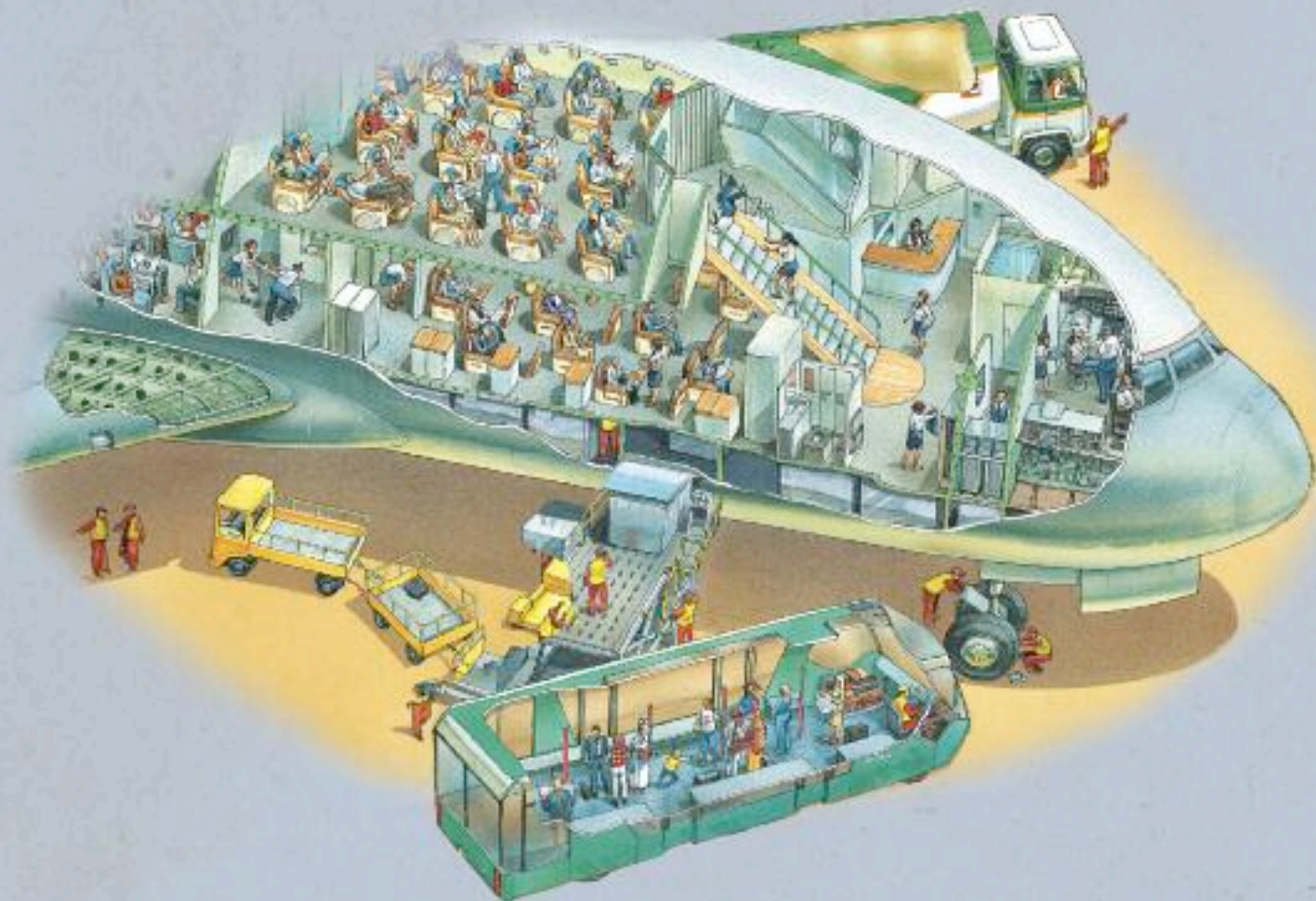


Inside Story

TRANSPORT



Inside story TRANSPORT



Illustrated by Peter Dennis

 Orpheus

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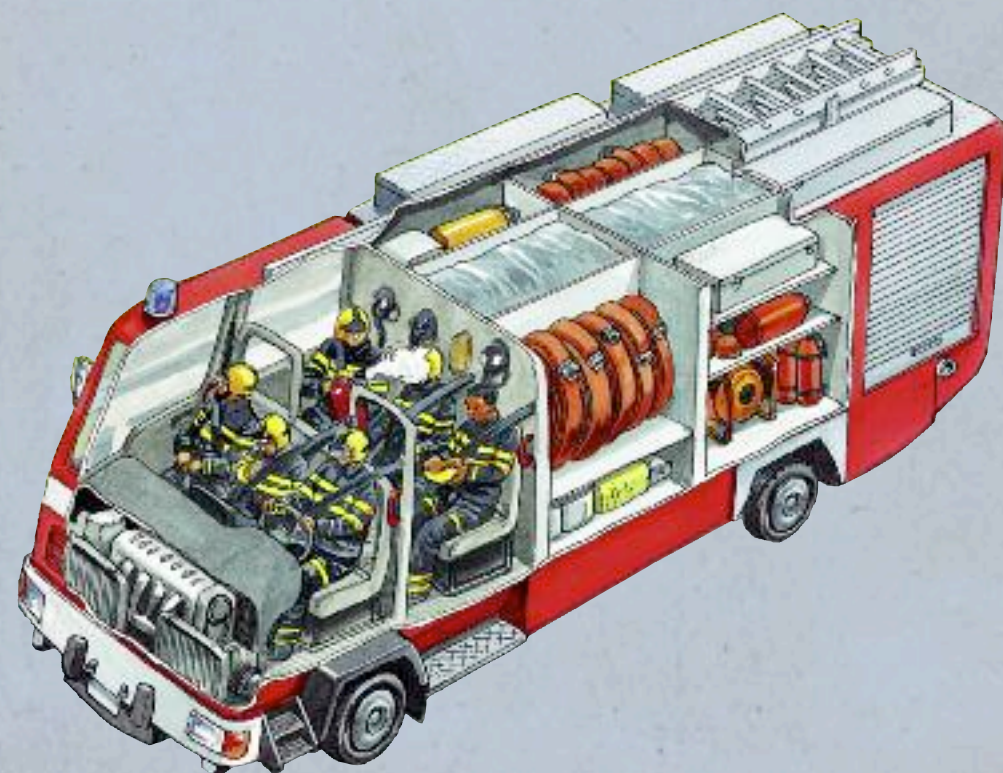
Illustrator Peter Dennis

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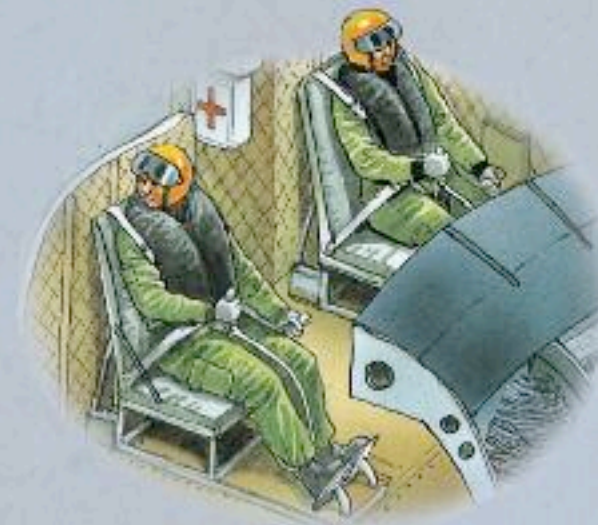
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The story of transport

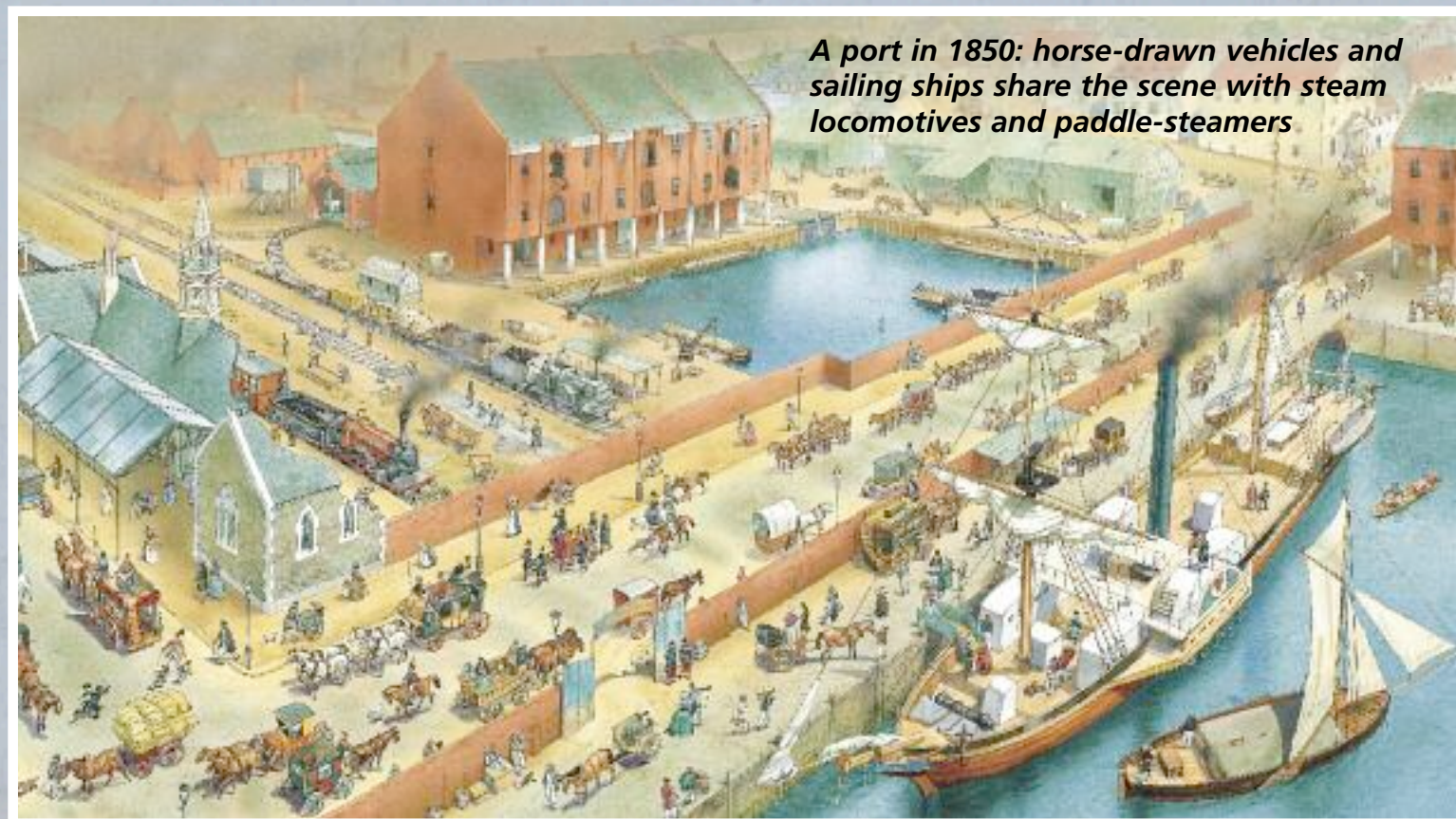
The first vehicles were probably just rafts of logs or reeds tied together. As time went on, people learnt to make boats by hollowing out logs and, later, fixing planks together. Adding sails made it possible to use the power of the wind. Sailing ships, such



