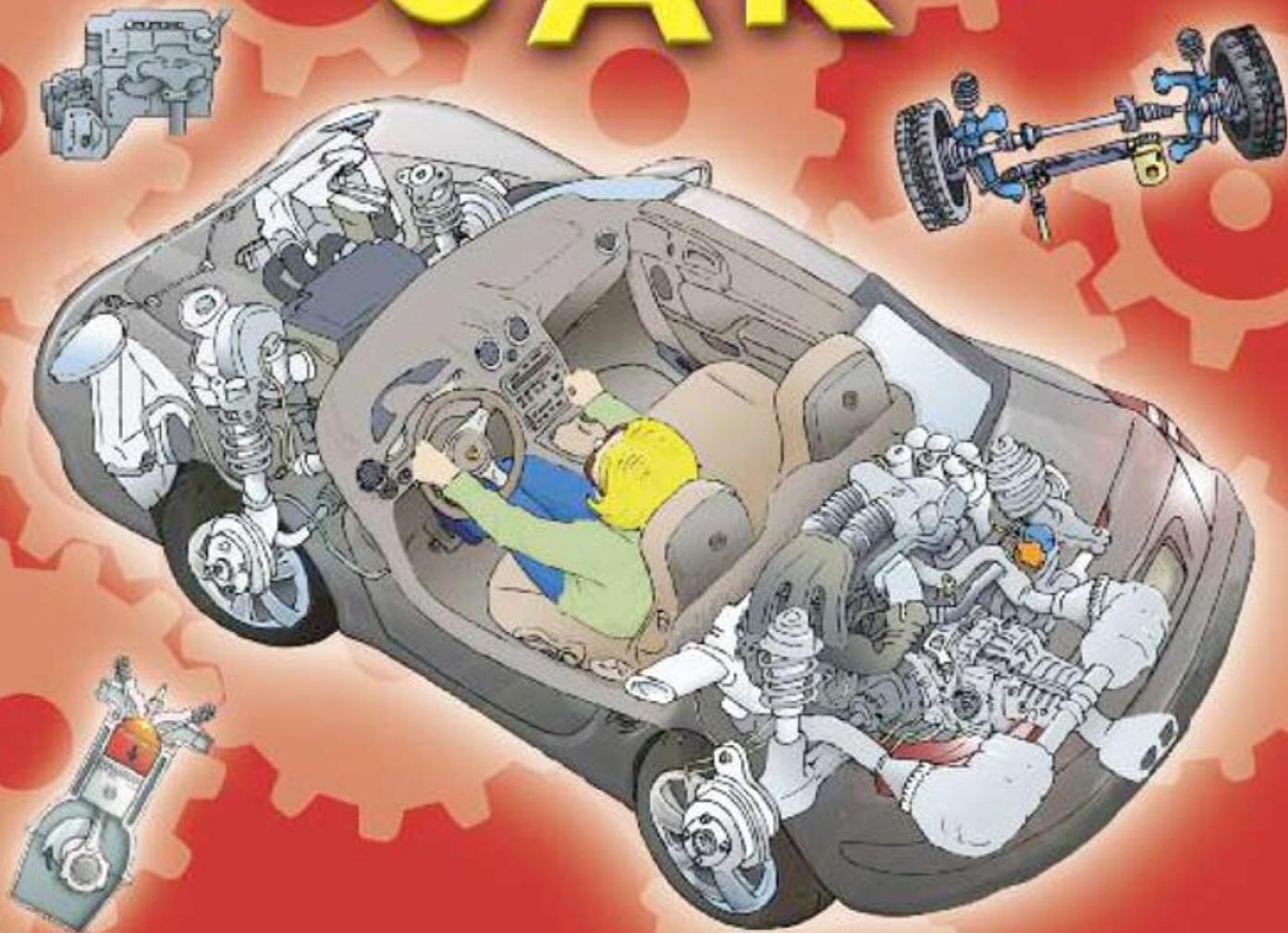


WHAT MAKES IT *GO*?

CAR



# WHAT MAKES IT GO?

# CAR



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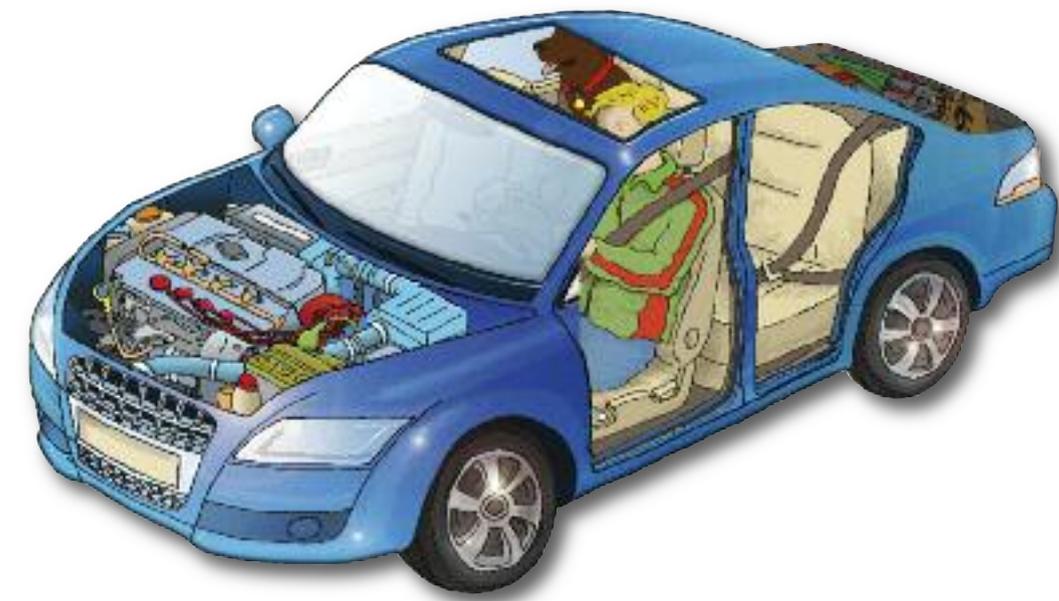
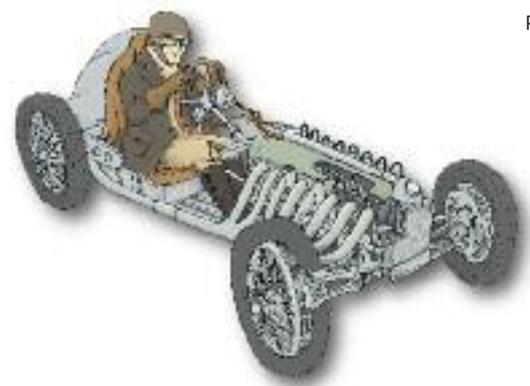
Consultant Chris Oxlade

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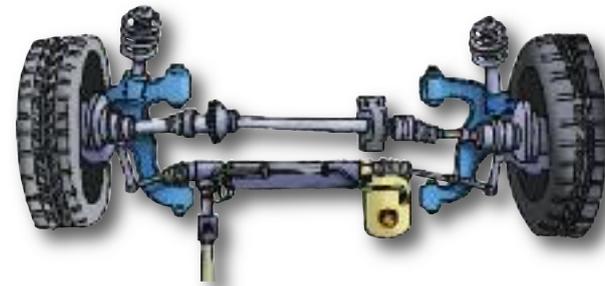
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# INTRODUCTION

**T**his book tells you all about how a car works. You'll discover how the engine drives it forward, how it is steered, what the gears are for and how its brakes slow it down. You can also find out about racing cars and how they are driven.

A car is a wheeled motor vehicle. It carries its own engine or motor and is used for transporting passengers. It usually has four wheels. There are about 600 million cars worldwide and the numbers are rising fast.

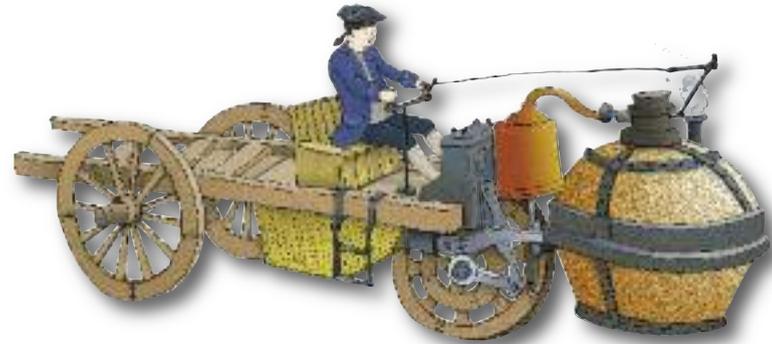
Most cars use petrol or diesel oil as fuel. Unfortunately, the waste gases they give off create air pollution. They are also greenhouse gases, and so they probably contribute to global warming.

So inventors are coming up with new types of car that use different fuels, such as electricity, biofuels (crops specially grown to be converted into fuel) or hydrogen.



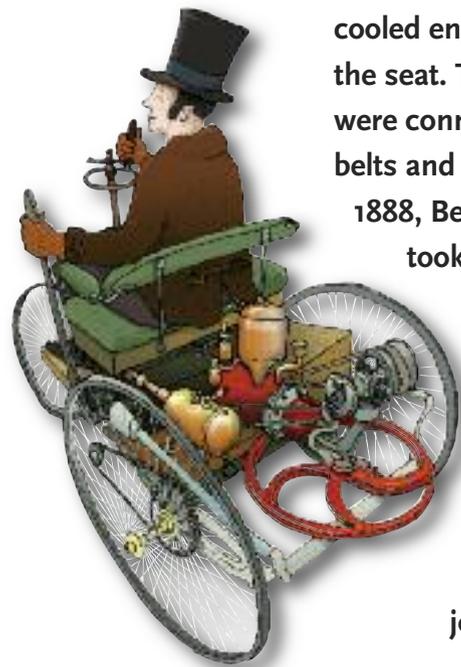
# THE FIRST CARS

The first self-propelled land vehicles were powered by steam engines. The first steam carriage was built in 1769. Designed to pull heavy guns, it caused the world's first motor accident when it crashed into a wall at its top speed of 4 km/h.



