Breakthroughs IN SCIENCE AND TECHNOLOGY

Who Invented the Automobile?

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Brian Williams

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World on wheels

From animal power to engines

Few inventions changed people's lives more than the automobile. Before the 1700s, all land vehicles, such as carts and carriages, were pulled by animals. Most people could not afford a horse or any sort of road vehicle and had to rely on their legs to carry them to where they wanted to go. Then came two revolutionary inventions: first the steam locomotive, and then, in 1885, the automobile.

From steam to gas

Steam engines were first used in the early 1700s to drive pumps, and later to power ships, trains, and factory machines. Steam was also tried on the road, but it was not very successful. The *modern* revolution in road travel really began with the invention of the "**internal combustion**" engine. Slowly, motorized cars and trucks replaced horse-drawn carriages and ox-drawn carts. Since the first cars appeared on the roads, over one hundred years ago, scientists and engineers have made many more improvements in auto technology, to produce the fast, comfortable, and safe cars we use today. Those changes are ongoing, as companies look to design cars for the future that use lighter materials and run on cleaner, **alternative fuels**.

Putting the pieces together

Many of the early car pioneers worked alone. They made parts themselves, coming up with and borrowing ideas, and adapting useful, existing technology—for example, from the steam engine and the bicycle. Pioneers were also quick to adopt new technologies, such as electric batteries or air-filled rubber tires. Often two inventors would have the same idea independently. Some inventors became rich and famous, founding international businesses. Others gave up and were soon forgotten.

Paris, France, in the 1860s. Horse-drawn carts and carriages rattled along city streets, but most people had to walk to wherever they needed to go. But less than 30 years later, cars had joined the Paris street traffic.

THAT'S A FACT!

In 1900, there were fewer than 25,000 cars in the world. By 1910, that number had risen to about one million. Today, there are more than 600 million. Car manufacturers make more than 40 million cars every year.

In Paris today, the streets are crowded with automobiles. Cities have had to adapt to the car—an invention that many people think they could not live without.

Over the years, each new piece of auto technology has been a breakthrough, but when Karl Benz drove his first car in 1885, he started a revolution. The car created new industries, changed the way people spent their leisure time, and altered the landscape. Today, with millions of cars on busy roads across every continent, the car’s success has become a challenge to science. Too many cars burn too much gas and give off too much harmful waste. The challenge now is to make new cars that use fuels that are less harmful to the environment. Today’s science breakthroughs will create the cars of tomorrow.

The horseless carriage

Steam power

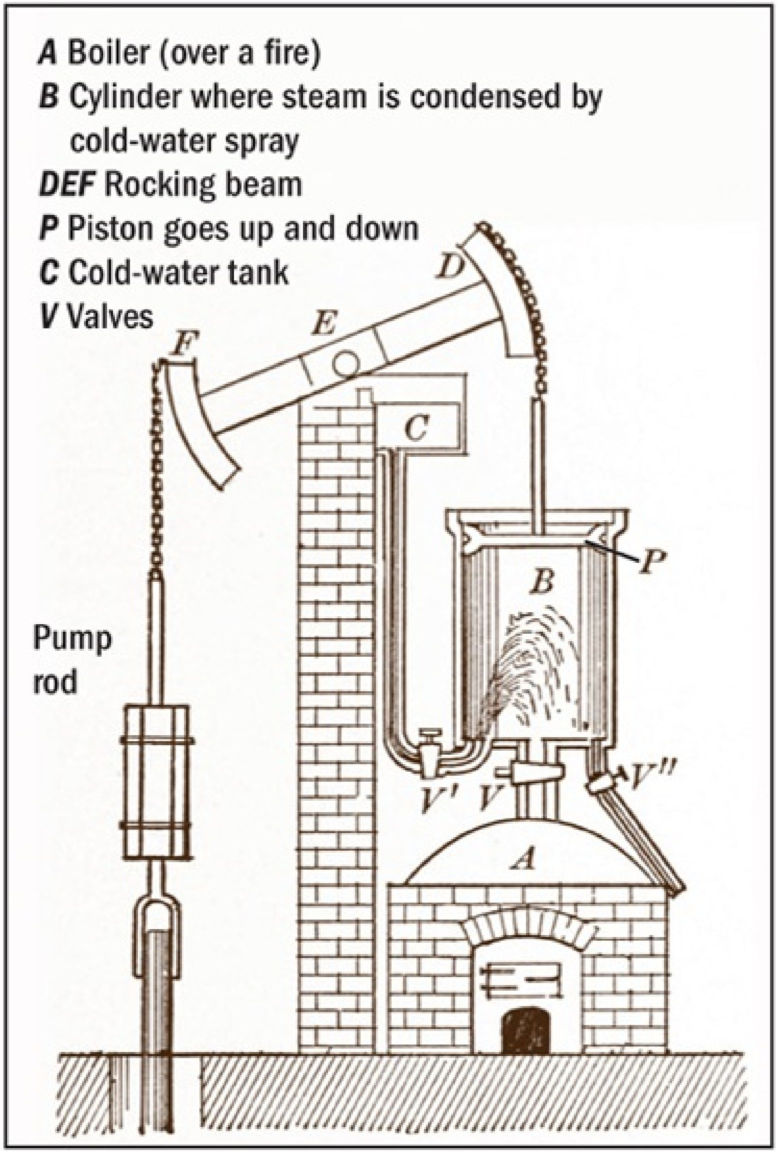
For thousands of years, no human traveled faster than a horse could gallop. After the invention of the first working steam engine in 1712, inventors started to dream of a “horseless carriage,” a vehicle that could travel “under its own steam.”

The steam engine

The ancient Greeks made steam toys for fun, but the first person known to put steam power to work was British inventor Thomas Newcomen. His 1712 “atmospheric engine” pumped water out of mineshafts and tunnels. A fire under a boiler heated water to turn it to steam. The steam entered a **cylinder** with a **piston** inside. The piston was forced up and down to work the pump. Similar pump mechanisms had existed for thousands of years, but powering one by steam was new. Other steam engines followed to power factory machines. In the 1760s, Scottish engineer James Watt built a steam engine with a sealed cylinder at both ends, to make it “double-acting”—the steam forced the piston down as well as up, giving more power. Watt also devised a way to turn the “up and down” piston motion into a “round and round” wheel motion.