as galleons (*above right*) took explorers to all parts of the world.



The invention of the steam engine in the late 18th century changed transport for ever. In boats and ships, steam engines turned paddle wheels and propellers. Huge iron ships carrying thousands of passengers and vast amounts of cargo were built. At around the same time, in 1783, the first manned flight took place in a hot-air balloon (*left*) built by the Montgolfier brothers.



A port in 1850: horse-drawn vehicles and sailing ships share the scene with steam locomotives and paddle-steamers

On land, before the invention of steam engines, people rode horses or used vehicles pulled by animals. Now steam locomotives could pull trucks and carriages along railway tracks.

They first appeared in the 1820s and spread across the world. The fastest steam locomotive ever built was *Mallard* (*top right*), which set a speed record of 201 km/h in 1938.

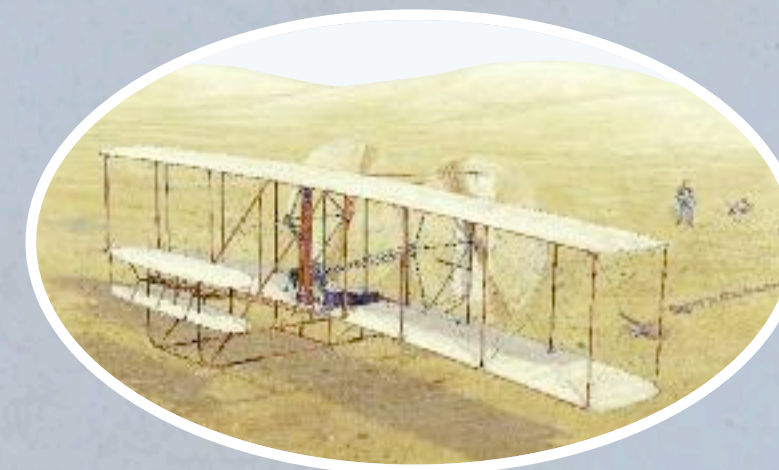


The invention of lightweight, petrol-driven engines in the 1880s led to the development of the motor car. The first petrol-driven car (*above right*) was invented by German engineer Karl Benz, in 1885.



The arrival of jet engines in the 1940s and rocket engines in the 1950s allowed people to travel faster and even to go into space. In

1969, US astronaut Neil Armstrong became the first person to set foot on the Moon as part of a mission called Apollo 11 (*below*).



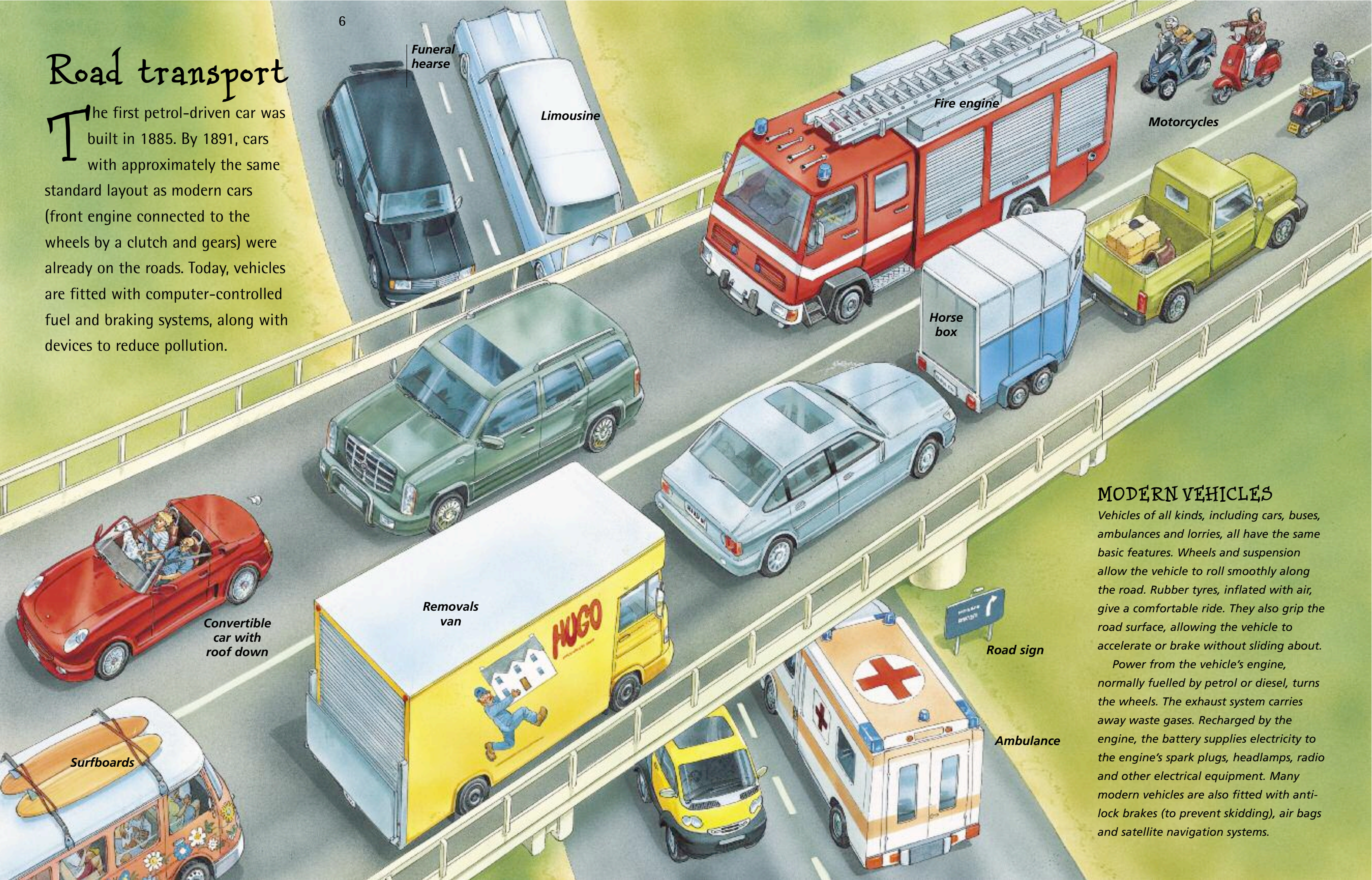
The first heavier-than-air aircraft were gliders. In 1903, two American brothers, Orville and Wilbur Wright, made the first powered, controlled aeroplane flight in *Flyer 1* on the sand dunes at Kitty Hawk, North Carolina. It flew for only 12 seconds before landing 36 m away (*above*).

This is the INSIDE STORY of transport. In this book you can explore the interiors of cars, trains, ships, aircraft and spacecraft, and find out how their engines propel them along.



Road transport

The first petrol-driven car was built in 1885. By 1891, cars with approximately the same standard layout as modern cars (front engine connected to the wheels by a clutch and gears) were already on the roads. Today, vehicles are fitted with computer-controlled fuel and braking systems, along with devices to reduce pollution.



Funeral
hearse

Limousine

Fire engine

Motorcycles

Horse
box

Convertible
car with
roof down

Removals
van

Road sign

Ambulance

Surfboards

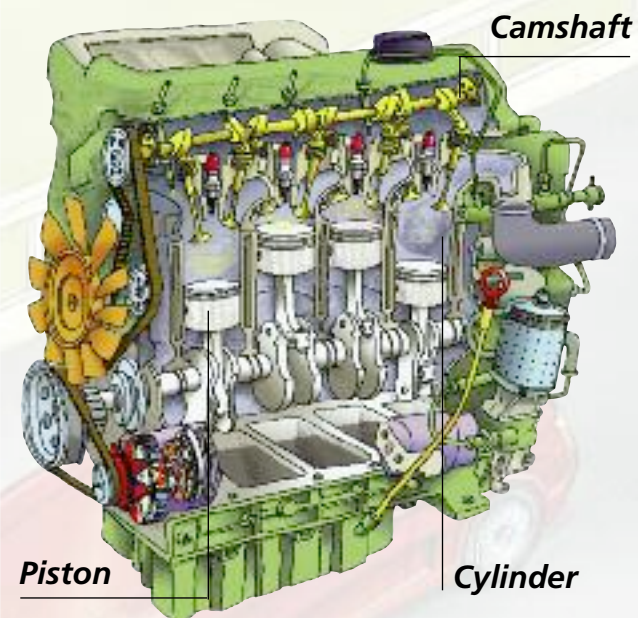
MODERN VEHICLES

Vehicles of all kinds, including cars, buses, ambulances and lorries, all have the same basic features. Wheels and suspension allow the vehicle to roll smoothly along the road. Rubber tyres, inflated with air, give a comfortable ride. They also grip the road surface, allowing the vehicle to accelerate or brake without sliding about.