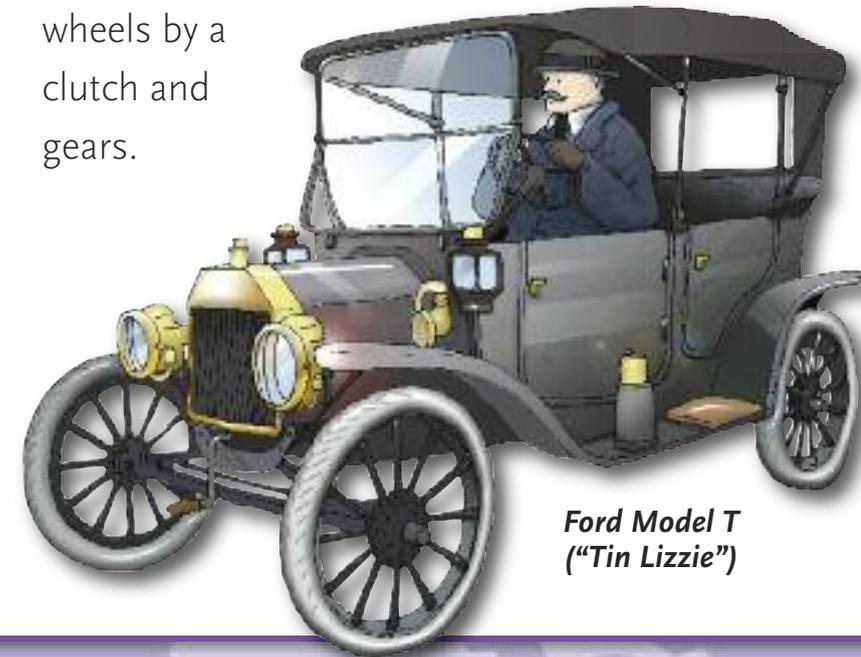
**The steam carriage, built by Frenchman Nicolas Cugnot, could carry four people, although it would have been quicker for them to walk. Hard to steer, it had to stop for refuelling every 15 minutes.**

The age of the automobile really began in 1885 when German engineer Karl Benz successfully fitted a petrol engine to a three-wheeled tricycle. To begin with, his new car lurched dangerously around the streets of Mannheim, but a smooth ride was soon achieved. Meanwhile, another German engineer, Gottlieb Daimler, was hard at work. Also in 1885, he invented a petrol-driven motorcycle



**Benz's first car had a water-cooled engine fixed under the seat. The rear wheels were connected to it by belts and bicycle chains. In 1888, Benz's wife, Bertha, took the car on a 100-km drive to visit relatives, and so became first person to undertake a long journey by car.**

The following year, he built the first four-wheeled car fitted with a powerful petrol engine. It was known as a "horseless carriage". In 1890, two French machine toolmakers, René Panhard and Emile Levassor, began making cars using Daimler engines. Their 1891 model could be described as the first modern car. Fitted beneath a square bonnet at the front, its engine was connected to the rear wheels by a clutch and gears.



**Ford Model T ("Tin Lizzie")**

**The first car to include tyres, gears and steering was the Mercedes 35 hp. Built by the German company Daimler in 1901, it was a luxury car only the rich could afford.**

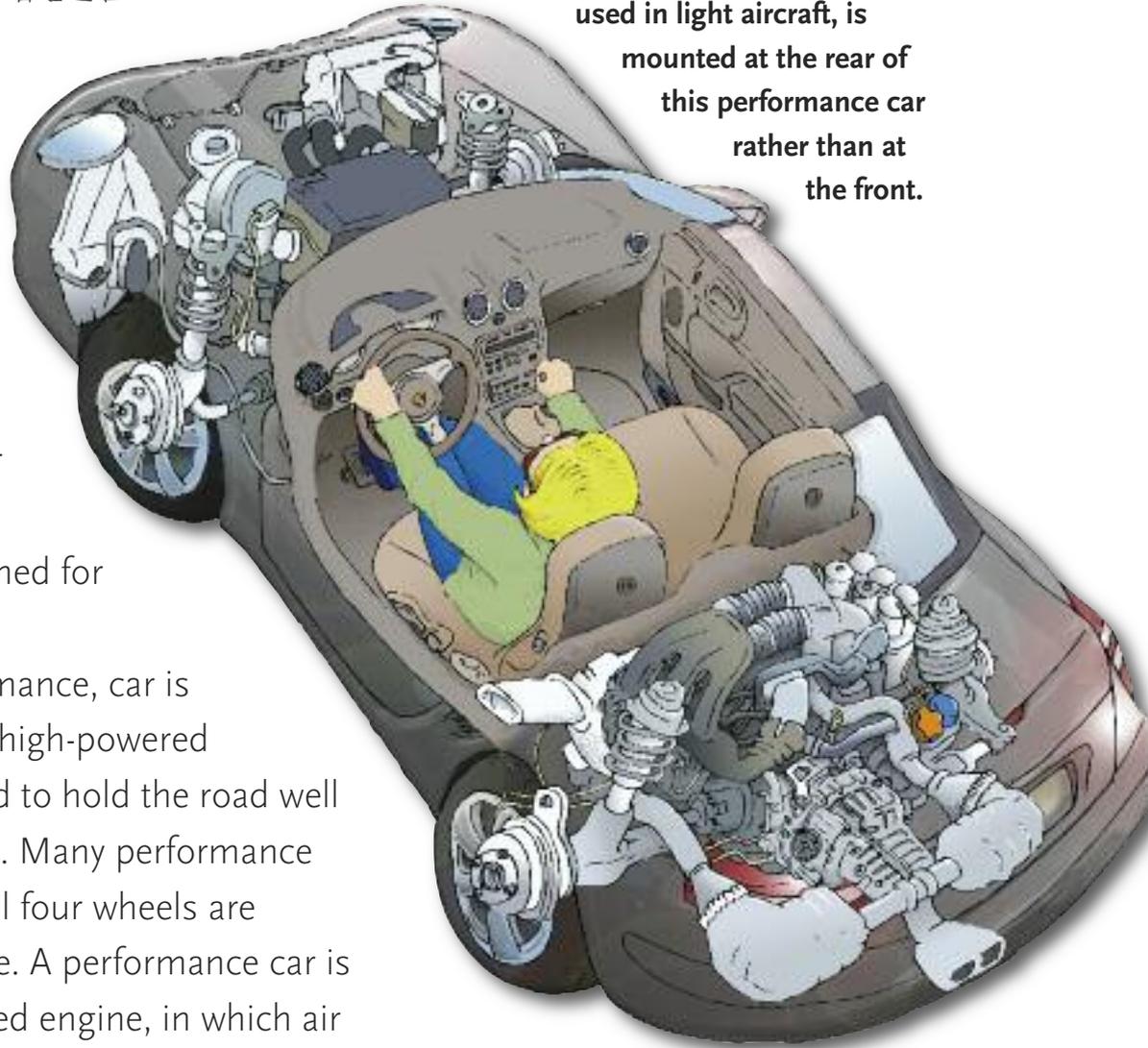


Other modern devices made their first appearances in early French designs: hollow rubber tyres were first used on a 1895 Peugeot and a propeller shaft replaced chain drive in the first Renault built in 1898. Large numbers of the Ford Model T were built in a factory by the American Ford company. They were the first inexpensive cars.

## TYPES OF CAR

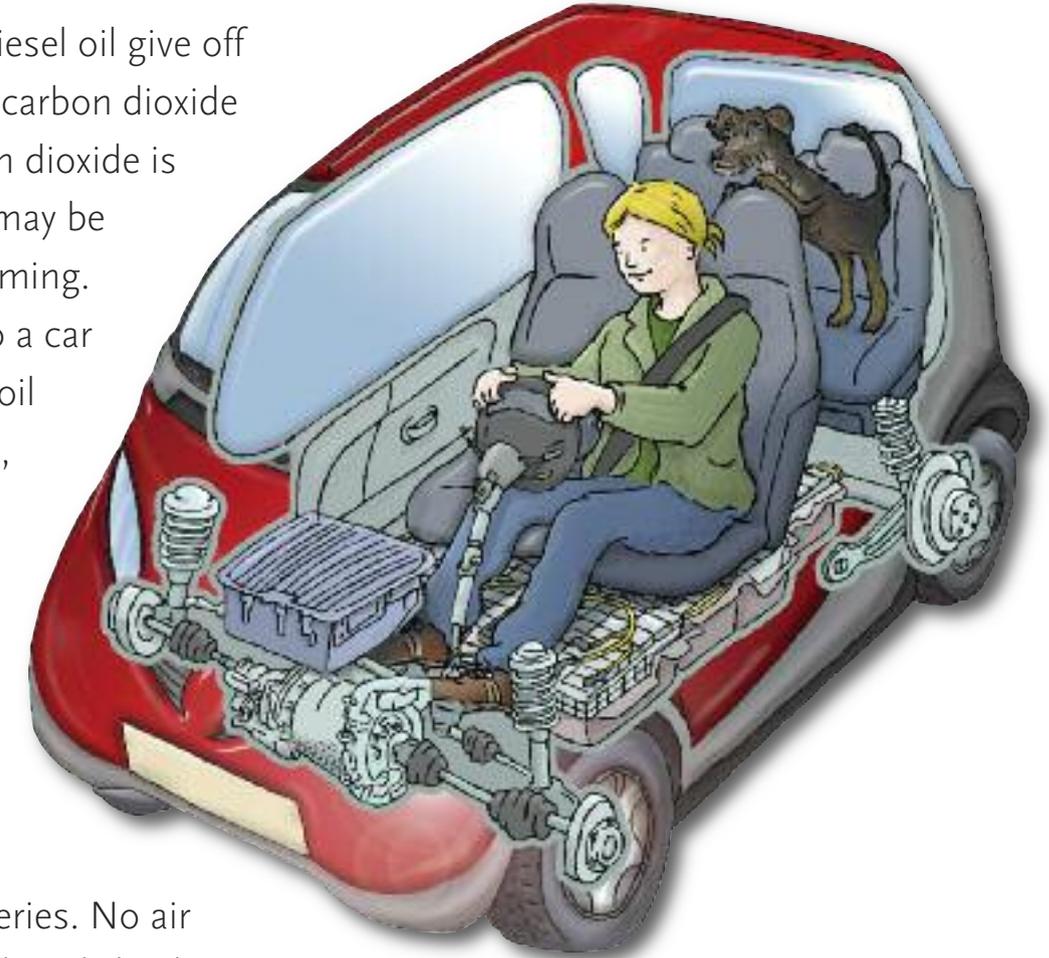
**C**ars are small vehicles with room for a driver and a few passengers. Saloon cars have a separate boot, hatchbacks have room for luggage behind the back seat, while estate cars have a larger space for carrying extra loads. Some cars are specially designed for speed, including racing.