Inventors show the way

So, if a steam engine could drive a factory machine, why not a vehicle? In 1769, Frenchman Nicholas Cugnot fitted a steam engine to a three-wheeled gun carriage. It trundled along at 3.7 mph (6 km/h) but crashed and was soon forgotten. It was Englishman Richard Trevithick who made the breakthrough. He discovered that using steam at high pressure produced more power. Watt thought this dangerous because the boiler could explode, but Trevithick went ahead in 1801 with his first high-pressure steam carriage, the “Puffing Devil.” In 1803, he drove his second vehicle from Cornwall to London—over 300 miles (500 km). Given the terrible roads, it was a miracle of engineering and persistence.



This is Newcomen's 1712 steam engine. Steam from the water boiler was let in through a valve to the cylinder, while the piston was at the top. A spray of cold water cooled the steam, which condensed, lowering the air pressure inside the cylinder. Higher air pressure outside pushed the piston down. The piston drove a rocking beam linked to a pump. The weight of the pump rod pulled the piston up, for the cycle to begin again.

This modern painting shows Richard Trevithick's 1803 steam carriage. A wooden carriage sat on two huge, iron wheels, with a small front wheel for steering. The same tricycle design was used for Benz's first automobile in 1885.

In the United States, Oliver Evans had a similar idea. In 1802, he showed his new "Amphibious Digger" in Philadelphia. Evans made it to dredge mud from the harbor, and it even looked like a boat on wheels, but the Digger needed no horses

> ***"It frequently happens that two persons, reasoning right on a mechanical subject, think alike and invent the same thing without any communication with each other."***
> Oliver Evans

Breakthrough

The invention of the steam engine to power machinery spurred inventors to try to build steam-powered road vehicles. In 1801, Richard Trevithick proved that a steam-powered carriage was possible.

The golden age of steam

Steam on the rails

At about the same time as Trevithick and Evans unveiled their steam-driven vehicles, railroad pioneers such as George Stephenson were building the first steam rail locomotives. Steam on the rails progressed faster than steam on the roads. By 1830, Britain had the world's first steam railroad. By the 1850s, railroads were spreading across Europe and the United States. Most people were thrilled by this new and fast way to travel. To the surprise of some doctors, train passengers did not collapse or die when speeding along, faster than a horse!

Go slow on the roads

It was a different story on the roads. In Britain in the 1830s, Walter Hancock started a steam bus service in London, and Sir Goldsworthy Gurney ran an intercity steam coach service, but neither enterprise lasted long.

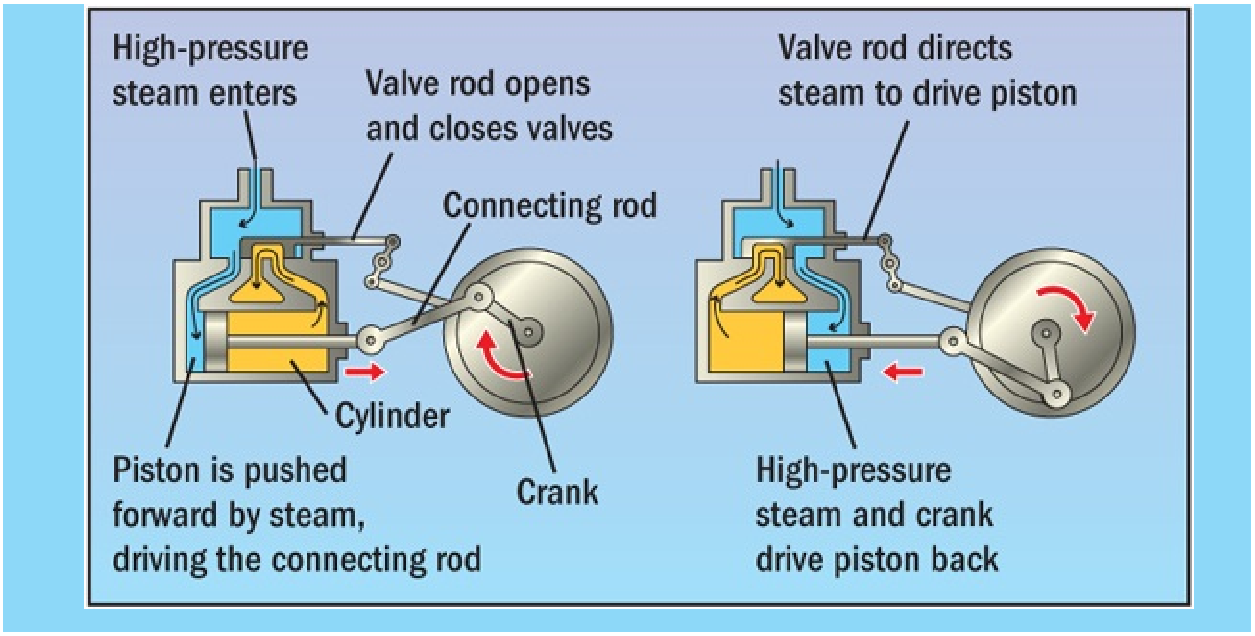
Gurney's steam coach

Sir Goldsworthy Gurney's 1829 steam coach could carry 21 people and ran at 12 mph (19 km/h). It had six wheels; the front two were for steering. The metal boiler contained metal tubes filled with water. A firebox burning wood or coal heated the water to steam, and steam pressure drove two pistons in cylinders. The piston motion was linked by rods and cranks to the back wheels of the coach.

This is Gurney's steam coach on the road. The drivers often found their way blocked by stones or trees, put there by people eager to keep newfangled steam engines off the highways.

How steam engines work

In a double-acting steam engine, high-pressure steam drives a piston up and down inside a cylinder. The cylinder motion is linked through a connecting rod and crank to turn the wheels. The crank action moves rods to open valves, which open and close to release used and fresh steam. As steam enters the cylinder, the piston is pushed one way, then, as more steam is let in through the inlet valve, it pushes the piston back up inside the cylinder for the cycle to start again.