Power from the vehicle's engine, normally fuelled by petrol or diesel, turns the wheels. The exhaust system carries away waste gases. Recharged by the engine, the battery supplies electricity to the engine's spark plugs, headlamps, radio and other electrical equipment. Many modern vehicles are also fitted with anti-lock brakes (to prevent skidding), air bags and satellite navigation systems.

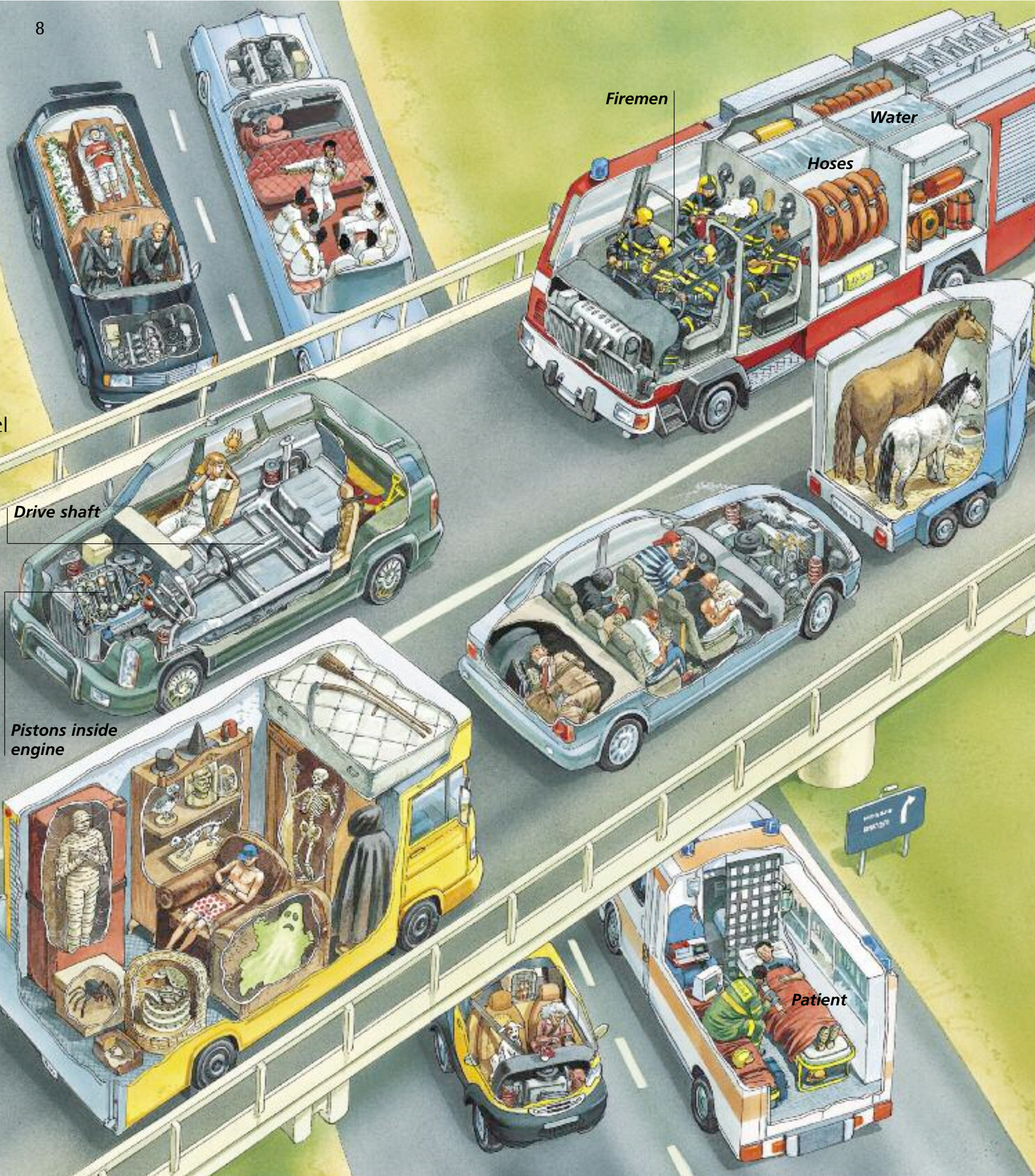
How cars work

Most cars are powered by either a petrol or diesel engine. Pistons in the engine turn a crankshaft, which is connected to the wheels by gears. The wheels are made to turn around, and so the car moves forward. The driver controls the car using the accelerator pedal, brake pedal, clutch, steering wheel and gear stick.



PISTON ENGINE

A piston engine is a kind of internal combustion engine. An internal combustion engine burns a mixture of fuel and air to produce power. The mixture is ignited by a spark plug and the resulting hot gases drive a piston down. An engine has several pistons, each snugly fitted inside a cylinder. As the pistons move up and down, they turn a crankshaft connected to the wheels.



FOUR-STROKE CYCLE



Most internal combustion engines work on a repeated four-stroke cycle. On the first stroke, the inlet stroke (1), the mixture of fuel and air is sucked through the inlet valve into the cylinder as the piston moves down. On the compression stroke (2), the mixture is squeezed as the piston rises. Just before it reaches the top, the spark plug ignites the mixture. The hot, expanding gases drive the piston down, This is the third stroke, the power stroke (3). On the fourth stroke (4), the exhaust valve opens and the exhaust gases are forced out by the rising piston.

High-speed train

High-speed trains travel much faster than most other trains—usually more than 200 km/h.

The first high-speed train, the Japanese *Shinkansen* ("bullet train"), started services in 1964.

Others include the French *Train à Grande Vitesse* (TGV) and German InterCity Express (ICE).

TGV: RECORD BREAKER

In 2007, a TGV set a new world record of 574.8 km/h for a train travelling on rails. Its high speed is made possible by its streamlined design, its high-powered electric motors and its relatively low weight. The TGV's articulated carriage design allows the train to bend at speed. Running on specially designed tracks without sharp curves avoids the need to decelerate. In-cab signalling means the driver does not even have to slow down to check and react to lineside signals.

Overhead power lines

Pantograph

Vent for motor air exhaust

Conductor

POWER SUPPLY

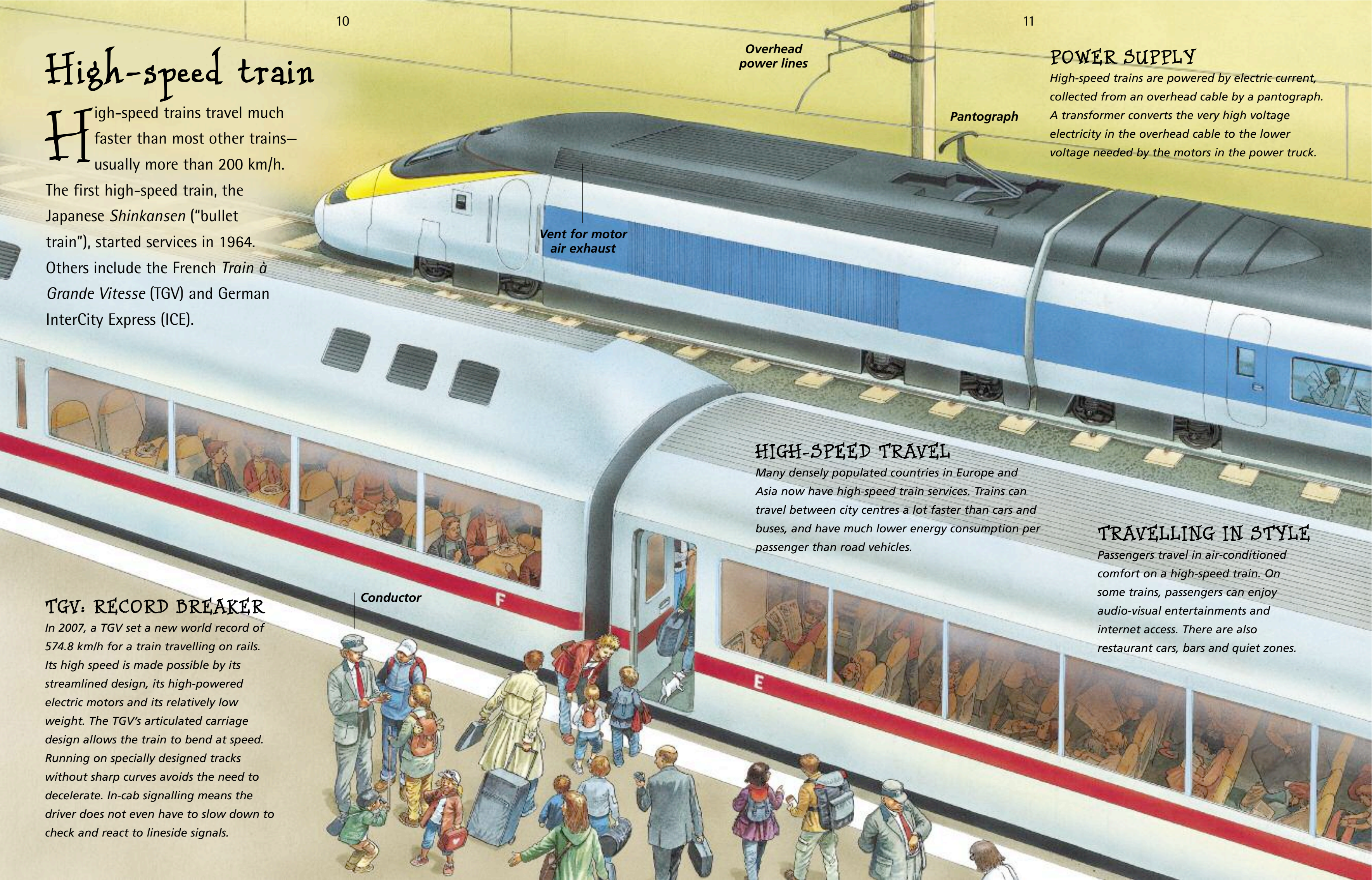
High-speed trains are powered by electric current, collected from an overhead cable by a pantograph. A transformer converts the very high voltage electricity in the overhead cable to the lower voltage needed by the motors in the power truck.

