 "stealth" bomber



Eurofighter Typhoon



Voyager

**Lilienthal, Otto (1848-1896)** German engineer who made multiple glider flights.

**Martin B-10** The first bomber made entirely from metal and with a fully enclosed cockpit. It was first built in 1932.

**Monoplane** An aeroplane with one pair of wings. Monoplanes have been the most common aircraft design since the 1930s.

**Montgolfier brothers** French brothers Joseph-Michel (1740-1810) and Jacques-Étienne Montgolfier (1745-1799). In 1783, their hot air balloon became the first aircraft to complete a manned flight.



Airship

**Sikorsky, Igor (1889-1972)** Russian-born American engineer who developed the first successful helicopter. He also designed the first aircraft to be powered by four engines, the **Sikorsky Le Grand**.

**Spirit of St Louis** An all-metal plane, specially designed by **Charles Lindbergh (1902-1974)** for the first non-stop, solo flight across the Atlantic. The journey took 33 hours and won Lindbergh \$25,000.

**Voyager** The first aircraft to fly around the world without refuelling. It had extremely long wings and took nine days to complete the journey in 1986.

**Triplane** An aeroplane with three pairs of wings, popular until the early 1920s.



Bell X-1

**Wright brothers** American brothers Orville (1871-1948) and Wilbur Wright (1867-1912), who made the first successful plane.

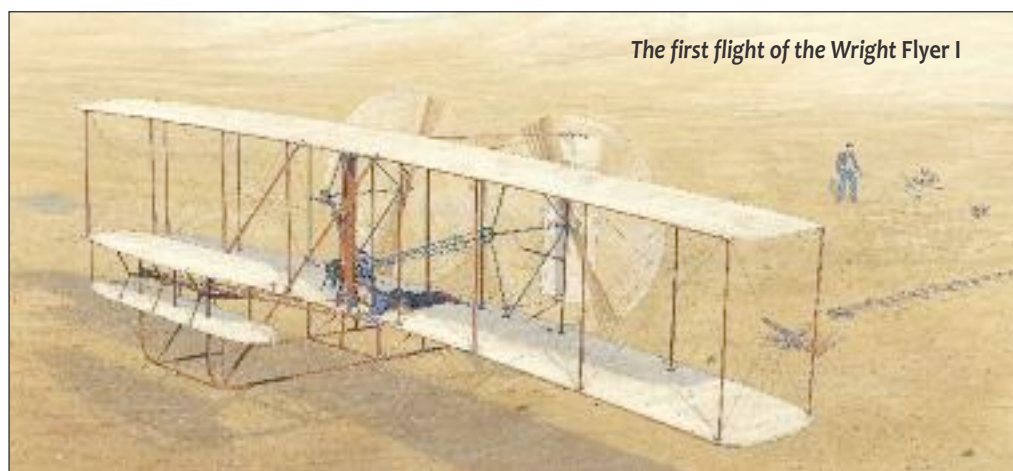
**Wright Flyer 1** An aeroplane with a petrol engine, built in 1903 by the Wright brothers. It was the first heavier-than-air machine to make a powered, controlled flight. The pilot lay on his front to steer the aircraft.

## A BRIEF HISTORY

- ★ 1783 The first manned flight takes place in the Montgolfier balloon.
- ★ 1852 The first airship is flown.
- ★ 1903 The first controlled, petrol-engine powered flight by the Wright brothers.
- ★ 1907 The first helicopter flight. It rises just 30 cm above the ground.
- ★ 1909 Louis Blériot makes the first flight across a large stretch of water.
- ★ 1923 The first autogyro is flown.
- ★ 1927 Charles Lindbergh makes the first solo non-stop flight across the Atlantic.
- ★ 1947 The Bell X-1 flies faster than the speed of sound.
- ★ 1952 The first jet engine passenger airliner starts service.
- ★ 1967 The X-15 sets the current world speed record.
- ★ 1970 The first wide-body airliner starts commercial passenger services.

**Stealth aircraft** A modern military aircraft that avoids attack by making itself nearly invisible to radar systems, which are used to detect aircraft and ships.

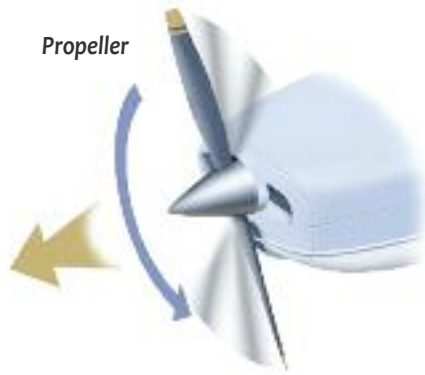
**X-15** A rocket-powered aircraft, built for research into high-speed flight. In 1967, it set the current world air speed record of 7273 km/h.



The first flight of the Wright Flyer I

# AIRCRAFT

All flying machines are types of aircraft. Aeroplanes and helicopters are heavier-than-air machines. They need wings or rotors to support them in the air by creating an upward force called lift. Engines provide a forward force called thrust. Aeroplanes vary in size from small single-seaters to huge airliners. They all have a long tube called a fuselage with a set of wings attached. Control surfaces on the wings and tail can be moved to change the plane's direction. A tailfin and tailplane at the rear of the craft keep it flying level. A set of wheels are used for takeoff and landing.



**Propeller** A mechanism formed of rotating, aerofoil blades. As a blade spins, air moves faster over the front of it than behind it. This sucks air around the propeller, pulling the blade and the plane forward.

**Ailerons** Control surfaces on the wings of an aeroplane. They can be raised or lowered in order to make the plane roll.

**Airbus A380** The largest passenger airliner, which can seat more than 500 passengers and can also fly long distances without the need to refuel.