Problems with steam

Steam trains were fast and efficient, but they ran on timetables, and they didn’t always take you where you wanted to go. It was impossible to build railroads that linked to every street in every town and village, but steam coaches and buses could go anywhere there was a road.

There were problems though. Steam engines were big, heavy, and dirty. They spat out steam and puffed out smoke and cinders. They also needed a lot of water and coal to keep going, and if the boiler ran dry, it blew up! The “steamers” scared horses and pedestrians so much that an 1865 law in Britain set a speed limit of 3.7 mph (6 km/h)—and half that in towns for steam road engines. Also, a man with a red warning flag (or a red lamp at night) had to walk in front. Interest in steam on the road fizzled out, and, while Britain led the world on rails, its roads still belonged to the horse. It was up to inventors and engineers in Europe and the United States to find alternatives to steam.

Breakthrough

Steam engine technology progressed, though road vehicles didn’t take off in the same way as trains. Steam vehicles used a linkage system to transmit piston energy to the wheels.

This link technology endured while people searched for a better fuel.

Gas engines

From steam to gas

Engineers started to look at the possibility of a gas engine as an alternative to steam. Interest in gas increased after the first use of gaslights (from burning **coal gas**) in homes and streets in the late 1700s. With gas, the combustion (burning) could happen inside the working parts, not outside as in the steam engine. The combustion, or explosion, would drive a piston in a cylinder.

The internal combustion engine

In 1794, Robert Street in Britain made a gas engine. He sprinkled "**petroleum** spirits" (liquid petroleum oil) into a cylinder, and heated it until the spirits evaporated (became a gas). As the gas warmed, it expanded and pushed up the piston. The rising piston opened a valve to let in air to mix with the gas. A flame was sucked in to ignite the mixture. The explosion pushed the piston down again. This was the first internal combustion engine. By the 1820s, other inventors had sketched out ideas for gas engines. Some used hydrogen. Others tried coal gas.

Promising experiments

Gas engineers used the basic parts of a steam engine: piston, cylinder, valves, and linkage (cranks and rods). Their ideas were sketchy, often just drawings, but they contained the seeds of a new power system. Some even built gas cars, though few people saw or heard about their experiments. In 1807, Swiss engineer François Isaac de Rivaz made a hydrogen-oxygen engine that drove a small trolley. In Britain, Samuel Brown made a gas carriage in 1820 and drove it on the London-to-Dover road, while William Barnett built a gas engine in 1838 that had a **two-stroke** cycle. This meant that it gave power for each upstroke and downstroke of the piston.

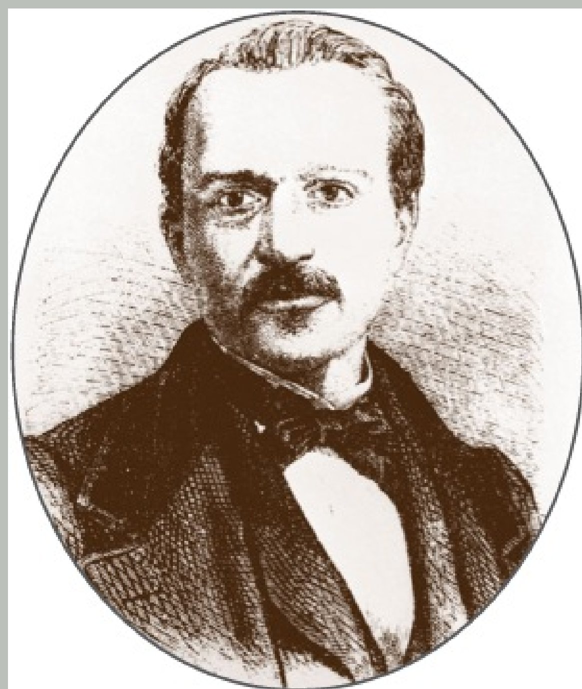
Étienne Lenoir

Date of birth: January 12, 1822

Place of birth: Mussy-la-Ville, Belgium **Greatest achievement**: He made the first practical internal combustion gas engine. He sold several hundred engines, and some were still working after 20 years.

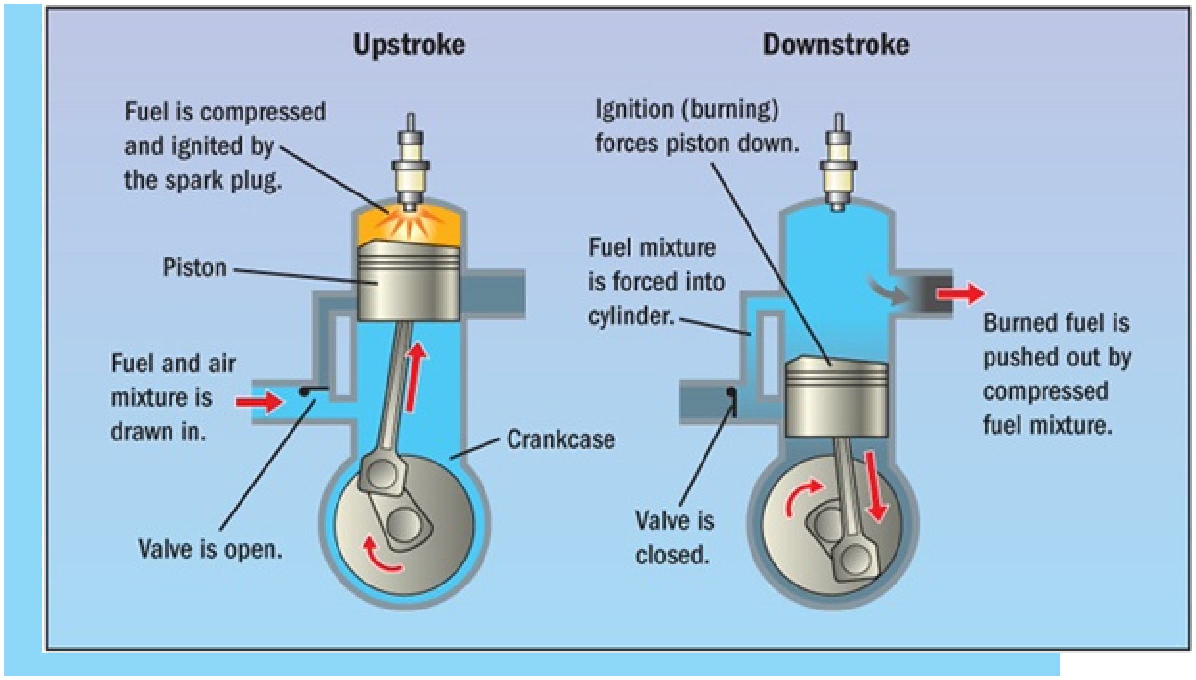
Interesting fact: Lenoir also made a motorboat and an electric brake for trains.