HIGH-SPEED TRAVEL

Many densely populated countries in Europe and Asia now have high-speed train services. Trains can travel between city centres a lot faster than cars and buses, and have much lower energy consumption per passenger than road vehicles.

TRAVELLING IN STYLE

Passengers travel in air-conditioned comfort on a high-speed train. On some trains, passengers can enjoy audio-visual entertainments and internet access. There are also restaurant cars, bars and quiet zones.



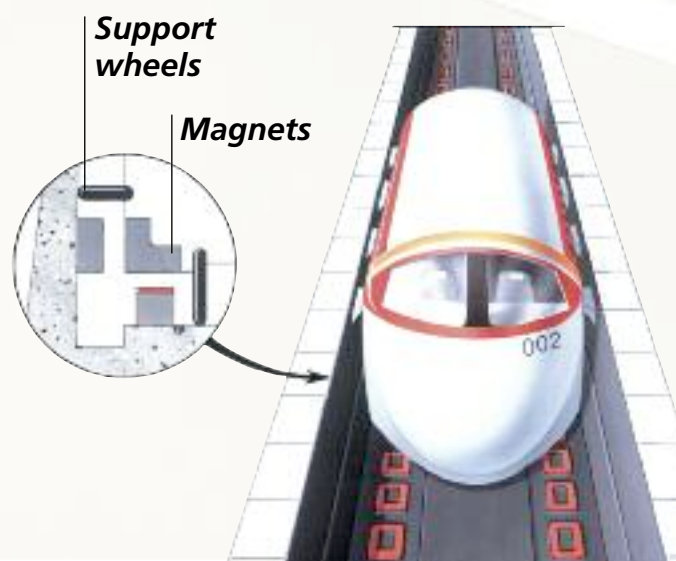
How trains work

On an electric locomotive, the wheels are moved by electric motors. The electricity comes either from overhead cables or from an electrified third rail. On a diesel-electric locomotive, the wheels are also driven by electric motors, but the electricity is generated by a diesel engine.

MAGLEVS

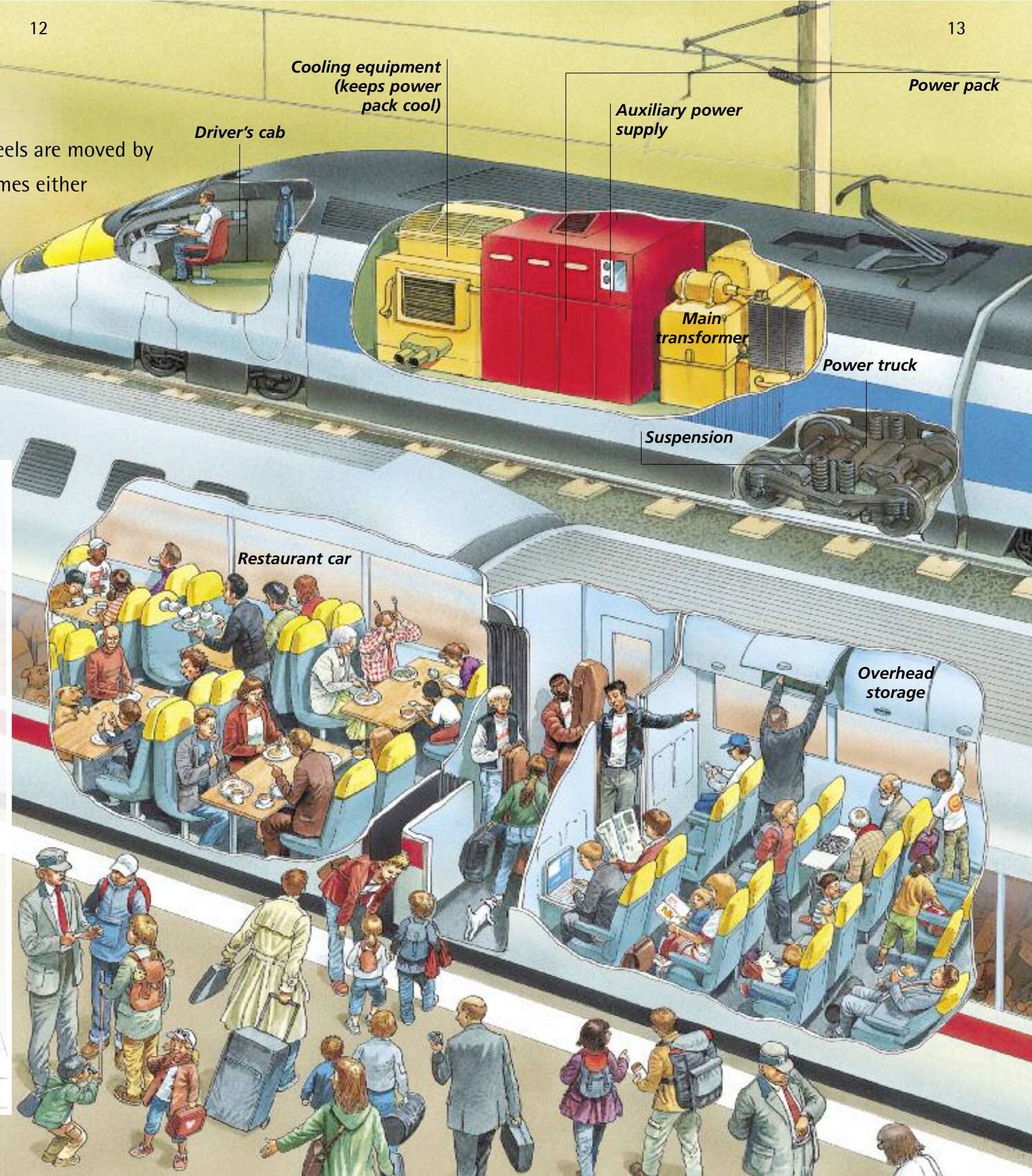
The fastest speed achieved by a train with passengers aboard is 400 km/h. This record was set in February 1987 by a test train in Japan using magnetic levitation.

A "maglev" train works on the principle that "like" magnetic poles push each other apart. Powerful magnets fixed to the track push away 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 between train and track, maglevs can reach high speeds.



POWER PACKS

Inside the locomotive, a power pack controls how much electricity goes to each motor, and thus the speed of the train. An auxiliary power unit supplies power for lighting, air conditioning etc.

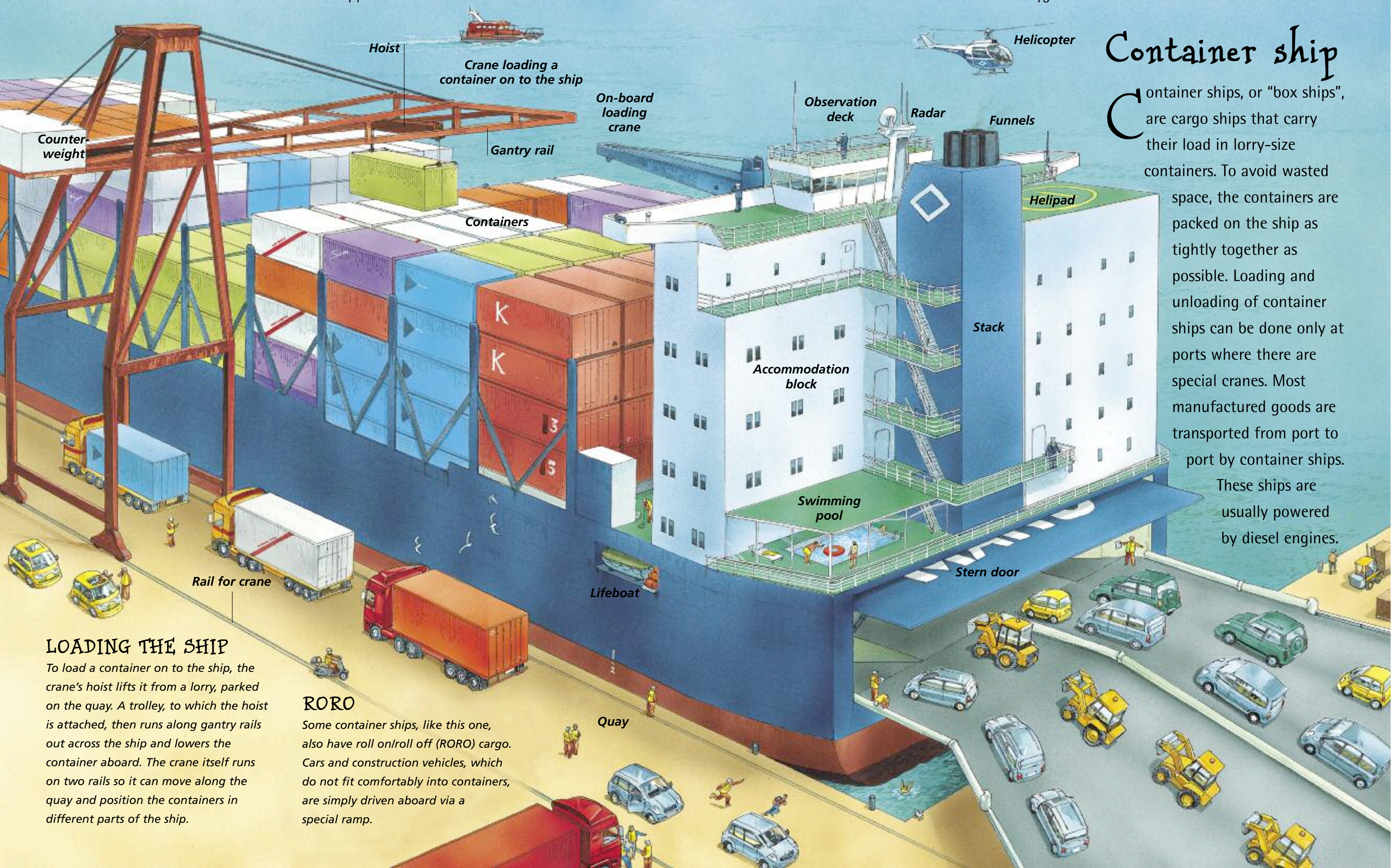


TYPES OF TRAIN

Electric trains are useful in places where smoke or fumes cannot easily escape into the air. Many large cities have electric trains which run under the ground, linking different parts of the city. The first underground trains ran in London in 1863. Originally steam-powered, they are now electric (above).