**Airliner** A passenger-carrying aircraft.

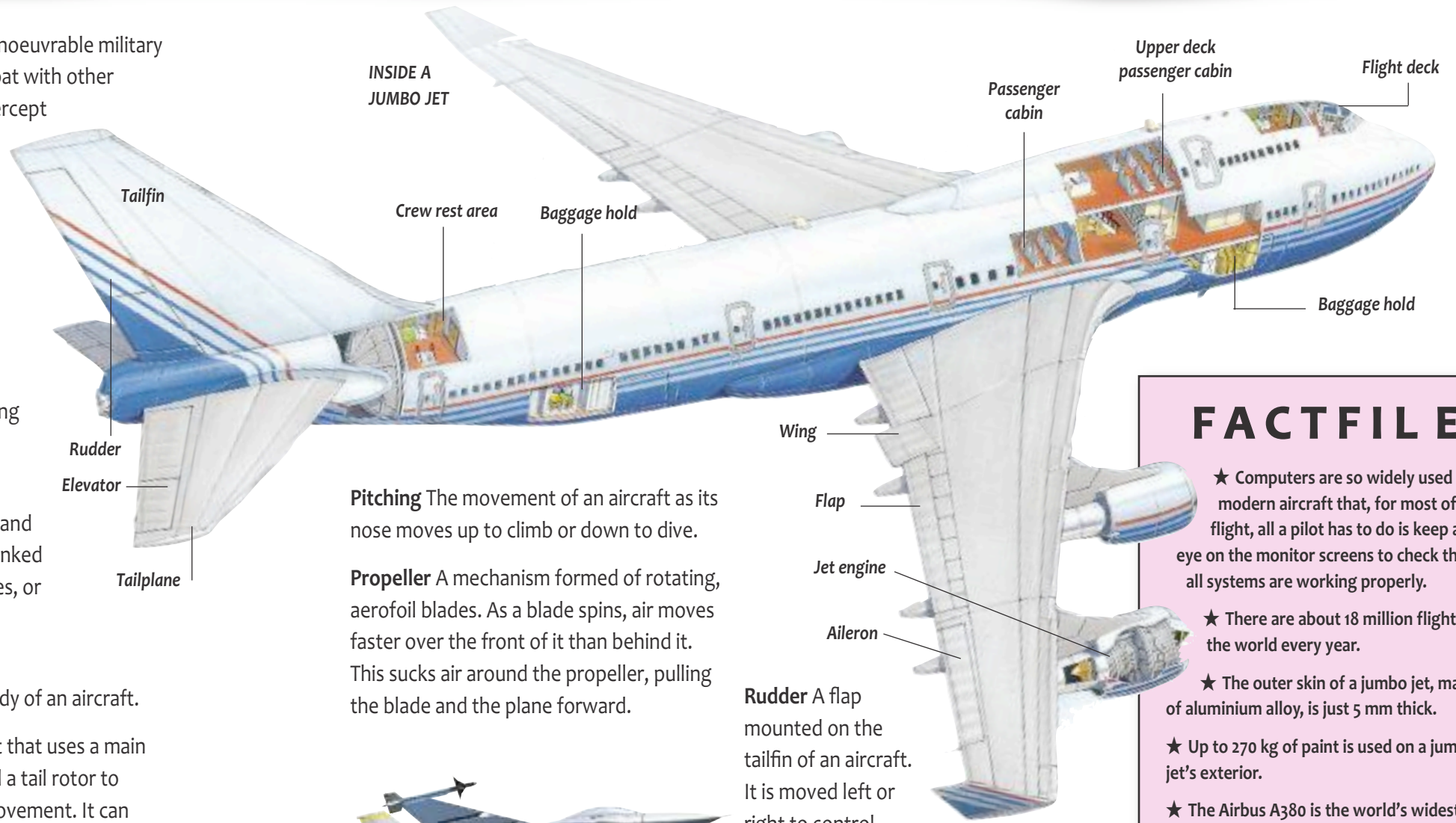
**Autopilot** An automatic flight control system that constantly adjusts a plane's controls to maintain the course, speed and altitude set by the pilot.

**Fighter jet** A fast, manoeuvrable military aircraft, used in combat with other fighters jets or to intercept enemy bombers.

**Flaps** Hinged surfaces fitted to the edge of an aircraft's wings. Flaps are used to extend the wing in order to exaggerate its curved profile and provide extra lift during take-off and landing.

**Fly-by-wire** A system where flight controls and control surfaces are linked by electronic data lines, or "buses", via a central computer system.

**Fuselage** The long body of an aircraft.



**Pitching** The movement of an aircraft as its nose moves up to climb or down to dive.

**Propeller** A mechanism formed of rotating, aerofoil blades. As a blade spins, air moves faster over the front of it than behind it. This sucks air around the propeller, pulling the blade and the plane forward.

**Rudder** A flap mounted on the tailfin of an aircraft. It is moved left or right to control yawing movement.

**Seaplane** An aircraft that can take off and land on water. Instead of wheels, it has large flotation devices that skim across the water's surface.



**Radar** A system that detects objects by transmitting radio waves and receiving the "echoes" that bounce back. Radar is used to detect other craft or oncoming storms.

**Rolling** The movement of a plane as it rotates on its main axis.

## FACTFILE

- ★ Computers are so widely used by modern aircraft that, for most of a flight, all a pilot has to do is keep an eye on the monitor screens to check that all systems are working properly.
- ★ There are about 18 million flights in the world every year.
- ★ The outer skin of a jumbo jet, made of aluminium alloy, is just 5 mm thick.
- ★ Up to 270 kg of paint is used on a jumbo jet's exterior.
- ★ The Airbus A380 is the world's widest aeroplane, with a cabin width of 6.58 m.

**Spoiler** A hinged flap on the upper side of a wing. When raised, it reduces lift and increases drag to slow an aircraft down.

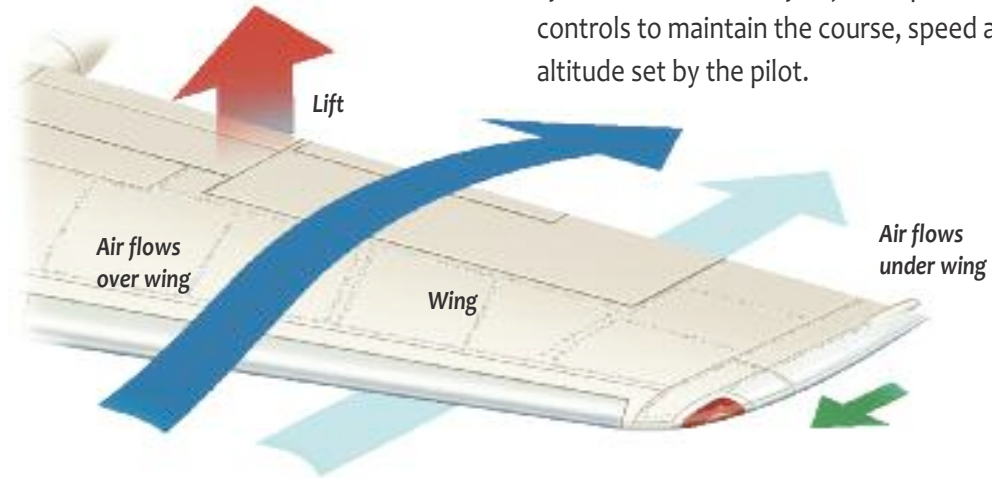
**Tailfin** The large vertical surface at the tail of an aircraft. It prevents a plane from yawing in order to keep it flying straight.