Date of death: August 4, 1900



Two-stroke internal combustion engine

This illustration shows how a modern two-stroke engine works. The basic cycle is the same as in the first gas engines made in the 1800s by Street and Lenoir.



Lenoir’s breakthrough

In 1860, Étienne Lenoir in France built a better two-stroke engine that burned coal gas. It had valves to let in a gas and air mixture, which was then ignited by an electric spark from an **induction coil** fed with **current** from a battery. This was the first spark-ignition system. It was feeble and noisy, but it worked, and people bought Lenoir engines for use in factories. His invention pointed the way forward. In 1862, Lenoir tried his engine on a cart, and it traveled 5.6 miles (9 km) in three hours. He then heard about a brand new fuel that was about to change everything.

Breakthrough

Lenoir’s engine was the first gas engine to work well enough for use in factories. Lenoir also showed that spark ignition was possible using electricity from a storage battery, if boosted by an induction coil.

The four-stroke gasoline engine

Four-stroke, more power

In 1862, French engineer Alphonse Beau de Rochas took Lenoir’s engine a step further, with a **four-stroke** engine (see also page 16). He came up with the idea of compressing the fuel before ignition, to make it burn more efficiently and give more power. Compression was tricky: it made the engine so hot that the metal would melt! The new engine needed a cooling system. Beau de Rochas tried to **patent** the four-stroke principle, but as he never built his engine, he did not receive the credit he deserved.

A new fuel

So, Lenoir had invented a combustion engine that worked, and Beau de Rochas had designed an engine that could work even better, but the problem of finding the right fuel remained. Gas engines burned coal gas from a pipe attached to the gas main, which was hardly suitable for a vehicle. Hydrogen was an alternative fuel, but that was expensive to produce and store. So inventors turned to a fuel that was suddenly making news: gasoline, or petrol. It proved to be the missing piece in the jigsaw puzzle.

The first oil boom

Petroleum oil from under the ground had been used in small quantities for thousands of years, for example, as tar or pitch. In the mid 1800s, a new oil industry began, accelerated by the need for oil for the machines driving the **Industrial Revolution**. In 1859, Titus Drake drilled America’s first oil well, in Pennsylvania, and by 1865, oil was being carried by U.S. railroads to cities and factories. From the thick, black “crude oil,” two thinner fuel oils were made: kerosene and gasoline. Kerosene was burned in oil lamps. Gasoline was burned in “gas” engines.

Oil gushes from one of America's first oil wells near Petrolla City, Pennsylvania, in about 1860. The oil boom helped start the car revolution.

This is a model of the car designed by Siegfried Marcus. Its gas engine was mounted at the rear on a wooden frame. This four-wheeler was a model for the future, but Marcus failed to develop his invention.

In 1870, Austrians Julius Hock and Siegfried Marcus made gasoline engines, but no one showed much interest. Marcus came up with the useful idea of a "spray **carburetor**" to mix air and gasoline into a fine droplet spray that would burn. In 1873, he tested a model car, but did not go on to develop his ideas. In 1879, American George Selden designed a car with a gasoline engine, but never built it. Instead, he spent years tinkering with the design, and by the time he filed his patent in the 1890s, others had overtaken him.

Combustion

Combustion needs oxygen from the air. Beau de Rochas and Marcus knew that air and fuel must mix for combustion to happen. Marcus made a spray carburetor that mixed gas and air. An electric spark ignited the spray. In a modern engine, the pistons suck in air through a narrow tube. Gasoline sprays into the air and vaporizes (becomes gas), before the mixture enters the cylinders for ignition.

THAT'S A FACT!

A model of Marcus's 1873 car was hidden in a Vienna museum. In 1949, engineers tested it. It ran at 3.1 mph (5 km/h).

Breakthrough

Beau de Rochas invented the four-stroke cycle, as used in most modern car engines. He never built a working engine, but his design inspired others who also had the new fuel—gasoline—to work with.

Otto’s four-stroke

Wasted energy

None of the gas engines made before the 1870s was efficient. In Lenoir’s two-stroke engine, only 4 percent of the energy generated by burning the fuel actually drove the machine. The remaining 96 percent “went up in smoke,” as wasted energy in exhaust fumes. The engine was also noisy and tended to shake.

Otto’s engine

German engineer Nikolaus Otto decided he could do better. In the 1860s, he had set up an engine business, supplying gas engines to factories. The engines were not very powerful, so Otto and his partner Eugen Langen came up with a better engine using Beau de Rochas’ four-stroke principle, with electrical spark ignition from a **magneto**. Their 1876 “silent engine” sold well, but it still had to be fixed to the floor so it was not usable in an automobile.

The four-stroke engine

Otto’s four-stroke engine was the model for the modern car engine—except for its fuel, which was coal gas, not petroleum gas. A four-stroke engine burns fuel more efficiently than a two-stroke engine, though it costs more to build and gives power on only one of its four strokes.