Trains usually run on double rails on the ground, but one kind of train, called the monorail, runs on a single rail. The illustration (below) shows the suspension monorail trains of Wuppertal, Germany.





Container ship

Container ships, or "box ships", are cargo ships that carry their load in lorry-size containers. To avoid wasted space, the containers are packed on the ship as tightly together as possible. Loading and unloading of container ships can be done only at ports where there are special cranes. Most manufactured goods are transported from port to port by container ships. These ships are usually powered by diesel engines.

LOADING THE SHIP

To load a container on to the ship, the crane's hoist lifts it from a lorry, parked on the quay. A trolley, to which the hoist is attached, then runs along gantry rails out across the ship and lowers the container aboard. The crane itself runs on two rails so it can move along the quay and position the containers in different parts of the ship.

RORO

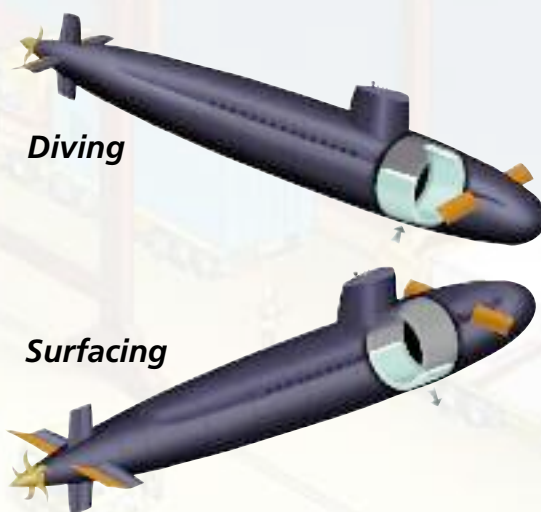
Some container ships, like this one, also have roll on/roll off (RORO) cargo. Cars and construction vehicles, which do not fit comfortably into containers, are simply driven aboard via a special ramp.

How ships work

Most ships are powered by engines that turn a propeller. The propeller is connected by a shaft to the engine. Its blades are large and curved. As they turn, the water around them is sucked in and pushed backwards. This drives the boat forwards. A rudder at the stern steers the ship. Large ships also have small electrically powered propellers for manoeuvring in port.

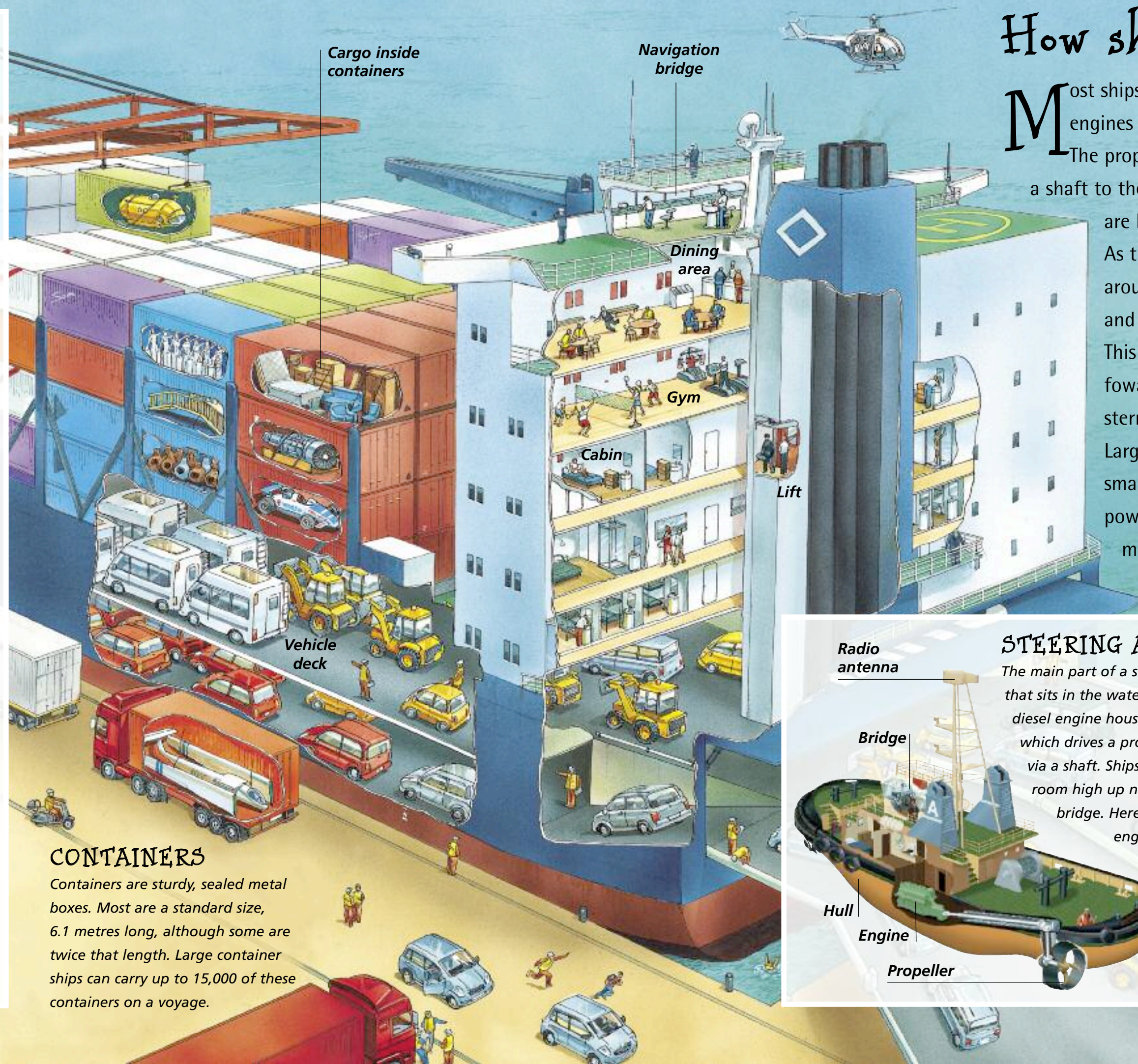
WHY A SHIP FLOATS

Water pushes upwards on anything that is immersed in it. Anything that is denser than water will sink, while objects less dense than water will float. A heavy metal ship floats because it contains lots of air, making it less dense than water.



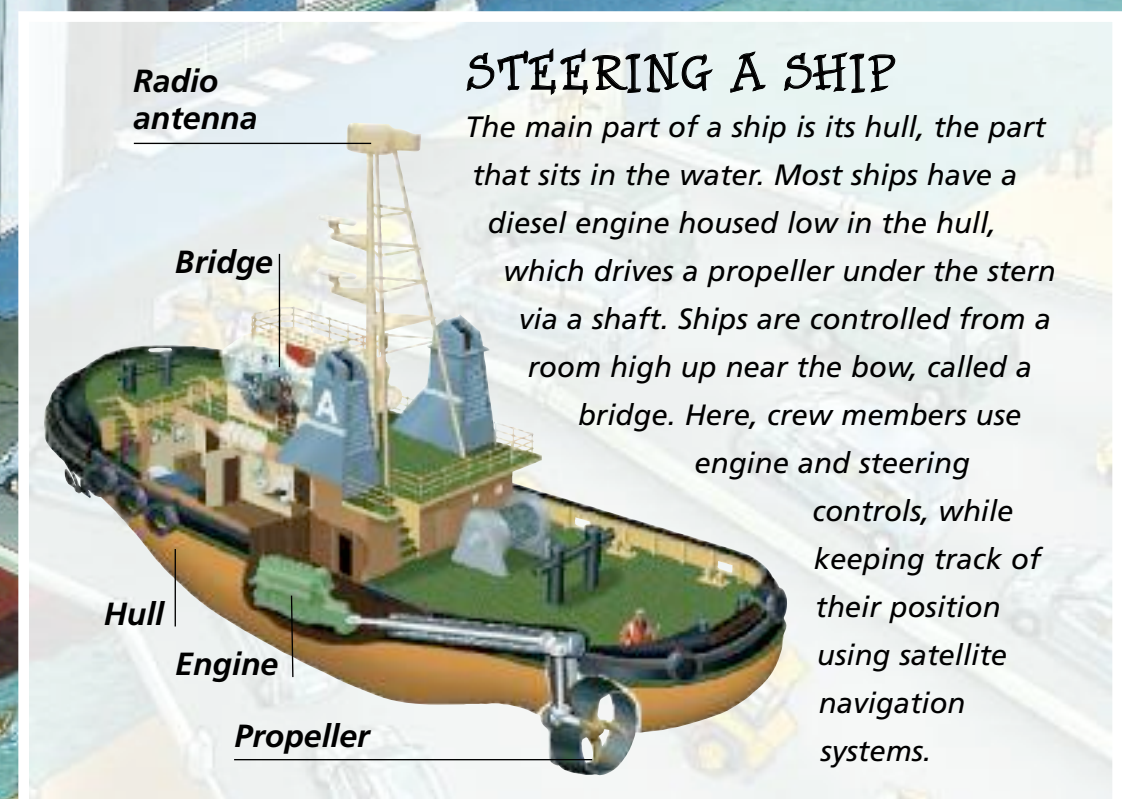
SUBMARINES

A submarine is a vessel that can travel submerged under the water as well as on the surface. A submarine needs an extremely strong hull to resist the pressure deep under water. To dive, water is let into special hollow spaces called ballast tanks, making the submarine heavier. To surface, the water is pumped out of the tanks.