A modern sports, or performance, car is usually lightweight and has a high-powered engine. It is specially designed to hold the road well when cornering at high speed. Many performance cars are four-wheeled drive: all four wheels are powered directly by the engine. A performance car is often fitted with a turbocharged engine, in which air is pumped into the engine to boost its power.



The engine, the same as a type used in light aircraft, is mounted at the rear of this performance car rather than at the front.

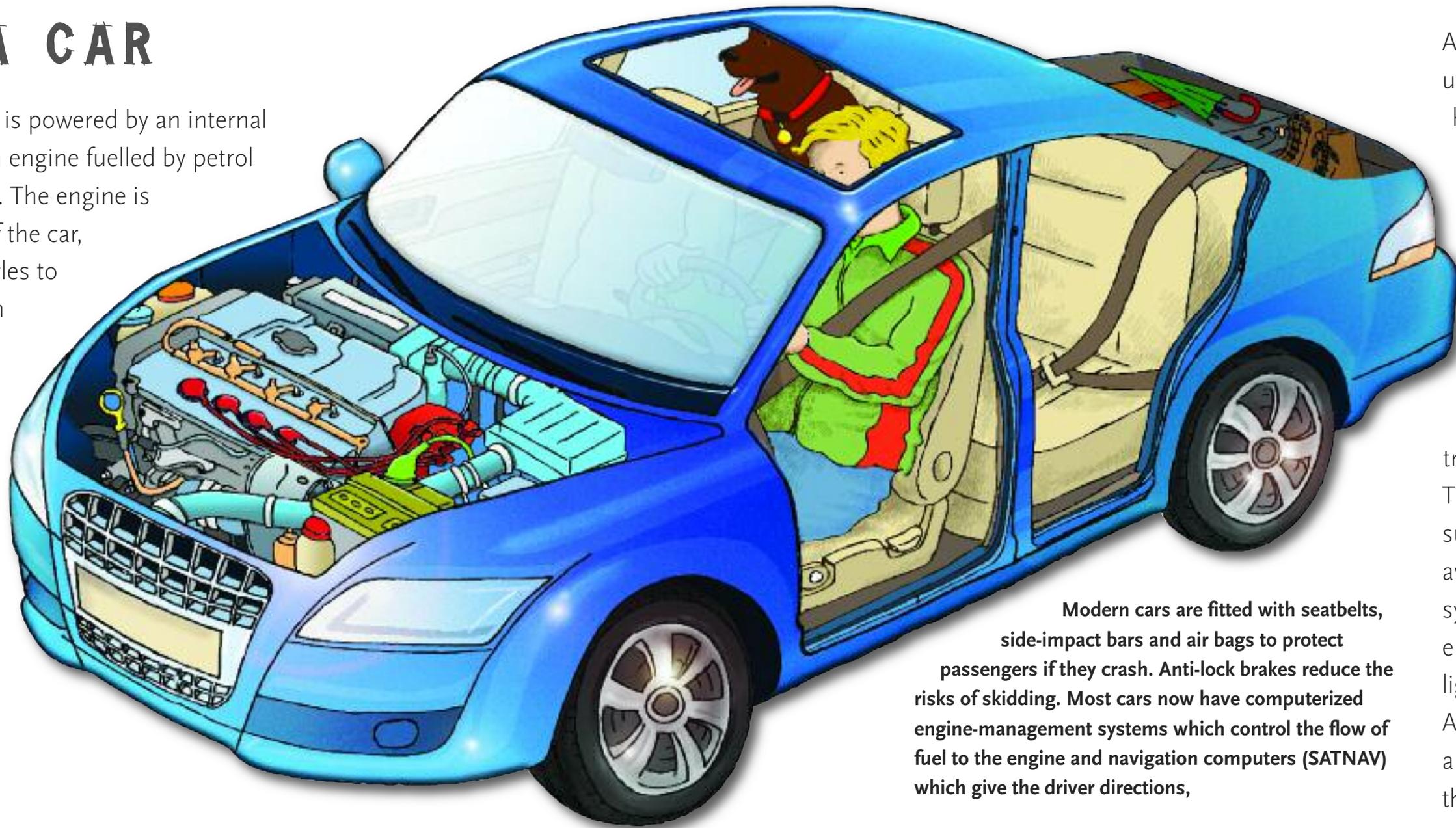
Cars fuelled by petrol or diesel oil give off exhaust gases, which add carbon dioxide to the atmosphere. Carbon dioxide is a greenhouse gas, which may be contributing to global warming. An “cleaner” alternative to a car fuelled by petrol or diesel oil is a battery electric vehicle, or BEV. Instead of an internal combustion engine, the car is fitted with batteries that power an electric motor. The car is “refuelled” by recharging its batteries. No air pollution is emitted directly by the car, and the silent running of the engine cuts down on noise pollution too. But the cars have a smaller range between “refuelling”, and the recharging may take a long time.



**This is a typical EV (Electric Vehicle). Some owners recharge the batteries using rooftop solar panels. While electric cars emit little in the way of pollution or greenhouse gas, they use up more electricity produced by power stations.**

# INSIDE A CAR

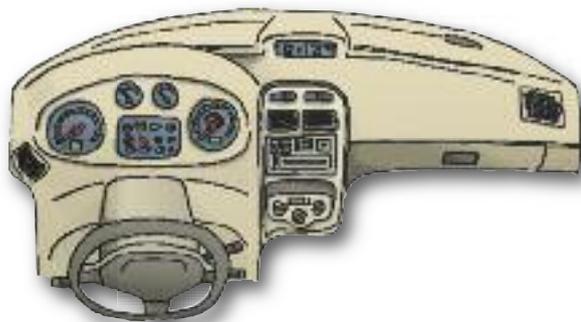
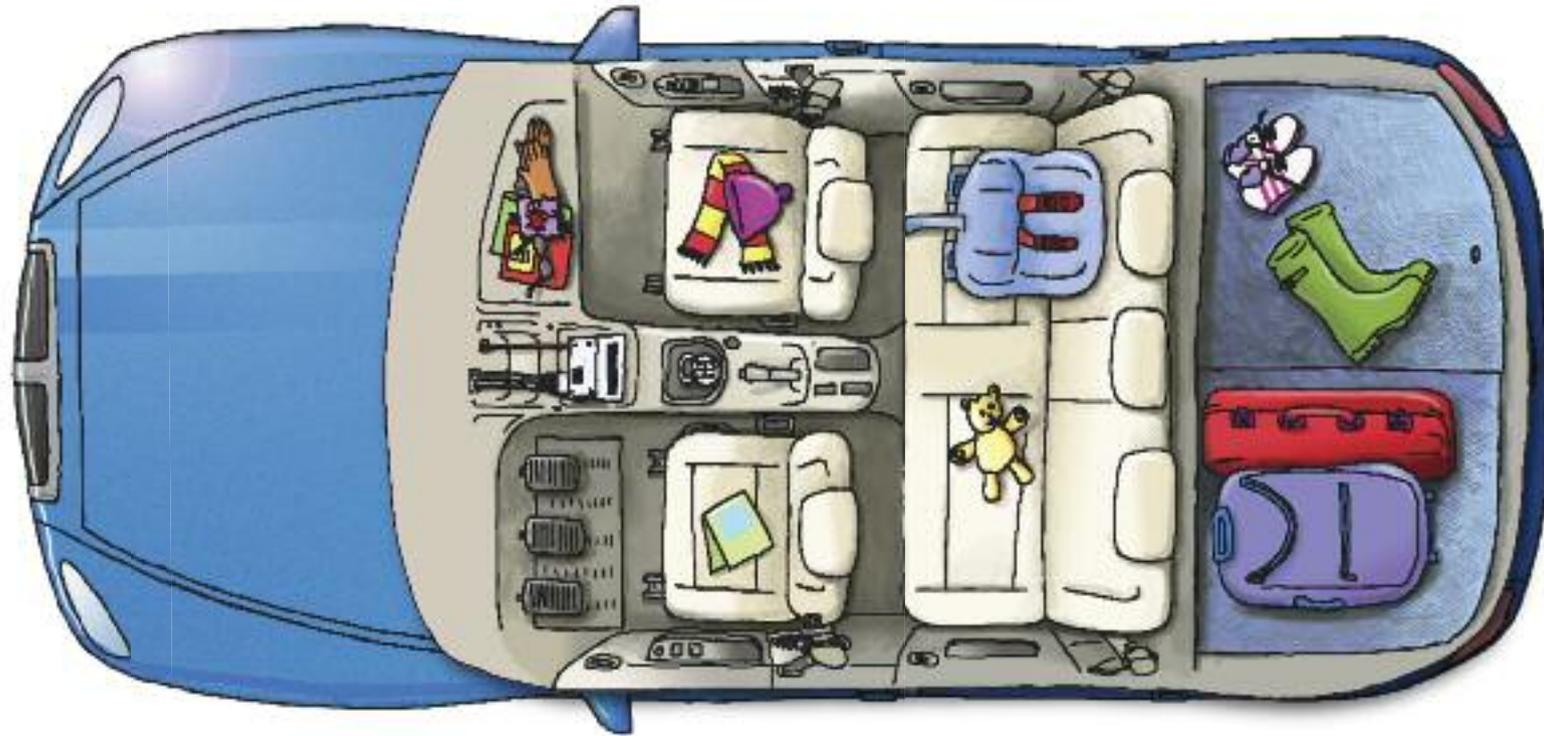
**A** modern car is powered by an internal combustion engine fuelled by petrol or diesel oil. The engine is usually at the front of the car, mounted at right-angles to the direction in which the car travels. The driver can make the car go faster by pressing the accelerator pedal, which increases the power from the engine. The car slows down when the brake pedal is pressed.