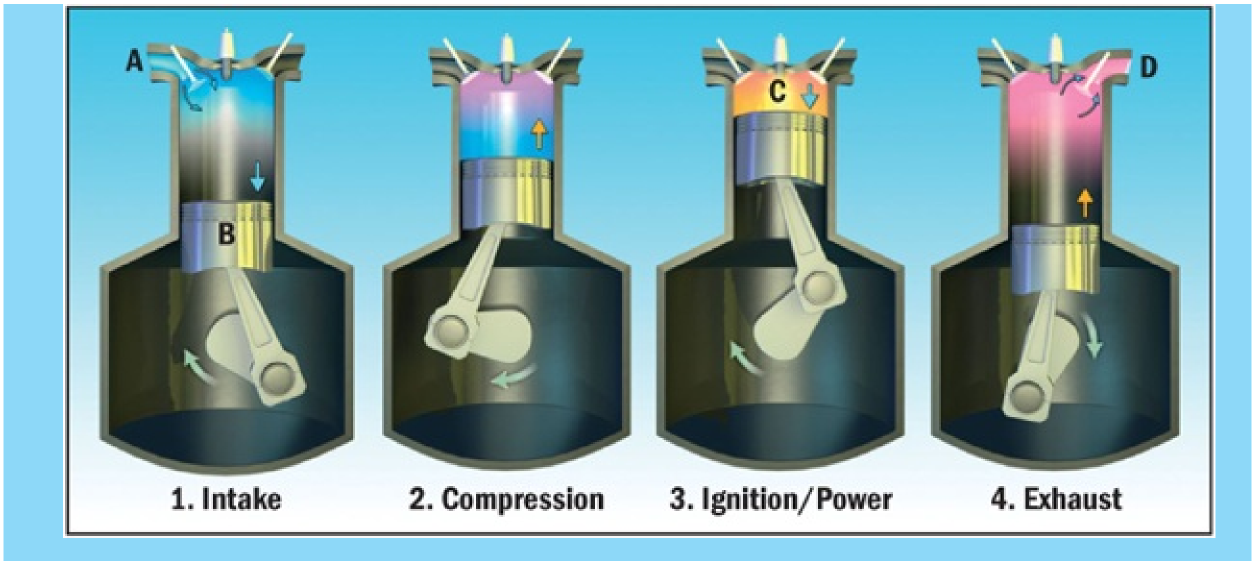
This diagram shows the four-stroke cycle of a modern car engine—suck, squeeze, bang, blow.

1. Suck = intake. The fuel and air are drawn in through the inlet valve (A) as the piston (B) moves downward.

2. Squeeze = compression. The valve closes, and the piston moves upward, squeezing the fuel and air mixture.

3. Bang = ignition. A spark from the spark plug (C) ignites the fuel. The explosion forces the piston down again.

4. Blow = exhaust. When the piston moves up again, the spent fuel is pushed out through an exhaust valve (D).



Enter Daimler and Benz

One of Otto’s employees was Gottlieb Daimler (see page 19). Daimler thought Otto’s engine could drive a vehicle if it ran on gasoline from petroleum, not piped gas. A few miles away, Karl Benz had the same idea. Benz ran a firm making gas engines. He knew about Otto’s “silent engine” and the four-stroke design, but (until 1886) a patent protected Otto’s engine. So Benz began building and selling two-stroke engines, with the dream of one day making a successful automobile.

Benz’s friends laughed at his dogged determination. Max Rose, Benz’s business partner, thought that people would stick with horses. He could not understand why Benz was obsessed with making an automobile, instead of making money from the firm’s factory engines. However, Benz refused to give up. He wanted to build an engine, build a vehicle around it, and then drive it out onto the road.

THAT’S A FACT!

Benz and Daimler were born only 62 miles (100 km) apart in southern Germany. (Daimler was older by 10 years.) Yet they never shared their ideas.

Karl Benz

Date of birth: November 25, 1844

Place of birth: Karlsruhe, Germany

Greatest achievement: He made the world's first gasoline-driven car. Later cars used much of his original technology.

Interesting fact: Benz was more interested in new ideas than making money. He spent his time improving his cars.

Date of death: April 4, 1929

Breakthrough

Nikolaus Otto's "silent engine" was a four-stroke engine with most of the features of a modern car engine. Benz and Daimler learned much from Otto, but believed gas would be the best fuel for an automobile.

Benz and Daimler get busy

Creating a new vehicle

Karl Benz’s ambitions to build a car were hampered by his lack of cash. Fortunately, in 1883, two friends agreed to put money into his company. This was a huge boost for Benz. He got busy, working day and night in his workshop in Mannheim, Germany, watched by his four children and his wife Berta.

What made Benz different?

Benz wanted to design a vehicle completely different from the horseless carriages built previously. Most inventors had taken a wooden carriage and had placed an engine on it. Benz wanted to make a new machine, a “motor wagon” designed around the single-cylinder engine he had built in his workshop. He designed and made all his vehicle’s systems: piston and cylinder, electrical ignition, spark plug, and valves that opened and shut as the **camshaft** turned. To cool his engine, Benz used water, circulating around the engine to a radiator, which released heat into the air. In his carburetor, air was sucked in through a valve and passed over a **perforated** plate wetted with gasoline. Exhaust gases heated the plate, the gasoline vaporized, and the gas mixed with the air before ignition. For his ignition system, Benz chose an accumulator battery and induction coil to provide an electrical current. A spark plug provided the spark needed to explode the petrol and air mixture in the cylinder.

A view of a busy Berlin street in 1880. Berlin was the capital of the German Empire. At this time, horses still mingled with pedestrians in the city, but many people had an appetite for new technology, which would soon include cars.

Gottlieb Daimler

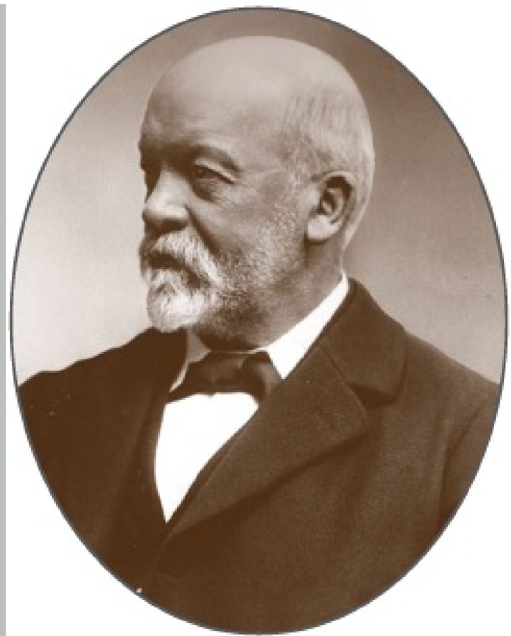
Date of birth: March 17, 1834

Place of birth: Schorndorf, Germany

Greatest achievements: A pioneer of the internal combustion engine, building the first high-speed gasoline engine. He went on to build the first four-wheeled automobile in 1886.