**Tailplane** A horizontal aerofoil at the rear of an aircraft. It prevents a plane from pitching in order to keep it flying level.

**Thrust** The force provided by an aeroplane's engines. Thrust propels an aeroplane forward, overcoming the backward force of drag.

**Yawing** The movement of a plane as it turns to the left or right.

**Wide-body aircraft** An airliner with two passenger aisles, typically with a fuselage 5-6 m wide.



**Aerofoil** The shape of an aircraft's wing, designed to cause lift. A wing is curved on its upper side so that, as the plane moves, the air flowing over the wing is made to move faster than that flowing under it. This creates lower pressure on the upper side than on the lower side, resulting in lift.

**Black box** A flight recorder in the cockpit. In the event of a crash, it can be recovered to discover the cause of the accident.

**Cabin** The part of an aircraft inside which passengers travel.

**Cockpit** The part of an aeroplane near its nose, where the control and navigation systems are located. The cockpit on an airliner is called the **flight deck**.

**Control surfaces** Flaps on an aircraft that can be moved to control direction. These include ailerons, rudders and elevators.

**Elevator** A hinged section of the tailplane, moved up or down to control pitching.

**Helicopter** An aircraft that uses a main rotor for lift and a tail rotor to control directional movement. It can hover forwards, backwards or sideways, and take off or land vertically.

**Jumbo jet** A jet-powered wide-body aircraft.



**Landing gear** The wheels and shock absorbers that support an aeroplane on the ground.

**Lift** The upwards force that keeps an aircraft in the air.

**Light aircraft** A small aeroplane propelled by a piston engine. Light aircraft are mostly used for recreation or learning to fly. They can cruise at speeds of up to 200 km/h.



Westland Sea King Helicopter



The controls in a light aircraft (below). The Primary Flight Display (1) shows altitude, speed and angle. A Multi-Function Display (2) monitors systems and engines. An Autopilot Control Panel (3) is used by the pilot to set course, speed and altitude.

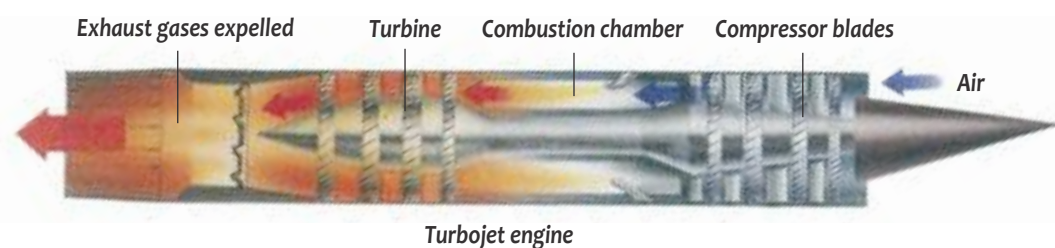
# JET ENGINES

In a jet engine, air enters a fan at its front end. The air is compressed by the spinning blades, mixed with fuel and burned in a combustion chamber. The hot exhaust gas escapes at speed through the rear engine, turning a turbine. The movement of air through the engine provides forward thrust, just like a balloon shoots forward if the air inside it is suddenly released. There are several kinds of jet engine, including turbojets, turboprops and turboshafts. Airliners, military planes, missiles and some speed boats are powered by jet engines.

**Afterburner** A device added to a turbojet to increase its thrust. Inside the afterburner, additional fuel is burned to use up any unburned oxygen left in the gases that leave the jet's exhaust.

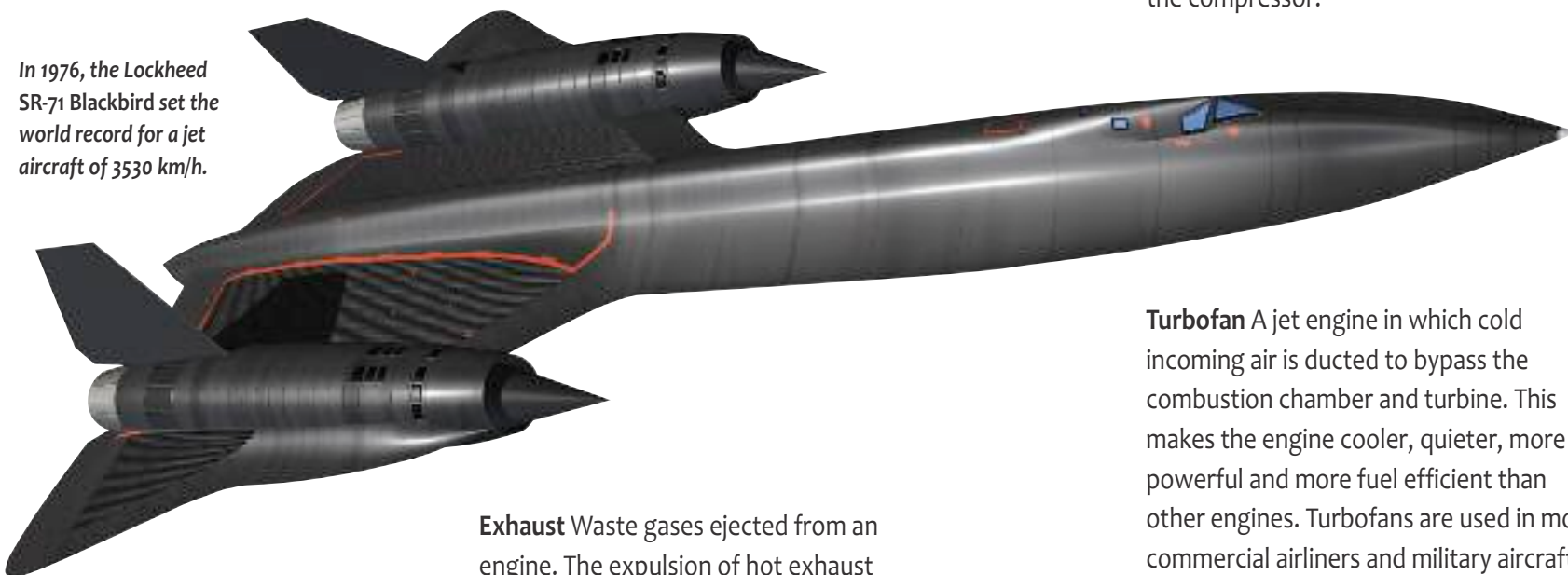
**Air intake** The part of a jet engine through which air is drawn. Jet engines do not work in space where there is no oxygen.