CONTAINERS

Containers are sturdy, sealed metal boxes. Most are a standard size, 6.1 metres long, although some are twice that length. Large container ships can carry up to 15,000 of these containers on a voyage.



STEERING A SHIP

The main part of a ship is its hull, the part that sits in the water. Most ships have a diesel engine housed low in the hull, which drives a propeller under the stern via a shaft. Ships are controlled from a room high up near the bow, called a bridge. Here, crew members use engine and steering controls, while keeping track of their position using satellite navigation systems.

FUSELAGE

The main body of an aeroplane, called the fuselage, consists of ribs, beams and an outer skin. All the parts are made of lightweight aluminium alloys (aluminium mixed with other metals). Inside, air is pumped into the pressurized passenger cabin both to provide sufficient air to breathe and to keep air pressure at comfortable levels.

There are four engines on an Airbus A380, two on each wing.

Engine cowlings

Communications aerial

Upper deck portholes

Lower deck portholes

Surface of wing

Headlamp

Wing slat

Emergency exit

Emergency exit

Baggage loading

Loading platform

Engine cowlings

LOADING THE PLANE

Luggage checked in at the airport terminal is carried by moving belt to the bag room. Here it is placed in containers and taken to the aircraft for loading by baggage handlers. The containers are loaded aboard using a loading platform that can be raised up to the level of the hold.

READY FOR TAKE-OFF

Before an airliner takes off, the ground crew gets to work. The aircraft is refuelled from a tanker, while firefighters stand by. Baggage handlers load luggage on to the aircraft, and various vehicles arrive to replenish food, drinks and water supplies. Lavatories are refilled with water and disinfectant. Following last-minute checks to the airliner's instruments and controls, it is ready for take-off.

AIR TRAVEL

The development of the jet airliner in the 1950s made it possible for everyone to fly to destinations all over the world. Nowadays, about 2 billion people travel by airliner every year.

Airliner

An airliner is a large aeroplane that transports passengers from one airport to another. The largest airliners, known as wide-bodies, have two aisles inside the passenger cabin. The Boeing 747 Jumbo Jet and the new A380 are wide-bodies.

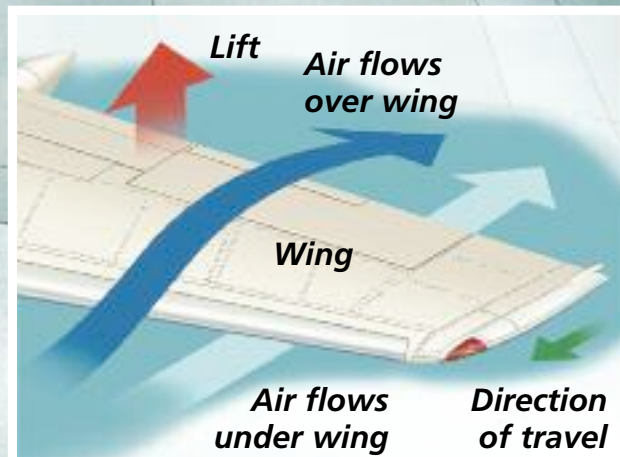
Airliners have the same features as all other aeroplanes: fixed wings that provide lift, engines to give thrust, and a fin and tailplane to keep the plane flying straight and level. Moving hinged parts of the wings and fin allow the pilot to steer the aircraft through the air.

SUPERJUMBO

The Airbus A380, a double-decked, four-engine airliner, is the largest airliner in the world. It seats up to a maximum of 853 passengers and can fly from New York to Hong Kong non-stop. It is 73 m long with a wingspan of 79.8 m. Some versions of the A380 have room for beauty salons, casinos, showers and even a gymnasium!

Inspecting aircraft's landing gear

Airport bus



HOW A PLANE FLIES

As an aeroplane moves forwards through the air, air hitting the leading (front) edge of the wing separates above and below the wing. Because of the curved shape of a wing, called an aerofoil, the air that flows over it is faster than that flowing underneath. This creates lower air pressure above the wing than beneath it. The difference in pressure pushes the wing upwards with a force called lift.

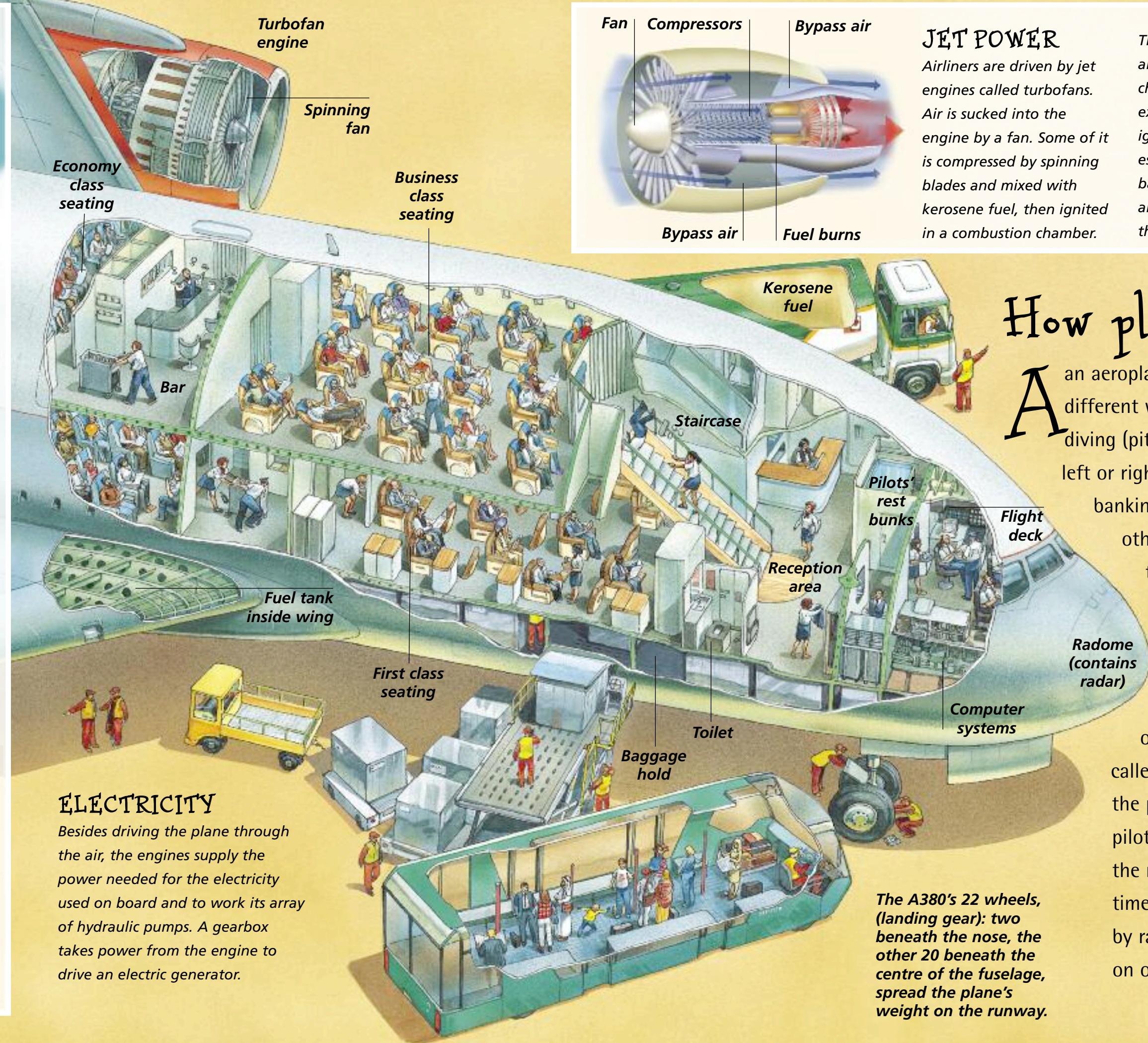
PROPELLER

Some planes are powered by propellers with curved blades. As the propeller turns, the blades suck in the air ahead of them and send it backwards, pulling the plane forwards.

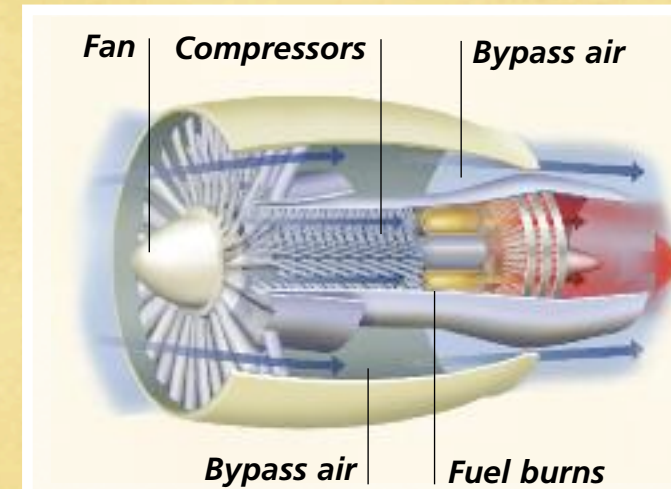


ELECTRICITY

Besides driving the plane through the air, the engines supply the power needed for the electricity used on board and to work its array of hydraulic pumps. A gearbox takes power from the engine to drive an electric generator.