Interesting fact: It is believed that Daimler died without ever learning to drive.

Date of death: March 6, 1900



Daimler and Maybach

As Benz's "motor wagon" took shape in Mannheim, Gottlieb Daimler was busy less than 62 miles (100 km) away in Bad Cannstatt (now a suburb of the city of Stuttgart). By 1882, Daimler and his partner Wilhelm Maybach had left Otto (who was not interested in cars) to set up on their own. The impatient Daimler was happiest in his summer house, tinkering with machinery. Maybach was a brilliant engineer, always interested in new ideas. Together they made a gasoline engine that could turn a **driveshaft** at the unheard-of speed of 600 revolutions per minute (rpm)—fast enough to power a high-speed vehicle. Daimler was eager to try the engine on the road but could not afford a carriage for the experiment. Benz meanwhile was building his own.

THAT'S A FACT!

Édouard Delamare-Deboutteville of France claimed he tested a car in 1884—while Benz and Daimler were still working on theirs. The Frenchman's car apparently broke down before or just after starting its first test run. There is no real proof it ever worked.

Breakthrough

By 1885 Daimler and Maybach had built the fastest-working gasoline engine yet made. Benz had put together all the essential parts of his car—and it was ready to go on the road.

The first automobile

Taking shape

By the spring of 1885, Benz's car was taking shape in his workshop. It had a metal frame, and three wheels—Benz copied the pedal tricycle. The front wheel was steered by a lever, like a tiller on a boat. The back wheels were linked to the engine, which was underneath the driver's seat. Inside the engine, the piston and cylinder were set sideways, not vertically as in most modern car engines. Also fixed sideways was a large **flywheel**. The flywheel's spinning motion stored power between piston strokes, and it was also how Benz started the engine—by giving the flywheel a brisk turn.

Wheels around the bend

Benz turned again to the bicycle for his drive-link system, using chains to connect the engine to the two back wheels. There was no **clutch** as in many modern cars (to disconnect the engine from the drive wheels, when changing **gear**). Gears and pulleys had fascinated Benz since childhood, and his **transmission** system used belts and pulleys. By moving a belt from a loose pulley to a fixed one, the engine was disconnected from the wheels. The brakes (blocks much like cart-wheel brakes) gripped a pulley wheel, not the main wheels, which had solid rubber tires and wire spokes like a bicycle. One tricky problem was turning—the rear wheel on the outside of the bend has farther to travel than the inside wheel. How was it possible to design an **axle**, driven by an engine, where one wheel went faster than the other? Here Benz was lucky: British engineer James Starley had already solved the problem by designing a **differential gear** for tricycles in 1877.

Benz (driving) and his clerk Josef Brecht, in the 1887 Benz Motorwagen, a refined version of the first car. Publicity helped attract the first car buyers.

The first drive

At last, Benz had his car ready. He spun the flywheel to start the engine, sat behind the steering lever, and set off around the workshop yard. The car made four circuits, watched by workmen and Benz's wife Berta. It was an historic moment—the first drive by a gasoline car. For the second test drive, Berta joined Benz on the seat. This time Benz forgot to steer and the car crashed into a wall. Fortunately, they were going so slowly that there was little damage.

The Benz 1888 model (left) sits beside a replica of the first car (1885). In 1888, Benz was still using three wheels, but the car body was developing, to provide more comfort for driver and passengers.

By the summer of 1886, Benz was driving the car around the streets of Mannheim. On July 3, 1886, the local newspaper reported how *"a velocipede [bicycle] driven by gas was tested early this morning"* and *"operated satisfactorily."* The journalist used the term *velocipede* because no one had given this new vehicle a name. What the journalist did not realize was that he had just witnessed the start of a new age. The car had arrived.

THAT'S A FACT!

At first, no one knew what to call the new machine. Discarded suggestions were "motor fly," "automaton," "motorig," and "locomotive car." *Automobile* (from two Greek words meaning "self-moving") and *motor car* caught on.

Breakthrough

Benz built and drove the first gasoline-driven car. He

pioneered many key features himself, setting out to design a radically new vehicle. He was the first person to drive a car in public.