**Modern cars are fitted with seatbelts, side-impact bars and air bags to protect passengers if they crash. Anti-lock brakes reduce the risks of skidding. Most cars now have computerized engine-management systems which control the flow of fuel to the engine and navigation computers (SATNAV) which give the driver directions,**

All modern cars, from the smallest urban car to the fastest racing cars, have similar basic features. Wheels and suspension allow the car to roll smoothly along the road. Tyres on the wheels grip the road surface, allowing the car to accelerate, brake and corner without sliding. Power from the engine is transferred to the wheels by the transmission, including 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, the car's lights and other electrical gadgets. All the car's parts are supported by a body shell, which also protects the driver and passengers.

# PARTS OF A CAR



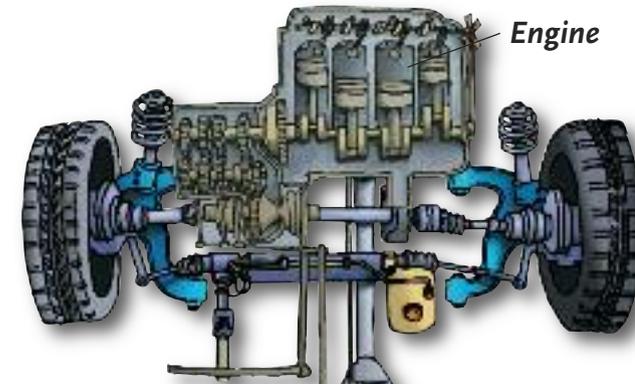
## DASHBOARD

Dials indicating oil levels, speed, engine temperature, etc., together with controls for wiper blades, headlamps, heating and radio, are all found on the dashboard.



## HANDBRAKE

This lever operates the rear brakes mechanically.



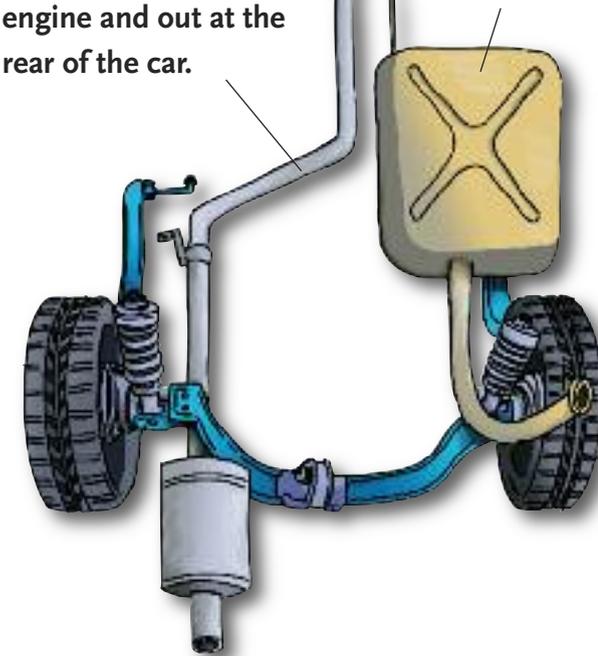
## Engine

## EXHAUST

A pipe takes exhaust gases away from the engine and out at the rear of the car.

## FUEL TANK

This holds the fuel, usually petrol or diesel oil, for the engine.



## RADIATOR

A pump drives water around channels inside the engine to cool it. The hot water then passes to the radiator, where heat is lost to the air.

**PEDALS** From the left, these are: clutch pedal, which the driver presses down when changing gear, foot brake and accelerator.



**GEARSTICK** This allows the driver to select the right gear.

## COOLANT RESERVOIR

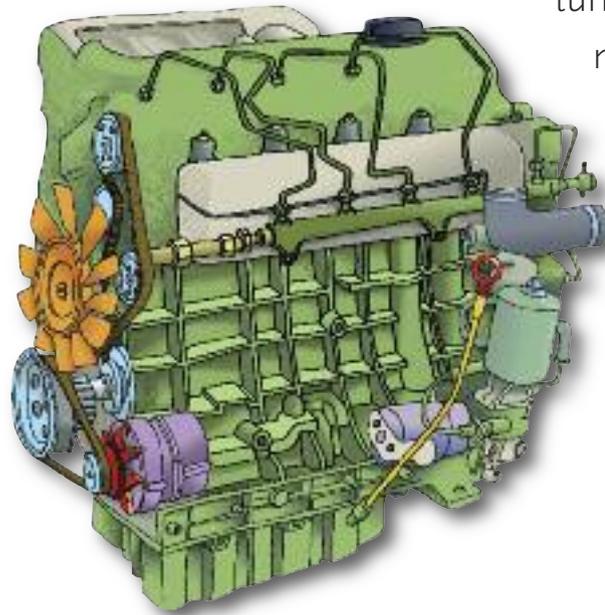
The water that cools the engine is mixed with anti-freeze to stop it freezing in cold weather.



**BATTERY** A car battery produces the strong current needed to turn the starter motor. It contains plates of lead immersed in acid.

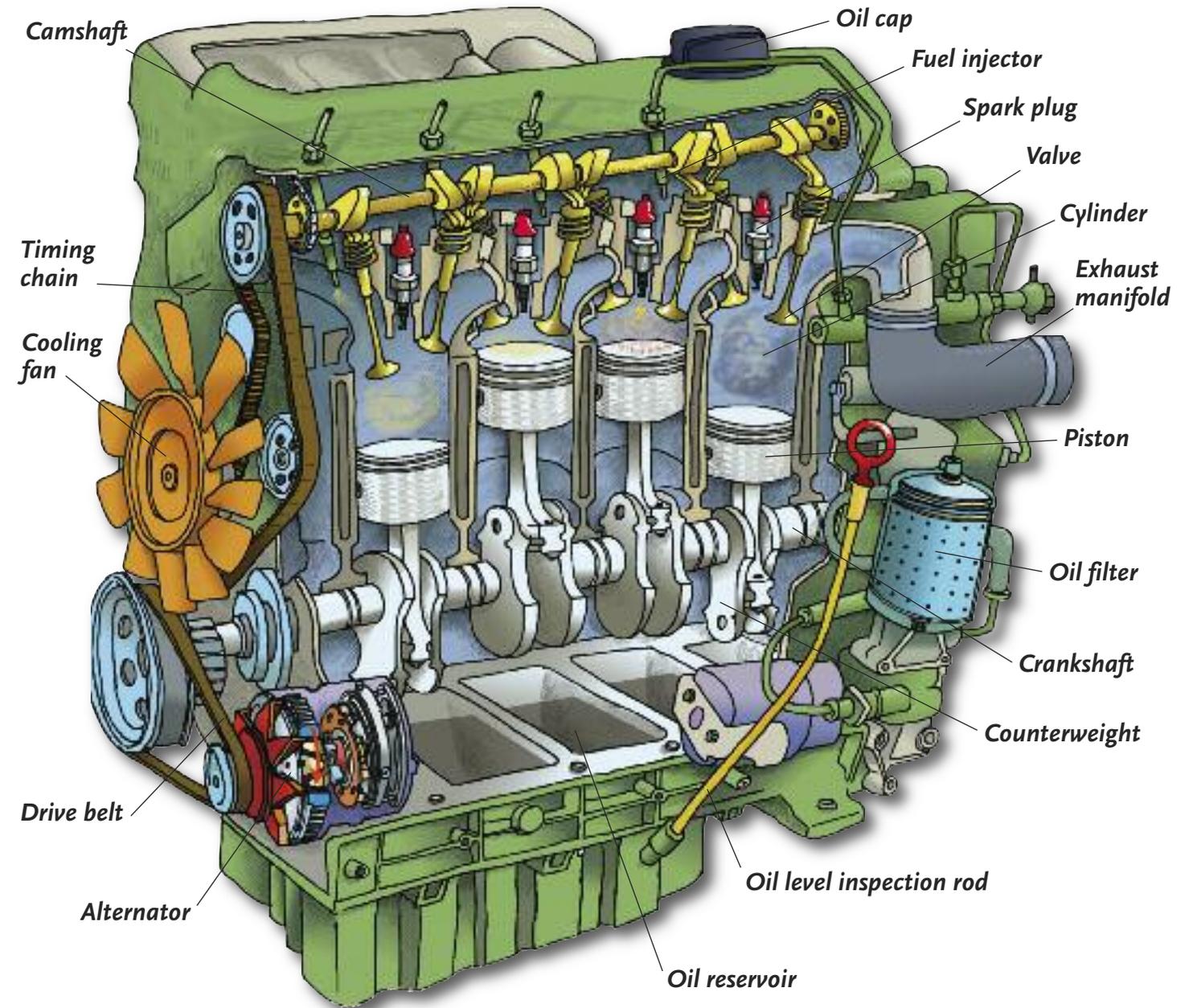
# THE ENGINE

A car is powered by a piston engine. It is a kind of internal combustion engine, so-called because fuel, usually either petrol or diesel oil, is burned (combusted) inside it. Fuel is pumped from the tank to an electronic fuel-injection system. There it is turned into a fine spray and mixed with air. Inlet valves let the fuel/air mixture into the engine's cylinders where it is ignited by electric spark plugs. During what is called the four-stroke cycle (see page 18), the explosions that result when the spark plugs light the fuel/air



mixture drive the pistons inside the cylinders up and down. The crankshaft, to which the pistons are attached, turns this up-and-down motion into a turning motion. The crankshaft is, via the gears, connected to the wheels, and so the car is driven along.

**This piston engine has four cylinders, arranged "in-line". Other, more powerful engines have two banks of four (or five or six) cylinders positioned on either side of the engine and tilted inwards to form a "V" layout. These are called V-8 (or V-10 or V-12) engines.**



# PARTS OF AN ENGINE



## SPARK PLUG

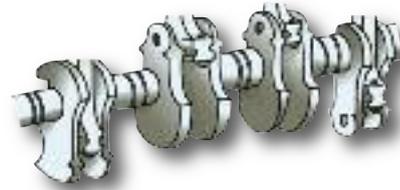
The spark plugs ignite the fuel-air mixture inside the cylinders.



## OIL CAP

Lubricating oil allows the engine's

moving parts to slide alongside one another smoothly.



## CRANKSHAFT

Besides turning the wheel of the car, the crankshaft also powers the alternator and turns the camshaft.



## FUEL INJECTOR

This injects a fine spray of fuel into each cylinder.