**Bypass duct** The part of a turbofan through which air flows, bypassing the core of the engine to join the exhaust gases at the engine's rear.



**Combustion chamber** The part of a jet engine in which oxygen is mixed with kerosene fuel and ignited. Temperatures inside the combustor can reach 2700°. Most combustors are lined with ceramic coating to make them heat-resistant.

**Cowling** The pod covering an aeroplane's jet engine. Cowling is also known as **cowl**. It is light and streamlined and is usually made out of aluminium.



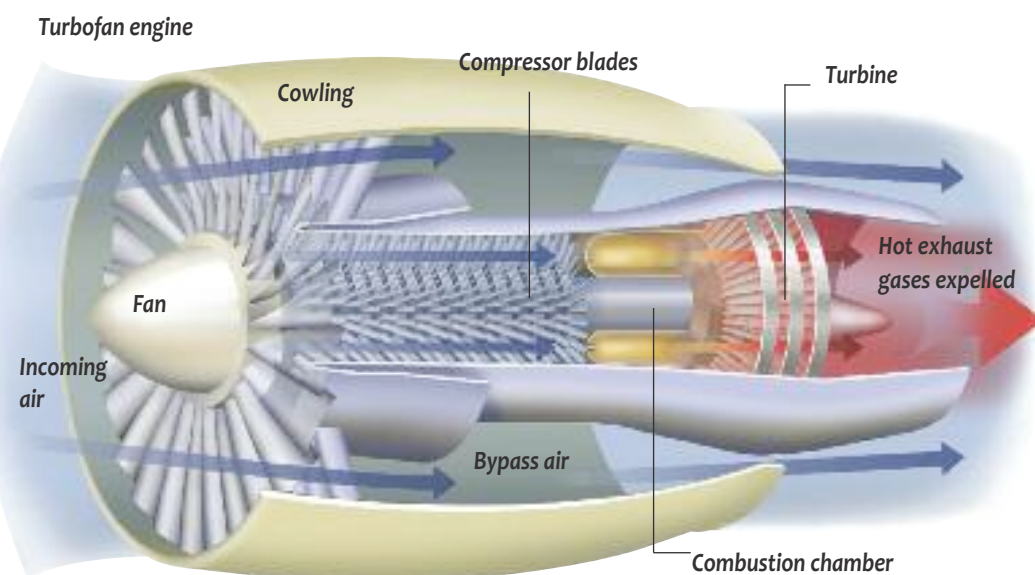
**Compressor** A device in a jet engine that compresses air. It consists of spinning blades that squeeze air into increasingly smaller spaces. The compressor then feeds air to the combustion chamber.

**Exhaust** Waste gases ejected from an engine. The expulsion of hot exhaust from the back of a jet engine provides its forward thrust.

**Kerosene** A colourless, highly flammable oil that is used as fuel for jet engines.

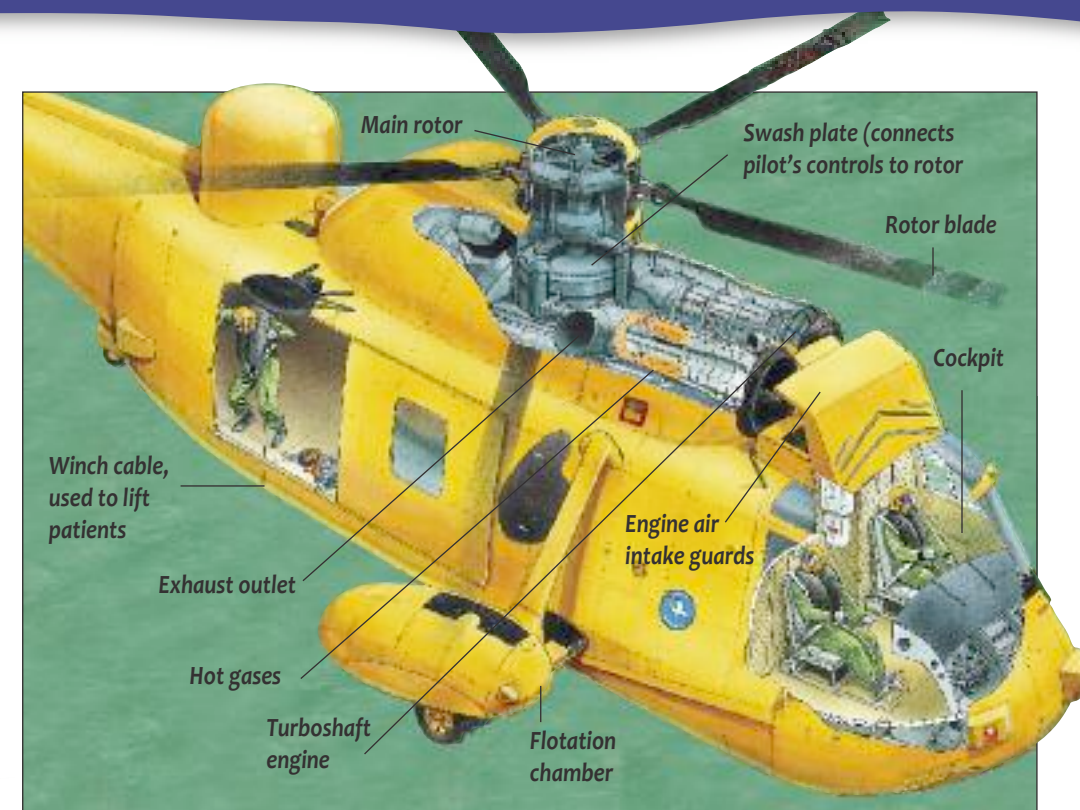
**Pulse-jet engine** A simple jet engine that uses intermittent or "pulsing" combustion. Air enters the engine through valves that shut behind it. As the exhaust leaves, the pressure inside the engine drops, and the valves open to let more air in. Pulse-jet engines are used for pilotless vehicles. They were used for the V-1 flying bombs, or "doodlebugs", during World War II.

**Ramjet** A simple jet engine with no rotating parts. It uses forward motion to compress or "ram" air into its engine. Ramjets need to be launched by another aircraft, as they can only operate at speeds of 320 km/h or more. They are mainly used for missiles.



**Rotor** Long, rotating blades on the top of a helicopter that provide lift. Each blade has the curved aerofoil shape of an aeroplane's wing. As the blades spin round, they push down the air beneath them, creating lift. By tilting the main rotor to the left or right, the pilot can change the helicopter's course.

**Turbine** A machine that is caused to rotate by a fluid (a liquids or a gas). The turbine in a jet engine is turned by the jet exhaust. Its motion drives the compressor.