The car gets going

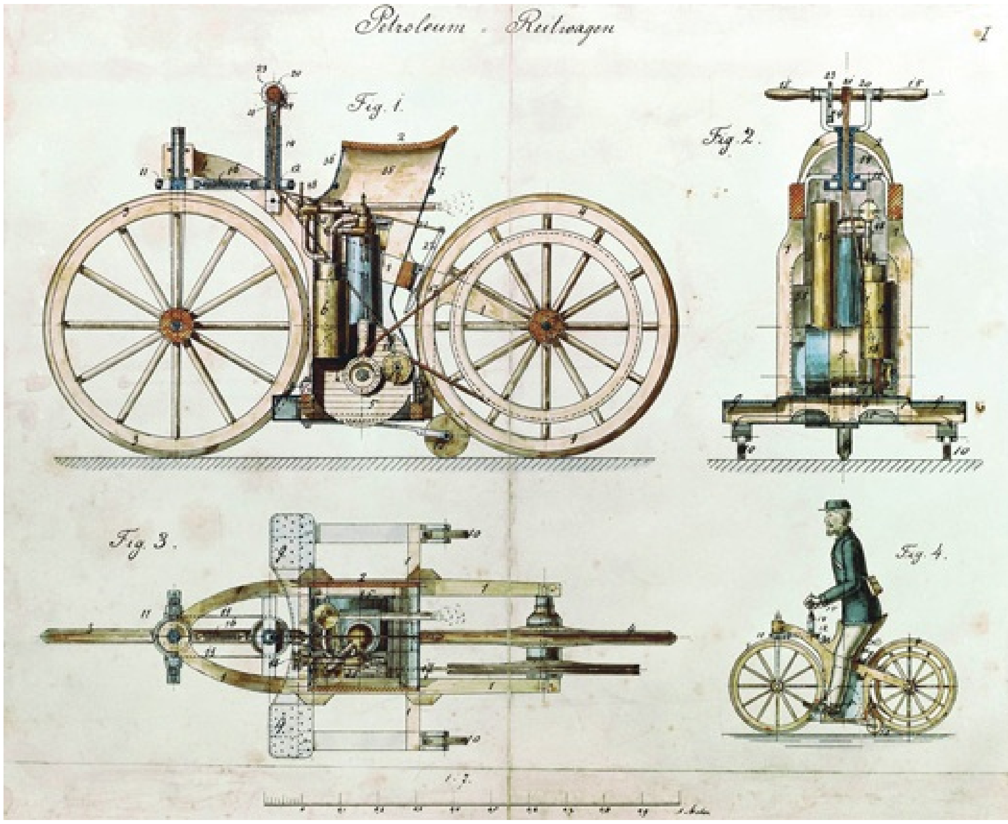
The first motorcycle

While Benz was testing his three-wheeled car, Daimler had turned his attention to bicycles. By the 1880s, people in the United States and Europe were enjoying the freedom of the road on bicycles. The bicycle had its own drive system—pedals, toothed wheels, and chain—and cost less than a horse carriage. Daimler decided to try his engine on a bicycle by replacing the pedals with a gasoline engine. The result would be a motorcycle. His test motorcycle was a solid contraption of wood and iron, with a small-scale version of the four-stroke engine Daimler and Wilhelm Maybach had nicknamed the “grandfather clock” (because it looked like one).

Daimler takes to the road

In November 1885, Daimler’s son Paul drove the motorcycle for 1.9 miles (3 km). Spurred on by the success, Daimler and Maybach built a four-wheeled car the following year. They modified a wooden horse carriage, adding an engine twice the size of the motorcycle’s. The car managed a top speed of 17 mph (28 km/h).

Daimler’s car was in some ways more crude than Benz’s. Daimler’s ignition system was a red-hot metal tube heated by a flame outside the cylinder. Benz’s electric spark plug was safer and more reliable. In the 1890s, Robert Bosch in Germany, Nikola Tesla in the United States and Richard Simms in Britain all improved spark plug technology, and it became standard on all car engines.



Daimler’s motorcycle, was the first in the world. It was not built for comfort, but it worked. Note the stabilizers, too.

Daimler and Benz together

Both Daimler and Benz went on to build better cars. By 1889, Daimler had made a car with a four-speed transmission, and a “friction clutch,” which the driver used to disconnect the engine from the wheels when changing gear. Both became common features on cars. In 1893, Benz made a four-wheeled car called the “Face to Face” because the passengers faced the driver. By 1895, he had produced an eight-seat car, and in 1897, he made his first two-cylinder engine—two cylinders giving extra power.

Daimler died in 1900. At this time, there were fewer than 25,000 cars on the road, and they were almost all owned by wealthy people. A year later, the Daimler Company, run by Maybach, built a new car with an amazing top speed of 55 mph (88 km/h)! They named it Mercedes, after the buyer’s daughter. Mercedes went on to become one of the famous names in car history. In 1926 (three years before Benz died), the Benz and Daimler companies merged to become Daimler-Benz.

Four-speed gears

Daimler made the first four-speed transmission system. The arrangement of toothed wheels in the transmission system changes the speed at which the engine turns the wheels. In first gear, the engine turns slowly but exerts maximum rotational (turning) force, or torque, to get the wheels turning from a standstill, or to pull the car up a hill. In top gear (fourth in Daimler's car, fifth in most modern cars), the engine produces less torque but turns faster, enabling the car to achieve higher speeds.

The Daimler factory was set up in 1890. Production was slow; about 30 cars were built in the first five years. This 1895 four-wheeler had a top speed of 12 mph (19 km/h).

Breakthrough

Daimler made the world's first motorcycle, and the first four-wheeled car. His work greatly increased public interest

in motoring. The Daimler and Benz companies merged and became a world leader, as it still is today.

The automobile takes shape

The French connection

Benz and Daimler were not lone pioneers for long. In France, automobiles attracted great interest. France had no “red flag” laws to slow enthusiasm for driving (see page 11), and France led the world in car making until 1906 (when it was overtaken by the United States).

The leaders of the French car revolution were René Panhard and Émile Levassor, who built their first car in 1890 with a Daimler engine. Their cars became the shape of the future, with engines at the front, beneath a metal hood. They moved on from the bicycle-type chain drive that Benz had used, connecting the engine to the rear driving wheels by a long, rotating metal shaft, linked to the transmission through a friction clutch. This “direct drive” transmission system was improved by Renault, a firm founded by and named after three brothers in 1899, and now one of the world’s leading carmakers.

Panhard-Levassor cars

Panhard-Levassor cars won many admirers. They were easy to drive and comfortable for passengers because they had decent suspension (spring systems). They were also fast, with powerful, four-cylinder engines. Car races attracted public attention, and again France started it all, staging the world’s first car race in 1895 from Paris to Bordeaux—won by a Panhard-Levassor.

This Panhard-Levassor car won the 1896 Paris-Marseilles-Paris trial, racing 1,056 miles (1,700 km) across France in under 68 hours. From start to finish the event lasted nine days.

Car racing

Car races quickly became a popular sport in the United States and Europe. Racing cars taught engineers how to “tune up” engines to make cars go faster and farther. Car manufacturers still use motor races and endurance rallies to test their newest innovations.

Pneumatic tires

France also led the way in tire technology. The first pneumatic (air-filled) tires for cars were French, made by the Michelin brothers in 1895. They were not the first to come up with the idea. Scottish inventor Robert Thomson had the idea for air-filled tires back in 1845, and John Dunlop, another Scot, had made air tires for his son’s tricycle in 1888. Such tires punctured easily on dirt roads and were not suitable for cars. However, when main roads were tarred, the Michelin brothers saw an opportunity. Their tires not only absorbed bumps, but they could be changed easily if they did burst. Even Benz, who seldom used other people’s ideas, was using them by 1901.

THAT'S A FACT!

Early cars had an extra brake for hills, in case the engine stopped. Like an anchor, it gripped the road to stop the car from sliding backward.