The A380's 22 wheels, (landing gear): two beneath the nose, the other 20 beneath the centre of the fuselage, spread the plane's weight on the runway.



JET POWER

Airliners are driven by jet engines called turbofans. Air is sucked into the engine by a fan. Some of it is compressed by spinning blades and mixed with kerosene fuel, then ignited in a combustion chamber.

The rest of the sucked-in air is ducted around this chamber and joins the exhaust gases from the ignited mixture. The gases escape at speed out of the back of the engine. This air provides forward thrust for the aircraft.

How planes work

An aeroplane can move in three different ways: climbing or diving (pitching), turning to the left or right (yawing) and banking to one side or the other (rolling). To make the plane climb or dive, the pilot pulls or pushes the control column, which moves flaps on the plain's tail, called elevators. To turn the plane right or left, the pilot uses pedals to swivel the rudder, at the same time as rolling the plane by raising a flap (aileron) on one of the main wings.

MAIN ROTOR

The main rotor is the assembly of rotor blades on top of the helicopter. Each blade has the curved shape of an aeroplane's wing.

HOW DOES IT FLY?

The rotor blades on a helicopter provide lift. As the blades spin round, they push down the air beneath them, creating lift. This helicopter's twin turbo-shaft (jet) engines power the spinning blades. By tilting the main rotor to the left or right, the pilot can change the helicopter's course. Tilting it forwards or backwards causes it to fly straight ahead or in reverse. The tail rotor provides a force that pushes sideways on the tail, preventing the helicopter from spinning round in the air.

LIFEBOAT

Driven through the waves by its powerful engine, a lifeboat has arrived on the rescue scene. It is specially built to be self-righting.

Helicopter

A helicopter can fly forwards, backwards and sideways, hover in mid-air and take-off or land vertically. Because of this, a helicopter does not need the runway that aeroplanes must have for take-off or landing.

Helicopters therefore have a wide range of uses. These include: flying passengers to and from city centre buildings, oil rigs or ships; providing a rescue service in floods, earthquakes, on mountains or at sea; assisting firefighting, police pursuit or traffic control; serving as troop carriers in war.

Rotor blade
(one of five)

Lifeboat

Tail rotor blade

Tail boom

Radome

Winch
operator

Winch

Engine
cowling

Engine air
intake guard

Cockpit

Winch
cable

Flotation
chamber

SEA RESCUE

The helicopter has been called out to rescue the crew of a capsized yacht. The steel winch cable carefully lifts the stretcher carrying the survivor.

FLOTATION AIDS

Rescue helicopters often operate over water. If one ever came down in the sea, its boat-shaped hull would help it to stay afloat. The craft also has special flotation chambers, each containing bags that can inflate with compressed air.

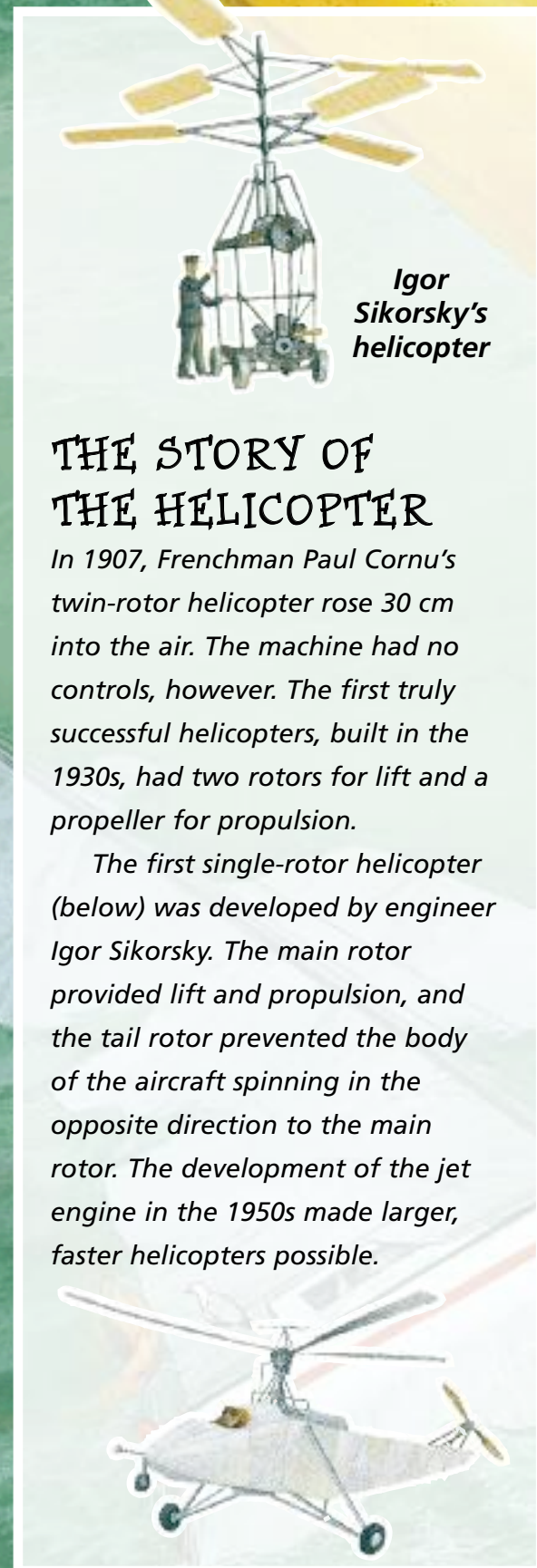
Emergency
life raft

Capsized
yacht

Stretcher

RADAR SCANNER

To navigate through the dark or thick fog, the helicopter makes use of a radar. It works by sending out and receiving radio signals.



THE STORY OF THE HELICOPTER

In 1907, Frenchman Paul Cornu's twin-rotor helicopter rose 30 cm into the air. The machine had no controls, however. The first truly successful helicopters, built in the 1930s, had two rotors for lift and a propeller for propulsion.

The first single-rotor helicopter (below) was developed by engineer Igor Sikorsky. The main rotor provided lift and propulsion, and the tail rotor prevented the body of the aircraft spinning in the opposite direction to the main rotor. The development of the jet engine in the 1950s made larger, faster helicopters possible.



Lifeboat captain

Propeller shaft

Main rotor

Hot gases

Turboshaft engine

Navigator

Co-pilot

Collective pitch lever

Pilot

Pedals

Swash plate (connects pilot's controls to rotor)

Exhaust outlet

Crew member still inside boat

FIRST AID

The flaps on the stretcher keep the survivor's body immobile. On board, there is medical equipment and oxygen bottles. All the crew are trained in first aid.

Cyclic pitch lever

FLIGHT CONTROLS

Moving the cyclic pitch lever tilts the rotor blades, altering the direction of flight. By operating the collective pitch lever controls, the pilot makes the helicopter go up or down. The pedals control the movement of its nose to the left or right.

How helicopters work

A helicopter is a type of aircraft that flies with a rotary wing (one that spins round) instead of a fixed wing. The spinning rotor on top of its fuselage gives the helicopter both lift and propulsion. The tail rotor stops the aircraft from spinning around.

Most helicopters are powered by a turboshaft engine—a jet engine that turns a shaft, causing the rotor blades to spin round very quickly. The rotor blades push the air downwards and so lift the aircraft upwards.

Space shuttle

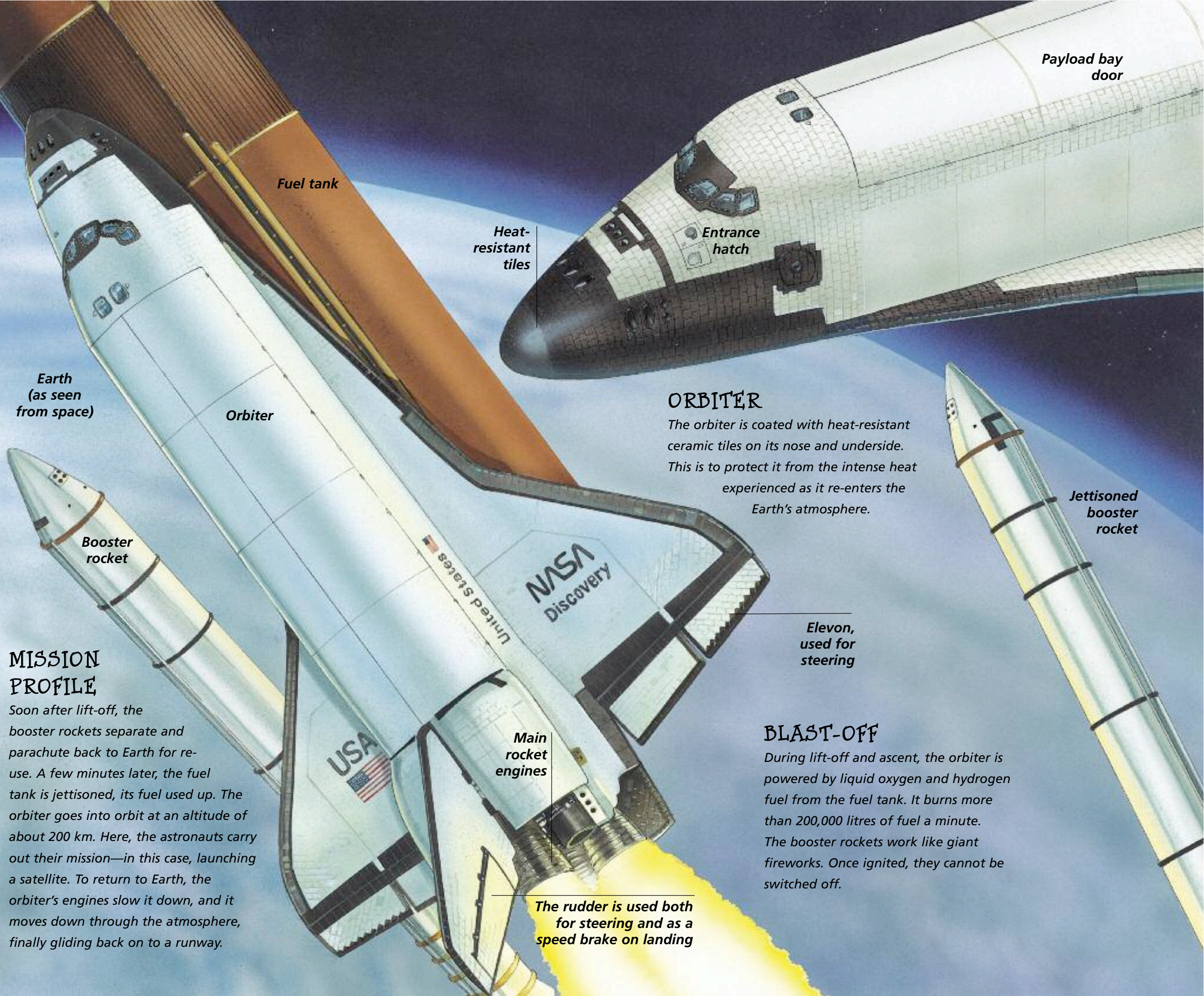
The Space Shuttle was a reusable spacecraft that flew 135 missions between 1981 and 2011. It flew into space like a rocket, then glided back to Earth like an aeroplane.