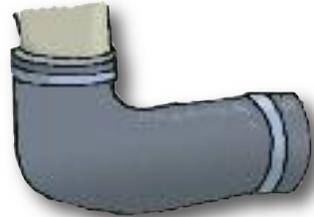
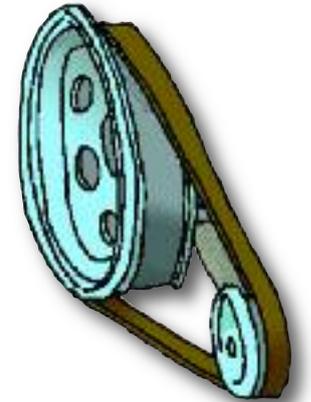


## VALVE

The inlet valve lets in the fuel/air mixture; the exhaust valve lets out the exhaust gases.

## DRIVE BELT

Taking power from the crankshaft, this drives the alternator.



## EXHAUST MANIFOLD

Exhaust gases escape the cylinders via the exhaust valve, and are piped out of the engine through the exhaust manifold.

## PISTON

The up-and down movement of the pistons is turned into a circular motion by the crankshaft.



## OIL FILTER

Oil passing through the filter is cleaned of any grit and other impurities.

## TIMING CHAIN

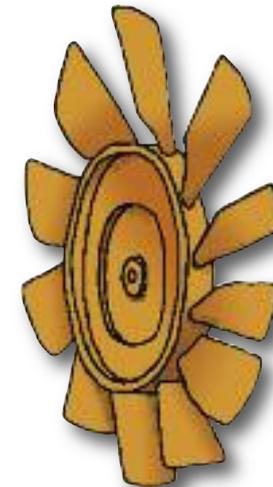
The camshaft is turned by the crankshaft. It is connected to it by this timing chain.



## OIL LEVEL

### INSPECTION ROD

Also called a dipstick, this is used to check the level of oil in the engine.

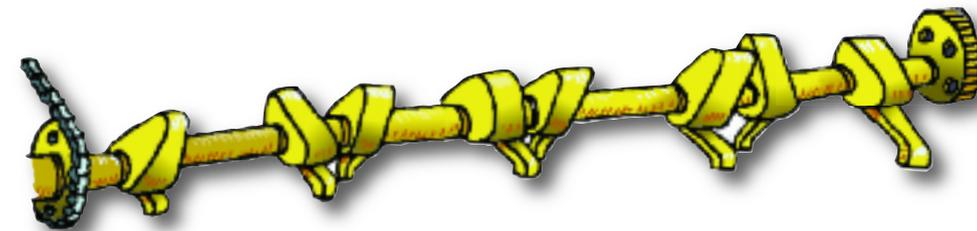
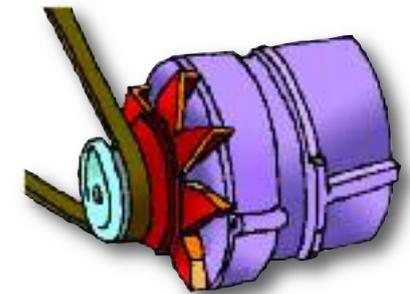


## COOLING FAN

Driven by a small electric motor, the fan helps to keep the engine cool.

## ALTERNATOR

When the alternator is turned by the crankshaft, it produces electricity to recharge the battery. It powers the car's electrical systems once the engine is running.

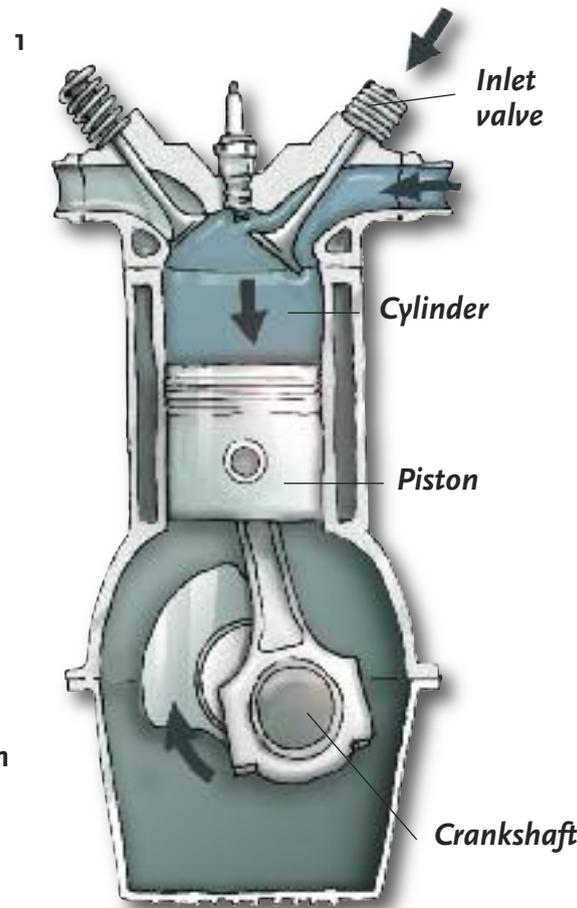


**CAMSHAFT** The camshaft opens and closes the valves.

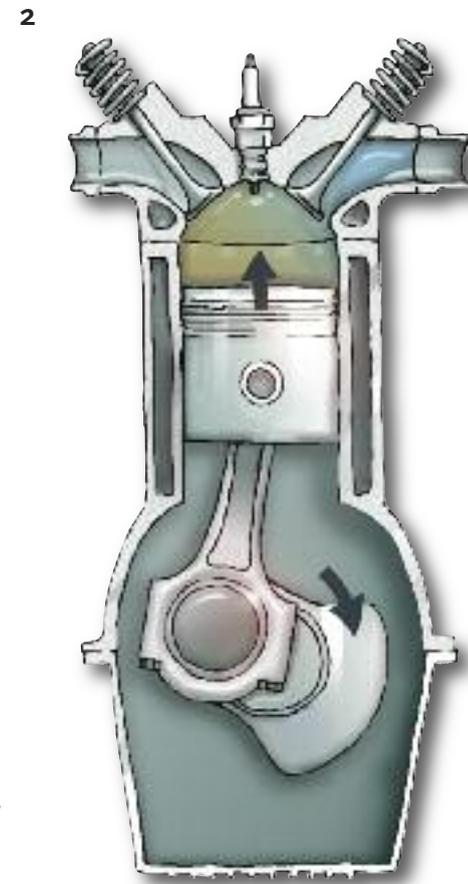
# THE FOUR-STROKE CYCLE

**M**ost car petrol engines use a four-stroke cycle to turn the crankshaft. One cycle consists of four strokes: induction stroke (1), compression stroke (2), power stroke (3) and exhaust stroke (4). During a four-stroke cycle, the crankshaft makes two complete revolutions (turns) per cycle.

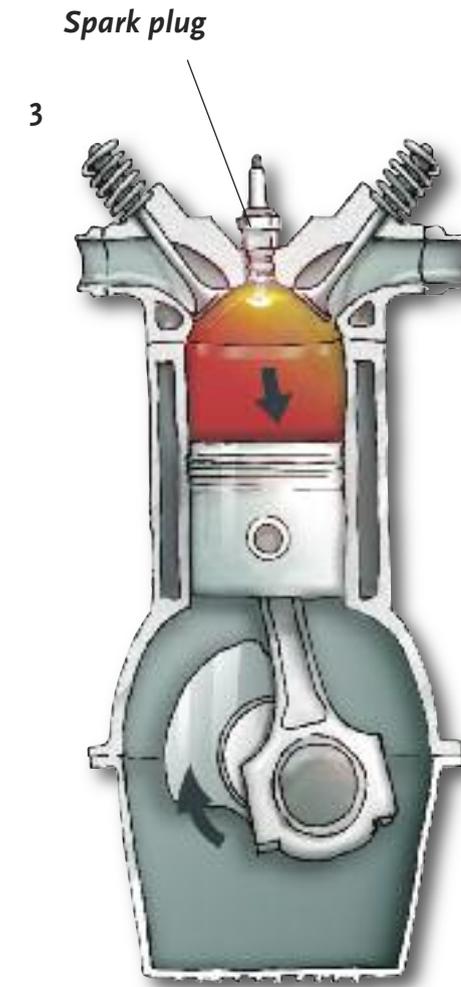
On the first stroke (1), the piston moves down and the inlet valve opens. A mixture of fuel and air is sucked into the cylinder.



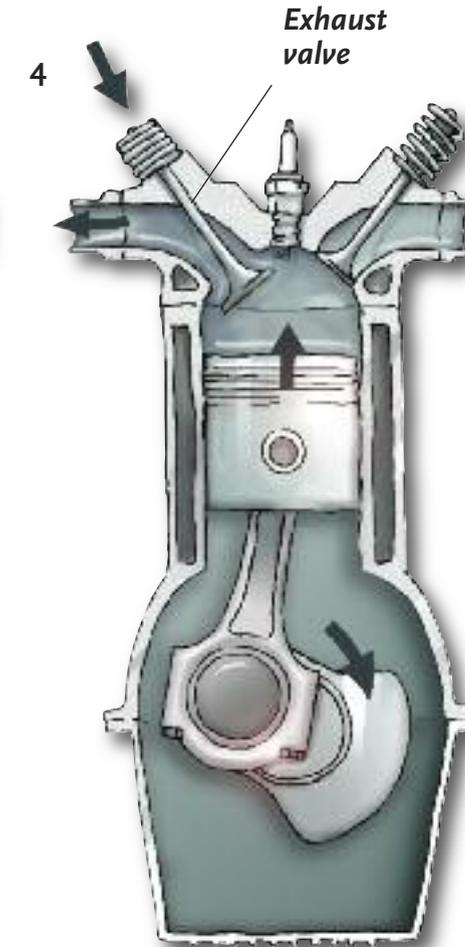
The fuel/air mixture is squeezed when the piston completes its second stroke (2). At that moment, a spark ignites it.



The expanding gases created in the explosion force the piston down again: the third stroke (3).



As the piston rises on the fourth stroke (4), the exhaust valve opens to let out the waste gases.



Inlet valves let the fuel-air mixture into the cylinder and exhaust valves allow the exhaust gases to be expelled from the cylinder. The opening and closing of the valves is precisely controlled and timed by the rotation of the camshaft. Four or more cylinders sparking one after the other very quickly produce a continuous power to the wheels.