**Turboprop** A jet engine that drives a propeller via a shaft. The shaft is turned by the rotary movement of the turbine. Some small airliners and transport aircraft are powered by turboprops.

**Turbofan** A jet engine in which cold incoming air is ducted to bypass the combustion chamber and turbine. This makes the engine cooler, quieter, more powerful and more fuel efficient than other engines. Turbofans are used in most commercial airliners and military aircraft.

**Turbojet** A jet engine in which hot gases escape through the rear at high speed. In a turbojet, all the air drawn into the engine goes through the combustion chamber. Turbojet engines cannot start on their own—their rotary motion must be started by an external motor.



The force of air escaping from a balloon sends it flying off in the opposite direction. A jet engine works by the same principle.



Power Jets W.2, a turbojet engine developed by Frank Whittle in the early 1940s.

**Turboshaft** A jet engine in which an additional turbine is used to turn a shaft, for example to power the rotors on a helicopter. The speed of the helicopter rotor is independent of the rotating speed of the turbine.

**Von Ohain, Hans (1911-1998)** German-American engineer who developed an early jet engine and worked on the first aircraft to be powered by jet propulsion.

A sea rescue helicopter with a turboshaft engine.

**Whittle, Sir Frank (1907-1996)** British pilot and engineer, who designed and patented the first turbojet engine in 1930. The Whittle jet engine made its first successful flight in 1941.

## A BRIEF HISTORY

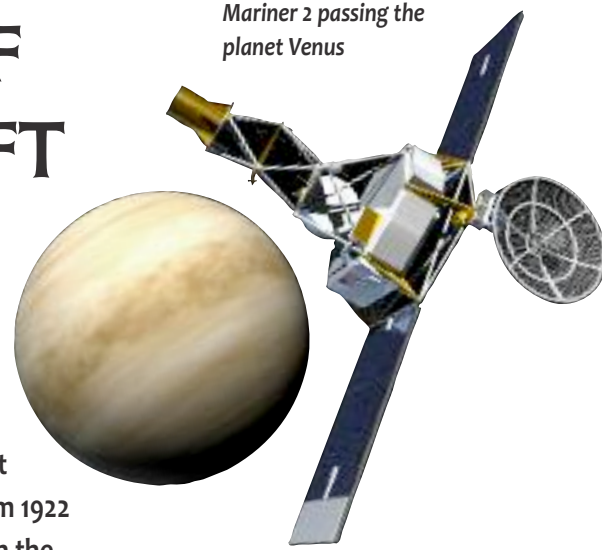
- ★ **1930s** The jet engine is developed separately in Germany, by Hans von Ohain, and in Britain, by Frank Whittle.
- ★ **1939** The first jet aircraft, the Heinkel He-178 takes to the air as part of the German Air Force.
- ★ **1941** The first fighter jet, the Messerschmitt Me 262 is built in Germany.
- ★ **1949** The Leduc 010, the first ramjet powered aircraft makes its maiden flight.
- ★ **1970** The first wide-bodied, jet-powered airliner, the Boeing 747, begins service.
- ★ **1976** The Lockheed SR-71 Blackbird sets the world speed record for a jet aircraft of 3530 km/h.

Messerschmitt Me 262



# STORY OF SPACECRAFT

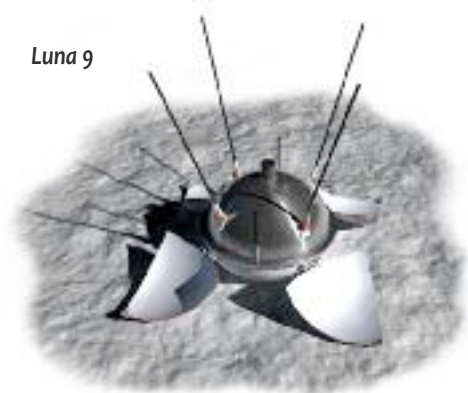
Mariner 2 passing the planet Venus



The first satellite to be launched into Earth's orbit was the Soviet satellite **Sputnik 1**. From then on, a "space race" took place between the Soviet Union (Russia and its territories from 1922 to 1991) and the United States. When the Soviet Union launched the first man into orbit in 1961, American president John F Kennedy announced that the US would land a man on the Moon before the end of the 1960s. The first Moon landing duly took place on 20th July 1969. Since then most space exploration has been carried out by unmanned space probes flying close to the other planets in our Solar System.

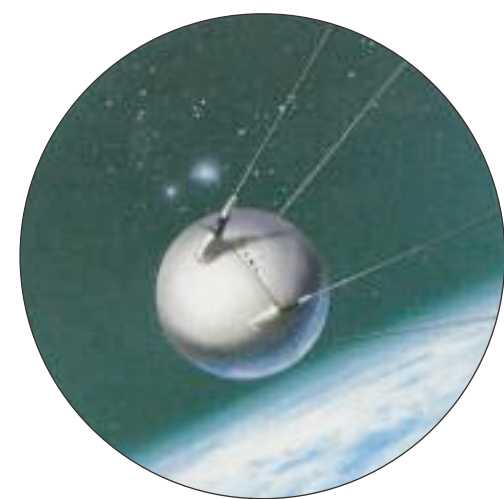
**Cassini-Huygens** A probe launched in 1997 to study Saturn and its rings and moons. In 2005, the Cassini probe released the Huygens lander, which landed on Saturn's moon, Titan. A parachute was deployed to slow the lander's descent and permit a soft landing.

Luna 9



**Apollo programme** A series of US expeditions between 1961 and 1972, that eventually landed the first man on the Moon. **Apollo 11** landed on the Moon on 20th July 1969. Five further Apollo missions landed astronauts on the Moon.

**Armstrong, Neil (1930-)** American astronaut who became the first man to walk on the Moon in July 1969.



Sputnik 1, the first manmade object to orbit the Earth. It weighed just 83 kg.

**Goddard, Robert (1882-1945)** American inventor who built the world's first liquid-fuelled rocket in 1926. Using liquid gases for fuel, it reached a height of 12.5 m.

**Hubble Space Telescope** A telescope that orbits the Earth as a satellite. It was launched into space in 1990. The pictures it receives are unaffected by weather or pollution that can reduce the quality of images taken by Earth-based telescopes.

**Laika** The Russian dog that, in November 1957, became the first animal to be launched into orbit.

**Leonov, Alexei (1934-)** Soviet astronaut who was the first human to walk in space. In 1965 he left the Voskhod 2, attached to a tether, and stayed outside the craft for 12 minutes.