It consisted of four parts: the orbiter, in which the astronauts travelled, a fuel tank, and two booster rockets. The boosters gave the Shuttle sufficient thrust for it to escape the Earth's gravity. To do this it needed to reach a speed of 28,500 km/h.

Once in space, the Shuttle's engines were turned off. It kept its speed because there was no air to slow it down. The orbiter was, however, equipped with two small additional engines, called the Orbital Manoeuvring System (OMS). These enabled it to make small manoeuvres in orbit, and slowed the spacecraft on its descent to Earth.

MISSION PROFILE

Soon after lift-off, the booster rockets separate and parachute back to Earth for re-use. A few minutes later, the fuel tank is jettisoned, its fuel used up. The orbiter goes into orbit at an altitude of about 200 km. Here, the astronauts carry out their mission—in this case, launching a satellite. To return to Earth, the orbiter's engines slow it down, and it moves down through the atmosphere, finally gliding back on to a runway.



Payload bay door

Heat-resistant tiles

Entrance hatch

ORBITER

The orbiter is coated with heat-resistant ceramic tiles on its nose and underside. This is to protect it from the intense heat experienced as it re-enters the Earth's atmosphere.

Jettisoned booster rocket

Elevon, used for steering

BLAST-OFF

During lift-off and ascent, the orbiter is powered by liquid oxygen and hydrogen fuel from the fuel tank. It burns more than 200,000 litres of fuel a minute. The booster rockets work like giant fireworks. Once ignited, they cannot be switched off.

The rudder is used both for steering and as a speed brake on landing

Fuel tank

Earth (as seen from space)

Orbiter

Booster rocket

Main rocket engines

USA

NASA Discovery

United States

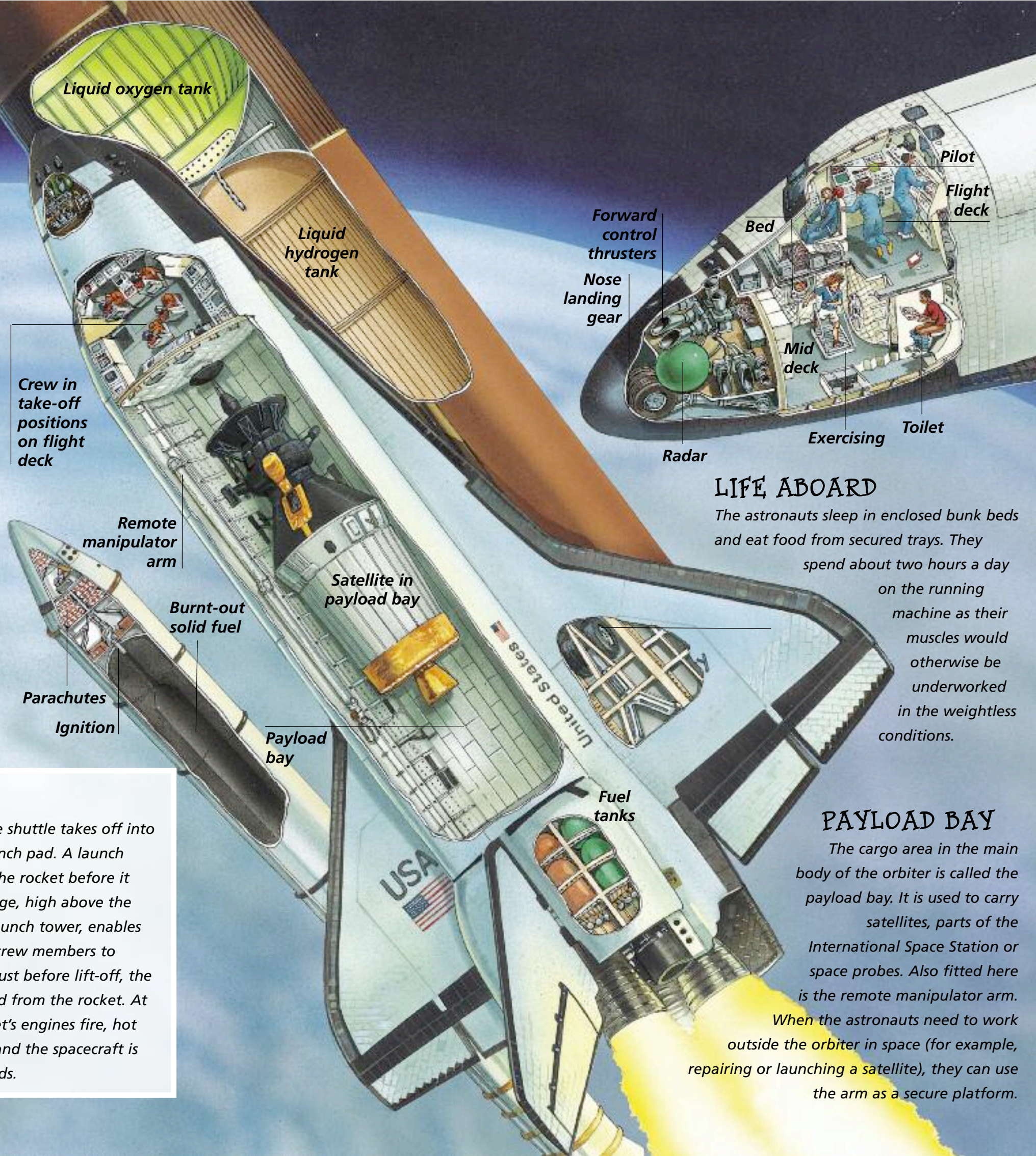
Rocket engines

In a rocket engine, two different fuels mix and react together inside a combustion chamber. Hot gases are created, and they rush out of a nozzle at high speed. The engine, and the spacecraft, are pushed in the opposite direction.

A rocket can operate in space where there is no air. On the Shuttle, a huge, separate fuel tank supplies liquid oxygen and hydrogen to the orbiter's three main engines. The two booster rockets use solid fuel.

LIFT-OFF

A rocket or space shuttle takes off into space from a launch pad. A launch tower supports the rocket before it takes out. A bridge, high above the ground on the launch tower, enables technicians and crew members to enter the craft. Just before lift-off, the tower is detached from the rocket. At lift-off, the rocket's engines fire, hot gases blast out, and the spacecraft is propelled upwards.



LIFE ABOARD

The astronauts sleep in enclosed bunk beds and eat food from secured trays. They spend about two hours a day on the running machine as their muscles would otherwise be underworked in the weightless conditions.

PAYLOAD BAY

The cargo area in the main body of the orbiter is called the payload bay. It is used to carry satellites, parts of the International Space Station or space probes. Also fitted here is the remote manipulator arm. When the astronauts need to work outside the orbiter in space (for example, repairing or launching a satellite), they can use the arm as a secure platform.

HISTORY OF SPACECRAFT



The first rocket was launched on 16th March 1926, by US inventor Robert Goddard (left). The first spacecraft, a satellite called Sputnik 1, was launched in 1957. It had no people on board. Then, in 1961, Soviet cosmonaut Yuri Gagarin became the first person to travel in space.



SPACE STATION

Orbiting the Earth is the International Space Station (below). It is made up of modules containing scientific laboratories and living quarters. In space, the Earth's gravity is weaker so everything floats around (above). Objects—and people—need to be secured. The astronauts use footholds to keep their feet on the ground.



Glossary

Articulated An object made of two pieces that are connected by a flexible joint.

Clutch A device that allows two rotating shafts to be connected or disconnected. In a car, it allows the engine to be disconnected while the gears are changed.

Combustion chamber The enclosed part of an engine where fuel is ignited.

Compressor A device inside an engine that squeezes a gas into less space.

Crankshaft The main revolving rod inside an internal combustion engine.

Fuselage The body of an aircraft.

Gear A toothed wheel on a shaft, which meshes with another to change the revolving motion of the shaft.

Internal combustion engine An engine in which fuel is burned inside the unit.

Piston A cylinder-shaped part or disc that slides backwards and forwards inside a hollow cylinder.

Pressure The amount of force being applied to a certain area.

Radar (RAdio Detection And Ranging)

A system that detects objects by sending out radio signals and receiving the "echoes".

Rotor The hub and connecting blades fitted to a helicopter.

Satellite A spacecraft that orbits the Earth.

Suspension A system of springs and shock absorbers that supports a vehicle over its wheels. It makes the ride inside the vehicle comfortable.

Transformer A device for controlling the voltage of an electric current.

Turbofan A jet engine in which some incoming air is allowed to bypass the combustion chamber.

Turboshaft A jet engine in which the heat energy produced is made to drive a shaft.

Voltage The push that drives an electric current around a circuit.



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