# MOVING FORWARD

**A** car engine relies on pistons for its power. They move up and down very quickly inside their cylinders, turning the crankshaft. The crankshaft is connected to the wheels via gears. The wheels are made to turn round and so the car moves forwards (or backwards when the reverse gear is selected). The driver controls the car using the accelerator pedal, which adjusts the car's speed, brake pedal, clutch pedal, steering wheel and gear stick.

The gearbox links the crankshaft in the engine to the car's wheels. Only when the driver has selected top gear does the crankshaft connect directly to the wheels. In the other, lower gears, a variety of cogs inside the gearbox ensure the wheels move at different speeds to the crankshaft.

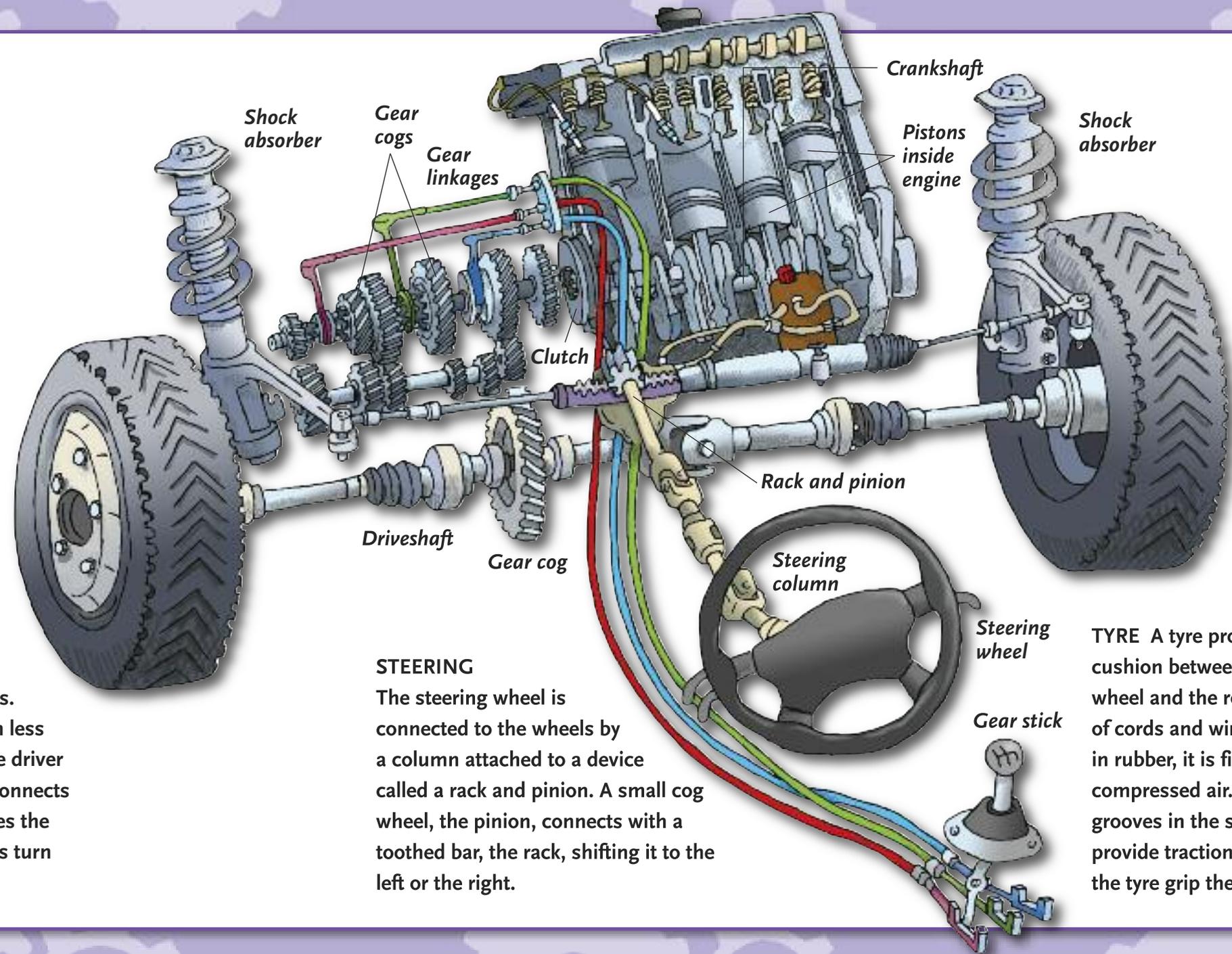
## GEARS

**Gears** These are a set of cogs that link the engine to the wheels. When the driver selects low gear, the cogs make the wheels turn slower than the crankshaft. This produces more power at slow speeds. The driver selects higher gears when less power is needed. To change gear, the driver presses the clutch pedal, which disconnects the gears from the engine, and moves the gear stick. The cogs make the wheels turn slower than the crankshaft.

## STEERING

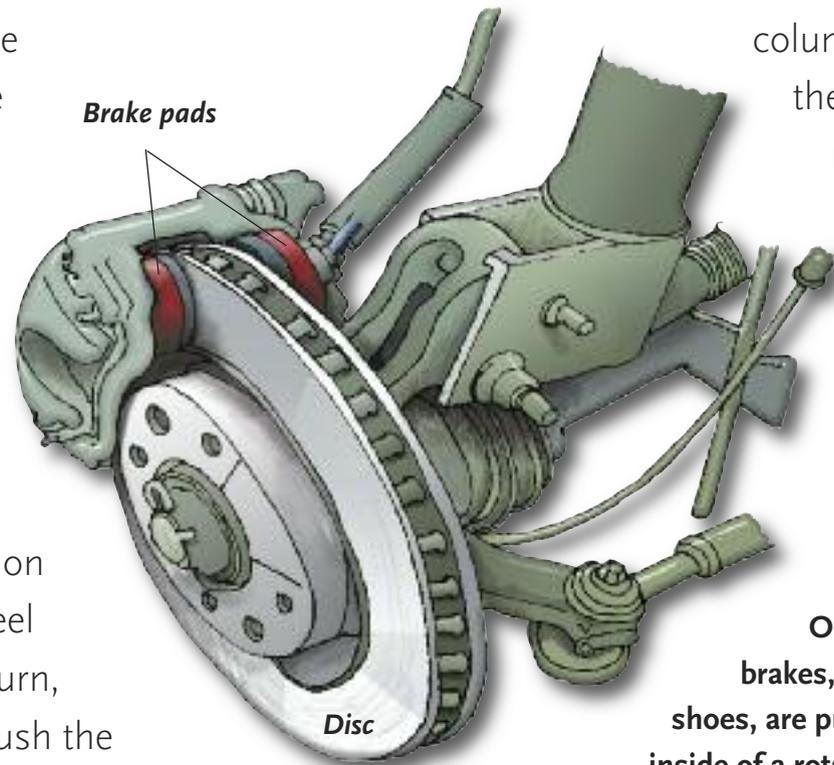
The steering wheel is connected to the wheels by a column attached to a device called a rack and pinion. A small cog wheel, the pinion, connects with a toothed bar, the rack, shifting it to the left or the right.

**TYRE** A tyre provides a cushion between the wheel and the road. Made of cords and wires encased in rubber, it is filled with compressed air. The tread, grooves in the surface, provide traction, helping the tyre grip the road.



# BRAKES AND SUSPENSION

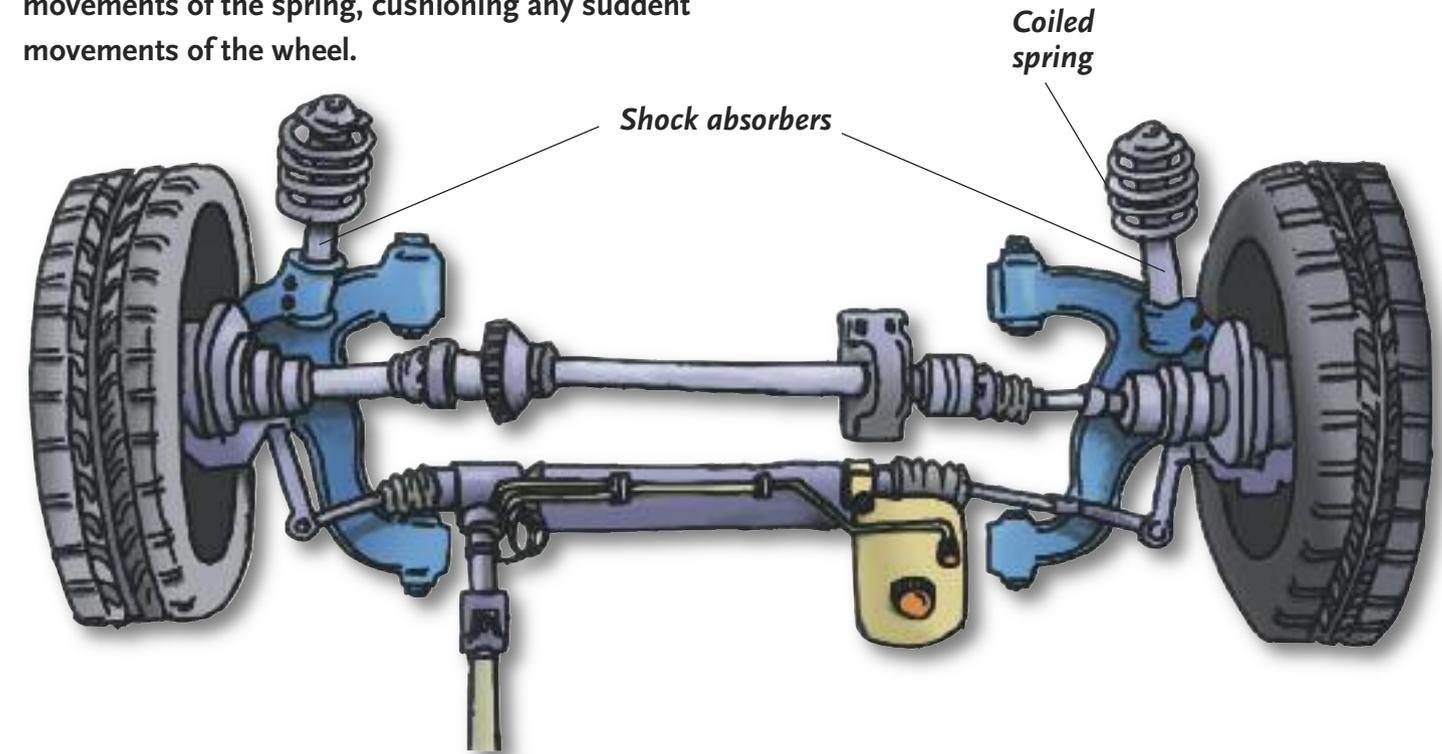
**W**hen the driver presses the brake pedal, two brake pads grip a disc fitted to the inside of each of the car's wheels. These slow the wheels down. The brake pedal is linked to a hydraulic braking system. The force of the driver's foot increases pressure on fluid inside the wheel cylinders. This, in turn, forces pistons to push the brake pads against the disc. In cars, the hand brake (also known as parking brake) is used to keep the car stationary.