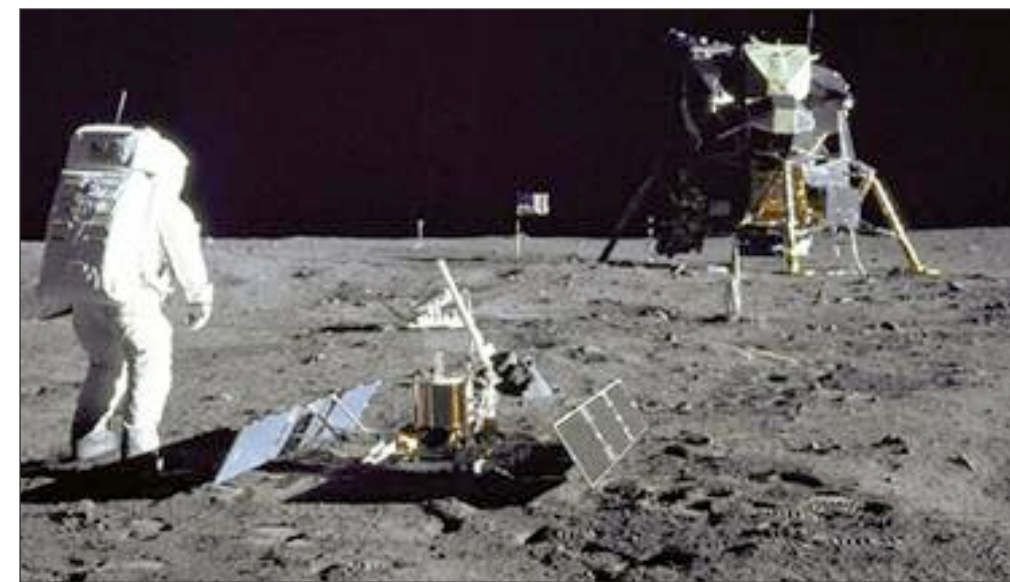
- 1 Command module
- 2 Service module
- 3 Lunar module
- 4 Third stage fuel tank
- 5 Second stage fuel tank
- 6 First stage fuel tank
- 7 Rocket engines

Saturn V (right)



Vostok

V2 missile



**Luna 9** The Soviet space probe that, in 1966, was the first spacecraft to make a successful landing on the Moon. It sent back television pictures after its protective casing opened.

The Lunar Roving Vehicle



**Lunar Roving Vehicle** A four-wheeled, battery-powered vehicle that was taken on the last three Apollo missions. It is also known as the Moon buggy. It was the first manned extra-terrestrial vehicle.

**Magellan space probe** US space probe, launched in 1989, that used radar to "see" through Venus's thick atmosphere and make images of its surface.

**Mariner 2** US space probe that was the first successful craft to reach another planet. In 1962 it flew past Venus, capturing data from the planet's surface.

**McCandless, Bruce (1937-)** The first person to go "outside" in space with no tether. He travelled in a small chair-like vehicle called a **Manned Manoeuvring Unit**, fitted with gas-powered thrusters.

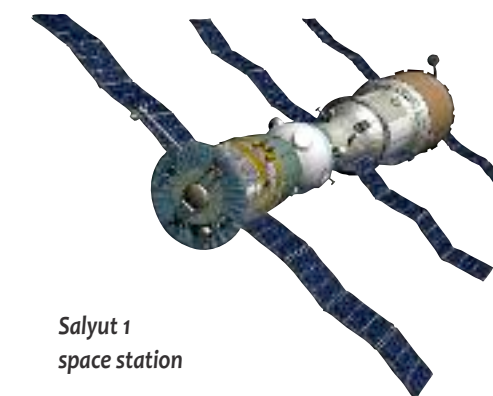
The Apollo Lunar Module on the surface of the Moon.

**Pioneer missions** US missions that sent space probes to Jupiter, Saturn and Venus in the 1970s. **Pioneer 10** was the first manmade object to leave the Solar System.

**Salyut 1** The first permanent space station (→ 27), launched in April 1971. It was 15 m long, powered by wing-like solar panels and manned by Soviet astronauts.

**Saturn V** The rocket launch vehicle built for the Apollo missions. It was split into parts, called stages, that fired one after another, dropping off when they ran out of fuel.

**Sputnik 1** The first manmade object to orbit Earth, launched in 1957. It remained in orbit for 92 days.



Salyut 1 space station

**Tereshkova, Valentina (1937-)** Russian astronaut who became the first woman in space in 1963, when she orbited the Earth 48 times on board Vostok 6.

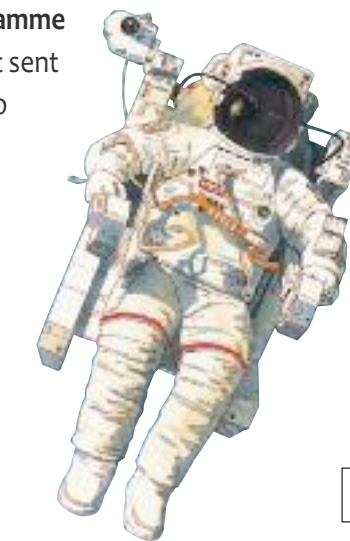
**V-2 missile** The first manmade object in space, launched in October 1942. The German V-2 was 14 m tall and powered by liquid fuel. It was used as a long-range missile during World War II.

**Viking programme** Two US space probes that were sent to Mars in 1975. Viking 1 and 2 were the first probes to land successfully on Mars and send back data.

**Vostok launcher** Russian rocket that launched Sputnik 1 into space.

**Voyager programme** US mission that sent space probes to Jupiter, Saturn, Uranus and Neptune in the 1980s.

Astronaut strapped into a Manned Manoeuvring Unit



## A BRIEF HISTORY

★ 1926 The first liquid-fuel rocket is built.

First rocket



★ 1942 The V-2 missile becomes the first man-made object in space.

★ 1957 The Soviet Union launch the first man-made satellite.

★ 1961 Yuri Gagarin makes the first flight in a manned spacecraft.

★ 1963 Valentina Tereshkova becomes the first woman in space.

★ 1965 Alexei Leonov makes the first space walk.

★ 1969 Neil Armstrong is the first man to walk on the Moon.

★ 1971 The first space station is launched.



Viking 1

# SPACECRAFT

Space begins only about 100 km above the Earth's surface, but it is very difficult to get there. Aeroplanes cannot fly in space because their jet engines stop working through lack of oxygen. Spacecraft use rocket engines, which do not rely on oxygen in the air. To escape the pull of the Earth's gravity, they must reach a minimum speed of 40,000 km/h. Once in space, the craft's engines can be turned off. It maintains its speed because there is no air to slow it down.

**Astronaut** A person who travels into space to carry out experiments and pilot a spacecraft. In Russia, astronauts are known as cosmonauts.



The International Space Station

**Booster rocket** A rocket attached to a larger rocket to increase its thrust. When its fuel runs out, it detaches from the rocket and parachutes back to Earth, where it can be collected and reused.

**Escape velocity** The speed (40,000 km/h) a spacecraft must reach to overcome the pull of Earth's gravity and enter space.

**International Space Station (ISS)** A space station orbiting 350 km above the Earth. It is made up of separate modules, inside which are laboratories and living spaces. The first part of the ISS was launched in 1998. Other components have been added on later missions. Solar panels provide the ISS with electricity.

**Jettison** The deliberate release of an item into space.

**Orbital Manoeuvring System (OMS)** Two small engines attached to a space shuttle orbiter. They are fired in short blasts to steer the orbiter into its correct orbit. When the orbiter returns to Earth, the OMS slows it down for a safe landing.

**Orbiter** The winged part of a space shuttle where the astronauts travel. When it returns to Earth, it puts down wheels and lands on a runway like an airliner.

**Lift-off** The moment when a rocket or other spacecraft leaves the ground.

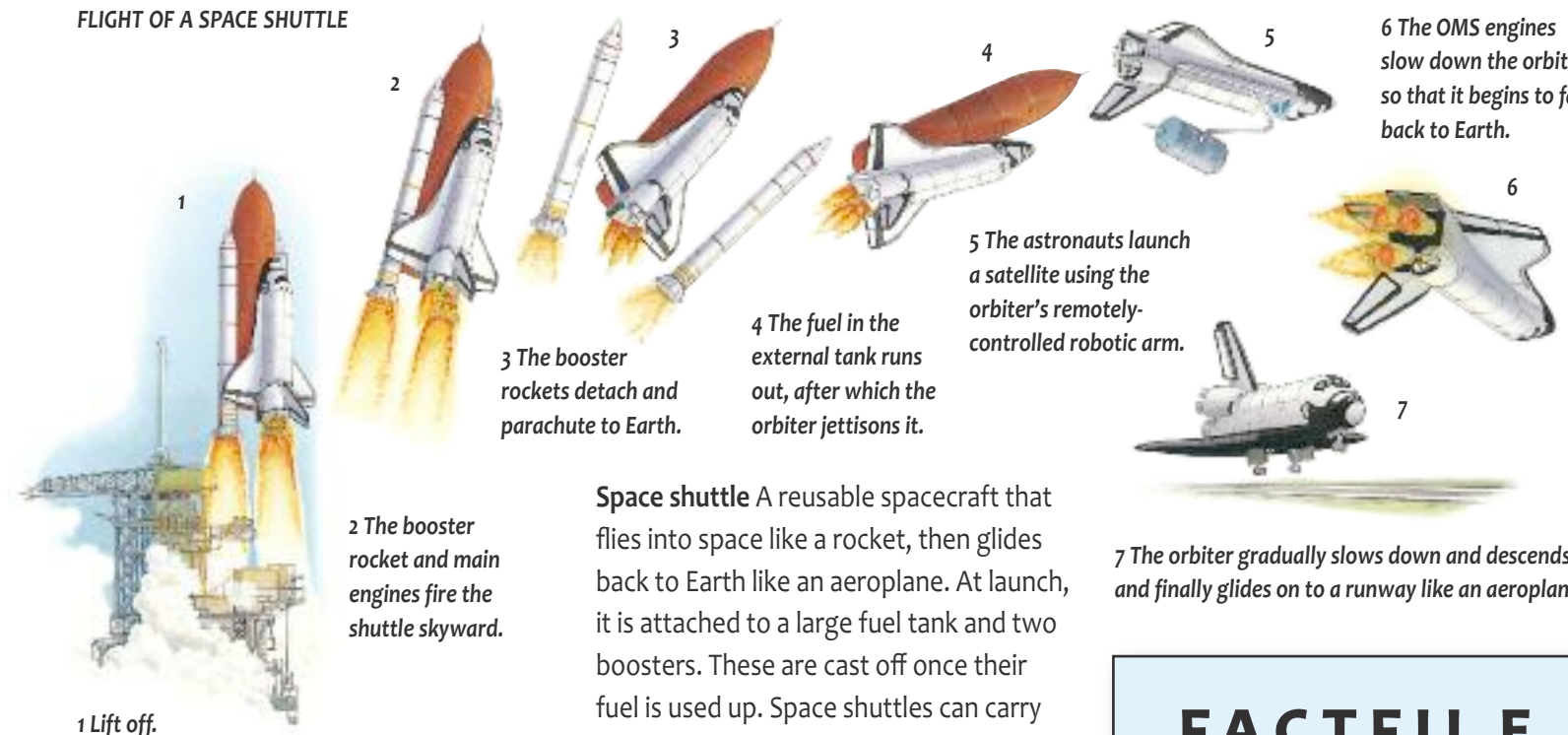


The Spirit rover, which landed on Mars in 2004.

**Payload bay** The area in a spacecraft where cargo, such as satellites, are carried.

**Rocket engine** An engine that burns fuel, creating a stream of gases that drive the engine in the opposite direction. Spacecraft are normally carried into space by rockets, which function without air.

## FLIGHT OF A SPACE SHUTTLE



**Space shuttle** A reusable spacecraft that flies into space like a rocket, then glides back to Earth like an aeroplane. At launch, it is attached to a large fuel tank and two boosters. These are cast off once their fuel is used up. Space shuttles can carry satellites into orbit. They also take people up to retrieve or repair satellites or carry out experiments.

**Rover** A vehicle used for exploration on the surface of a moon or planet. Rovers are robotic devices, fitted with cameras and sensors, and operated from Earth.