It is usually a hand-operated lever on the floor to one side of the driver, or a pull-handle located near the steering column. When pulled, the brake pads mechanically grip the discs but with less force than used by the hydraulic system.

**Older cars have drum brakes, in which pads, called shoes, are pushed against the inside of a rotating drum. The drum is attached to the wheel, so the car is slowed down. Drum brakes are still often used as hand brakes.**

In coil-sprung suspension, the coil around each shock absorber squeezes together as the wheel rises, smoothing out the jolts. The shock absorber damps down the movements of the spring, cushioning any sudden movements of the wheel.

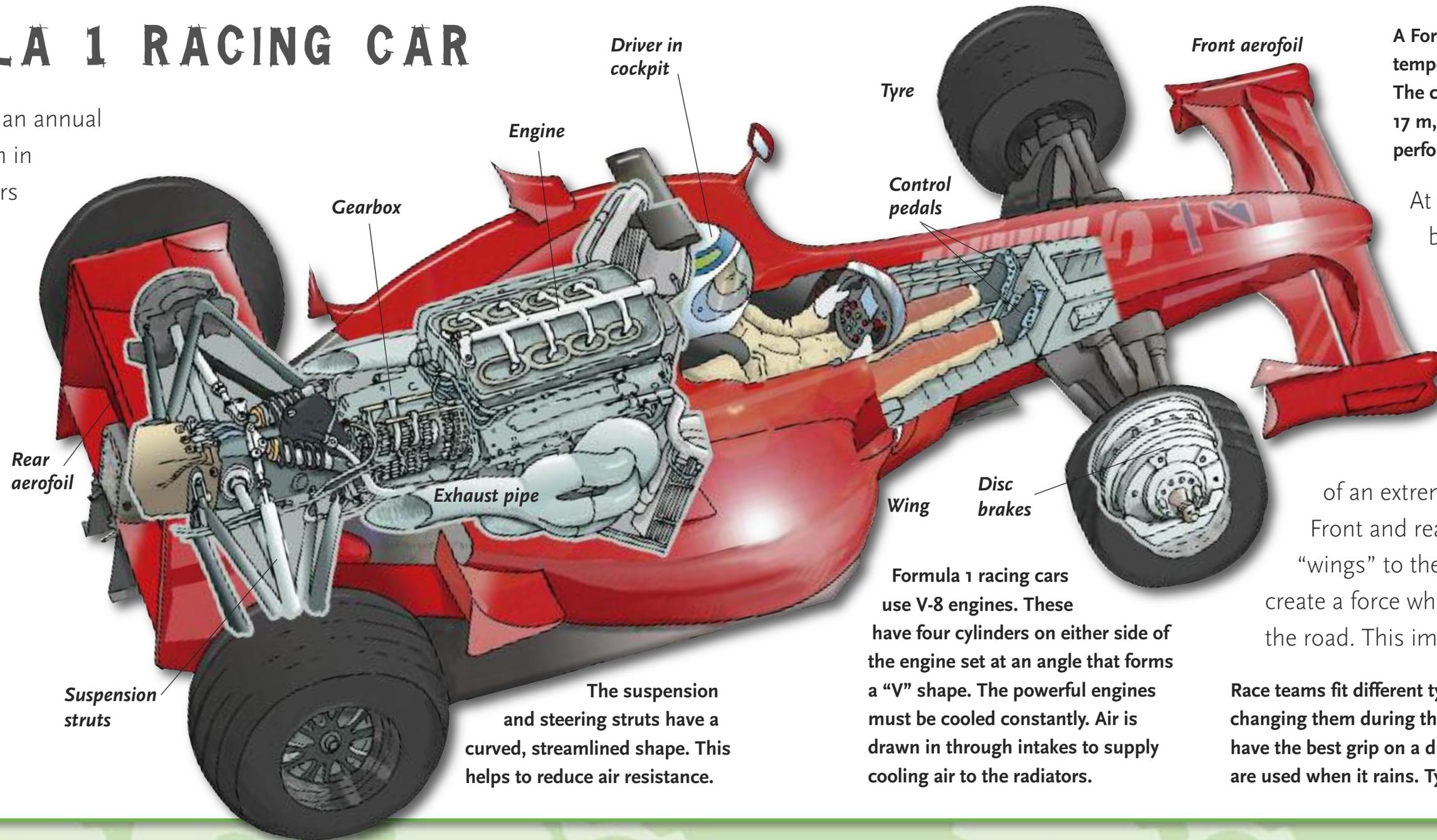


The suspension allows the car to drive smoothly over a bumpy road, with as little upwards and downwards movement as possible. A coil spring and a shock absorber are attached to each wheel.

The springs take the force of the jolts, while the shock absorbers dampen the up and down movement of the springs. The suspension ensures the wheels stay on the road, while giving a smooth ride.

# FORMULA 1 RACING CAR

**F**ormula 1 is an annual competition in which drivers race on different circuits around the world. The cars they drive use the latest technology to maximize speed, reliability and safety. A modern race team involves a large number of engineers, technical experts and pit-lane mechanics, as well as the drivers.



The suspension and steering struts have a curved, streamlined shape. This helps to reduce air resistance.

Formula 1 racing cars use V-8 engines. These have four cylinders on either side of the engine set at an angle that forms a "V" shape. The powerful engines must be cooled constantly. Air is drawn in through intakes to supply cooling air to the radiators.

A Formula 1 car's brakes must work at temperatures of 1000°C without parts melting. The car slows from 100 to 0 km/h in about 17 m, compared with just over 30 m in a performance car.

At high speed, the air itself holds back the most powerful vehicle, so a Formula 1 car has a smooth, streamlined shape to keep this air resistance to a minimum. The car must weigh as little as possible. Its shell, called a single-piece monocoque, is made of an extremely light carbon fibre material. Front and rear aerofoils, together with "wings" to the left and right of the cockpit, create a force which presses the car down on to the road. This improves the grip of the tyres.

Race teams fit different tyres for different conditions, often changing them during the course of a race. Slick (smooth) tyres have the best grip on a dry track but skid in the wet, so wet tyres are used when it rains. Tyres perform best at high temperatures.

# AT THE WHEEL

The steering wheel of a Formula 1 car is not like an ordinary car wheel. The controls, a set of buttons, switches and toggles (easy-to-grab switches), are positioned on the wheel itself so the driver's hands do not have to move far from the grip. Some of the controls help the driver communicate with the crew in the pits.

**CLUTCH AND GEARS** On a normal car, the clutch is a pedal and the gears are changed using a stick (see page 20). Here, the clutch and gears are controlled by hand. They are “paddles” fixed to the back of the steering wheel.

**NEUTRAL (1)** This button selects neutral gear. The engine is still running but, because it is disconnected from the wheels, the car stands still.

**PIT LANE SPEED LIMITER (2)** This prevents the car from going too fast in the pit lane.

**COCKPIT LIGHTS (3)** The warning flags used in the race—blue, red and yellow—also appear as lights on the wheel.

**RADIO (4)** The driver and his crew in the pits talk to one another by radio.

**PIT CONFIRM (5)** When the crew calls the car to the pits, the driver presses this button to indicate he has understood.

**MAIN DISPLAY** The main screen gives the driver all kinds of information, including speed, lap times, gear selected, etc. The driver uses buttons top left and top right of the wheel to scroll through.