**Satellite** An artificial object that orbits the Earth.

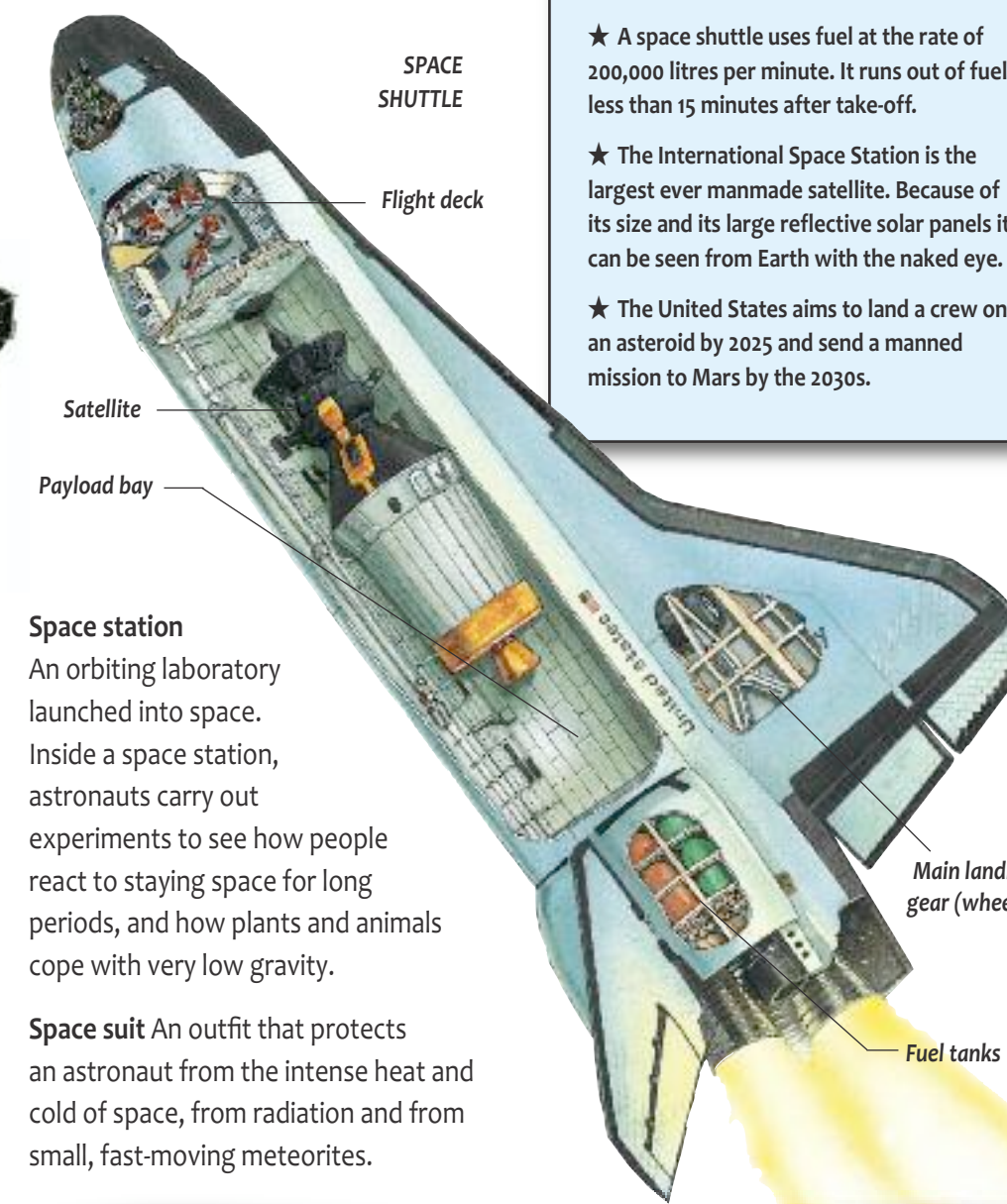


The Orion spacecraft, designed to take a crew to Mars in the future.

**Service module** A compartment within a spacecraft that contains life-support systems, such as oxygen and heating.

**Solar panel** A device that converts heat and light from the Sun into electricity.

**Space probe** An unmanned spacecraft, guided from Earth and used to take photographs and collect data. Some probes have passed close to or landed on the surface of other planets and moons.



**Space station** An orbiting laboratory launched into space. Inside a space station, astronauts carry out experiments to see how people react to staying space for long periods, and how plants and animals cope with very low gravity.

**Space suit** An outfit that protects an astronaut from the intense heat and cold of space, from radiation and from small, fast-moving meteorites.

## FACTFILE

- ★ On its journey into space, a space shuttle travels at 10 times the speed of a rifle bullet.
- ★ A space shuttle uses fuel at the rate of 200,000 litres per minute. It runs out of fuel less than 15 minutes after take-off.
- ★ The International Space Station is the largest ever manmade satellite. Because of its size and its large reflective solar panels it can be seen from Earth with the naked eye.
- ★ The United States aims to land a crew on an asteroid by 2025 and send a manned mission to Mars by the 2030s.

**VIRGIN OTSUKA Pacific Flyer**  
385 km/h  
Fastest balloon

**LYNX**  
400 km/h  
Fastest helicopter

**FORMULA ONE RACING CAR**  
320 km/h

**LE TERRIBLE**  
82 km/h  
Fastest destroyer

**ALFA CLASS SUBMARINE**  
82 km/h  
Fastest submarine



**RACING BICYCLE**  
72 km/h



**RACEHORSE**  
69 km/h



**UNITED STATES**  
66 km/h  
Fastest ocean liner

**J CLASS RACING YACHT**  
56 km/h

**THERMOPYLAE** 39 km/h  
One of the fastest clippers

**PEREGRINE FALCON**  
Over 300 km/h  
Fastest animal

**INDY CAR**  
360 km/h

**AIRBUS A300B AIRLINER**  
911 km/h

Apart from watercraft specially designed to break records, sea-going speed champions are well down the field, compared to others. Even the fastest sailing ship would be comfortably left behind by a racing horse. Only the quickest warships and submarines would outpace a racing cyclist, but any family car would easily overtake them all.

Illustrations are not drawn to scale

**LOCKHEED SR-71 Blackbird**  
3530 km/h  
Fastest jet aircraft

**SPIRIT OF AUSTRALIA**  
511 km/h  
Water speed record holder

**TGV**  
575 km/h  
Fastest wheeled train

**BUB ENTERPRISES SEVEN**  
591 km/h  
Fastest motorcycle

**THRUST SSC**  
1227.723 km/h  
Land speed record holder

**CONCORDE**  
2333 km/h  
Fastest airliner

**X-15**  
7274 km/h  
Fastest rocket-powered aircraft



**APOLLO 10 COMMAND MODULE** 39,897 km/h  
Fastest speed at which humans have travelled

## RECORD HOLDERS

The greatest speeds achieved by manmade machines have all been reached in space, where there is no air to slow an object down. An unmanned space probe, Helios B, sent to observe the Sun holds the all-time speed record for a manmade object of 252,800 km/h. A spacecraft travelling at that speed would reach the Moon in an hour and a half! The crew of Apollo 10, US astronauts Thomas Stafford, Eugene Cernan and John Young, hold the record for the fastest speed at which humans have travelled, when their Command Module returned from the Moon on 26 May 1969.



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