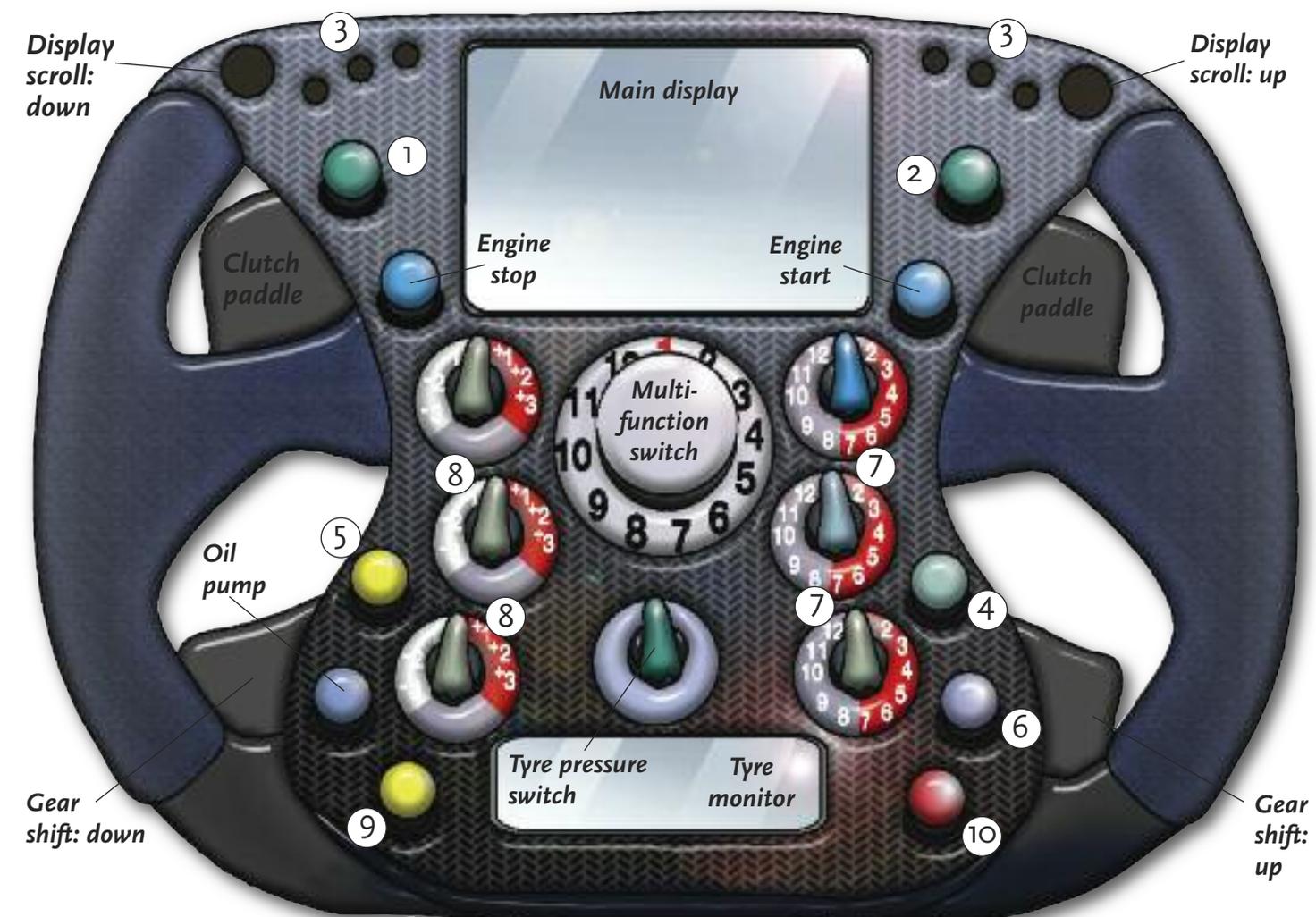
**DRINK (6)** This works a pump to supply the driver with drinking water.

**TYRE MONITOR** The condition of the tyres is very important in a F1 car. The monitor warns the driver if the tyres are wearing out.

**ENGINE CONTROLS (7)** The switches allow the driver to adjust, for example, the fuel/air mixture or sensitivity of the accelerator pedal.

**DIFFERENTIAL CONTROLS (8)** The differential is a device fitted to the axle. It allows one wheel to turn at a different speed to the other—vital for cornering.

**DIAGNOSTIC (9) and DATA CHECK (10)** When pressed, the crew can check the car's performance, so they know what adjustments to make in the pits.



# SPEEDSTERS

Only a few years after the motor car was invented, people wanted to drive them as fast as possible. The first land-speed record was set by Frenchman Count Gaston de Chasseloup-Laubat, driving a

Jeantaud *Duc* to a

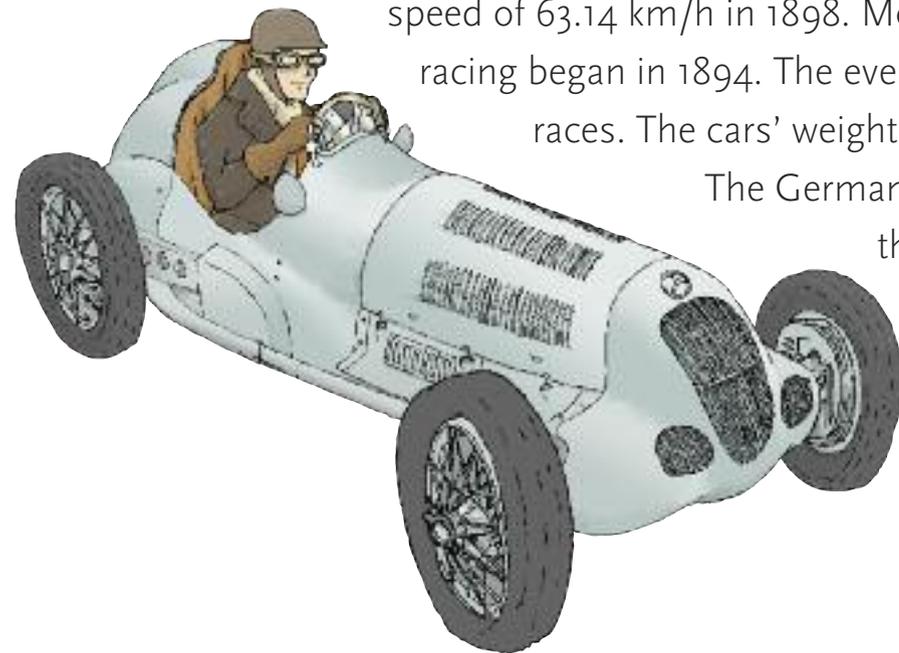
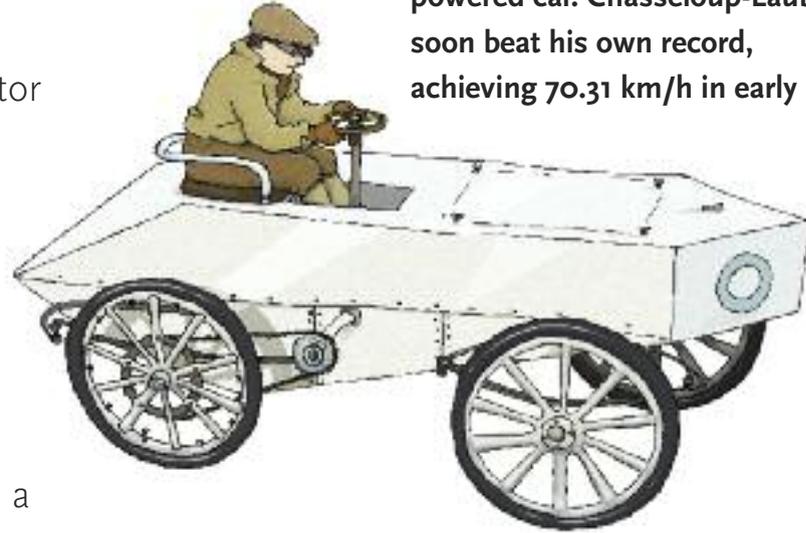
speed of 63.14 km/h in 1898. Motor

racing began in 1894. The events became known as Grand Prix races. The cars' weight was limited by an agreed "formula".

The German Silver Arrows, so-called because they were left unpainted to reduce weight, dominated Grand Prix racing in the 1930s.

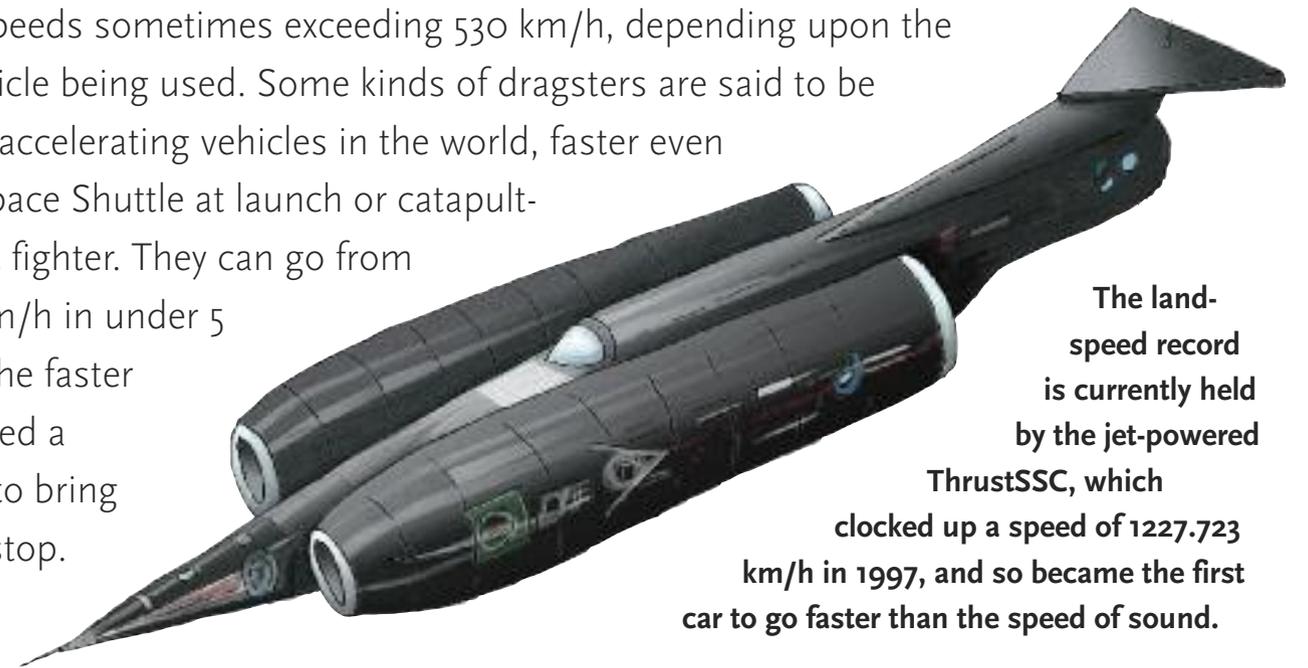
**The German-built Mercedes Benz W125 was the most powerful racing car of its day. It reached speeds of more than 300 km/h in 1937.**

**The Jeantaud *Duc* was an electric powered car. Chasseloup-Laubat soon beat his own record, achieving 70.31 km/h in early 1899.**



The top racing cars today reach speeds of up to 360 km/h, but the fastest racers are probably the dragsters. Most drag races begin with a standing start and are just 400 m long. Races last only a few seconds, with finishing speeds sometimes exceeding 530 km/h, depending upon the type of vehicle being used. Some kinds of dragsters are said to be the fastest accelerating vehicles in the world, faster even than the Space Shuttle at launch or catapult-assisted jet fighter. They can go from 0 to 500 km/h in under 5 seconds. The faster vehicles need a parachute to bring them to a stop.

**The high wing on this dragster is to improve traction (its grip on the road) at high speed.**



**The land-speed record is currently held by the jet-powered ThrustSSC, which clocked up a speed of 1227.723 km/h in 1997, and so became the first car to go faster than the speed of sound.**

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