British driver Charles Rolls in his Panhard-Levassor during the Thousand Mile Trial in 1900 – a race from London to Bristol to Edinburgh and back to London. Rolls won this 14-day endurance test, and with Henry Royce, he went on to create Rolls-Royce, one of the great names in engineering.

Breakthrough

Panhard-Levassor cars set the pattern for car design, and helped France become the world's leading car manufacturer. The French made cars exciting and more reliable, which

encouraged more people to become motorists.

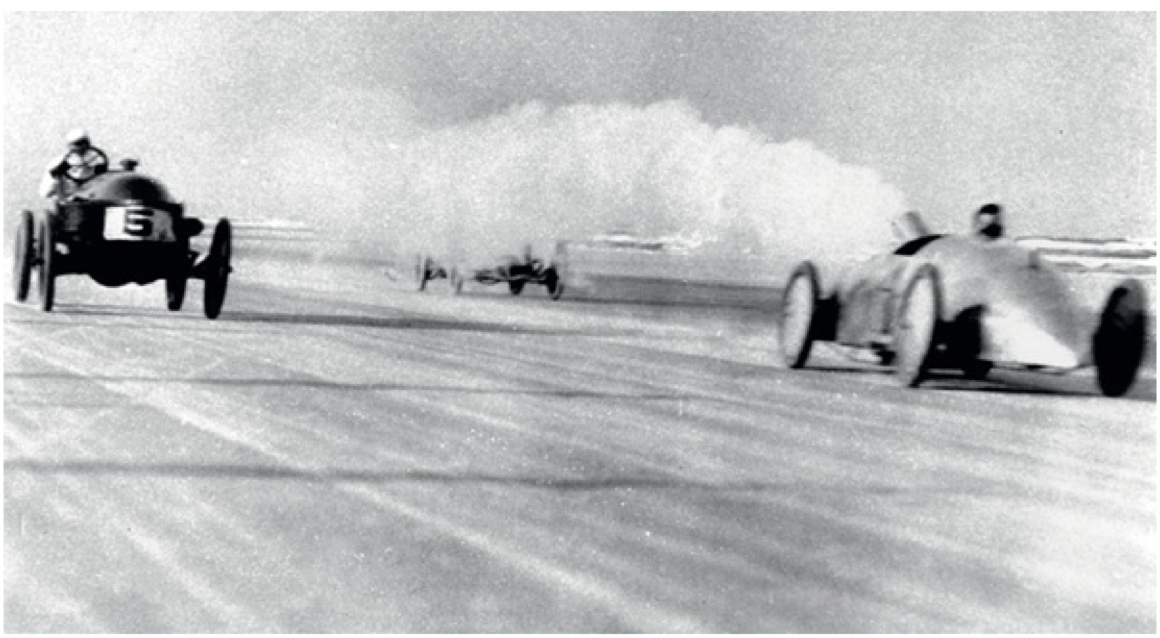
Electric and steam cars

The comeback of steam?

In all the excitement about gasoline cars, steam cars made a brief comeback. They had a big advantage over gasoline–they were easier to start. In the United States, Ransom E. Olds experimented with a steam car in 1890, before becoming a pioneer in gasoline cars. In 1897, the brothers Francis and Freelan Stanley began making their Stanley Steamers. These cars were popular for some years. Even the New York Police Department used them for a time. Another good steam car was the Doble Model B of the early 1900s; virtually silent, it could accelerate from 0 to 60 mph (0 to 97 km/h) in 15 seconds—very fast for the time. However, steam cars were expensive to make and service, so when an electric motor for starting cars was invented in 1912, the interest in steam just … evaporated!

THAT'S A FACT!

In 1906, a Stanley steam car set a new world land-speed record of 127 mph (204 km/h). This record lasted until 2009, when a British steam car raced along at 148 mph (238 km/h).



Full steam ahead! In a 1905 speed trial at Daytona Beach, Florida, Louis Ross in a Stanley Steamer hissed past gas-burning rivals, a Napier (left) and a Mercedes (hidden by steam). Ross raced a mile in 41 seconds.

This magazine cover from 1900 shows French firefighters showing off their new electric fire engine.

Electric speedsters

Steam was never a serious rival to gas, but electric motors were. By the 1870s, electric lights, telephones, and sound recording were new inventions. Why not electric cars? Electric cars get power from batteries. The current drives an electric motor that turns the wheels. Electric cars first appeared in Europe, and in 1891, William Morrison built America's first. Electric cars were popular because

1891, William Morrison built America's first. Electric cars were popular because they were quiet, produced no smelly fumes, and were easy to drive. They were fast, too. In 1899, Frenchman Camille Jenatzy's electric car broke the "mile-a-minute" barrier, equivalent to 60 mph (97 km/h). Electric cars had one big drawback: no battery could power a car more than about 99 miles (160 km) before needing a recharge. When the battery gave out, the car stopped. Recharging took hours. Filling up with gasoline was simpler. In 1900, 38 percent of American cars were electric. Five years later, only 7 percent were. Gasoline cars had won—for now.

Car batteries

The "wet" battery in a modern car contains acid and metal plates (one lead, one lead oxide) inside a case. Each pair of plates is called a cell, and inside the battery, a number of cells are connected. The battery is first charged using an electrical circuit. It stores electricity, used to start the car. As the engine runs, a dynamo (a type of generator) turned by the engine keeps the battery charged, by turning motion energy into electrical energy.

Breakthrough

At the end of the 19th century, carmakers were producing cars that ran on gasoline, steam, and electricity. Electric cars were popular because they were clean and quiet, but the convenience of gasoline eventually made this the fuel of choice.

Diesel’s engine

A different kind of engine

At the same time as Benz and Daimler were selling their first gasoline cars, another German inventor, Rudolf Diesel was trying to make a different kind of internal combustion engine. He wanted to make one that would burn cheaper fuel and stand up better to wear and tear.

The Diesel solution

Diesel decided the way to do this, and make the engine simpler and more efficient, was to do away with spark ignition. Instead, he compressed the air inside the cylinder, squashing it so tightly that it got hotter. In a diesel engine, this heat ignites the fuel. You can feel the heat effect when you pump up a bicycle tire—the pump starts to feel warm as the air inside is compressed into a smaller space.

Triumph of compression

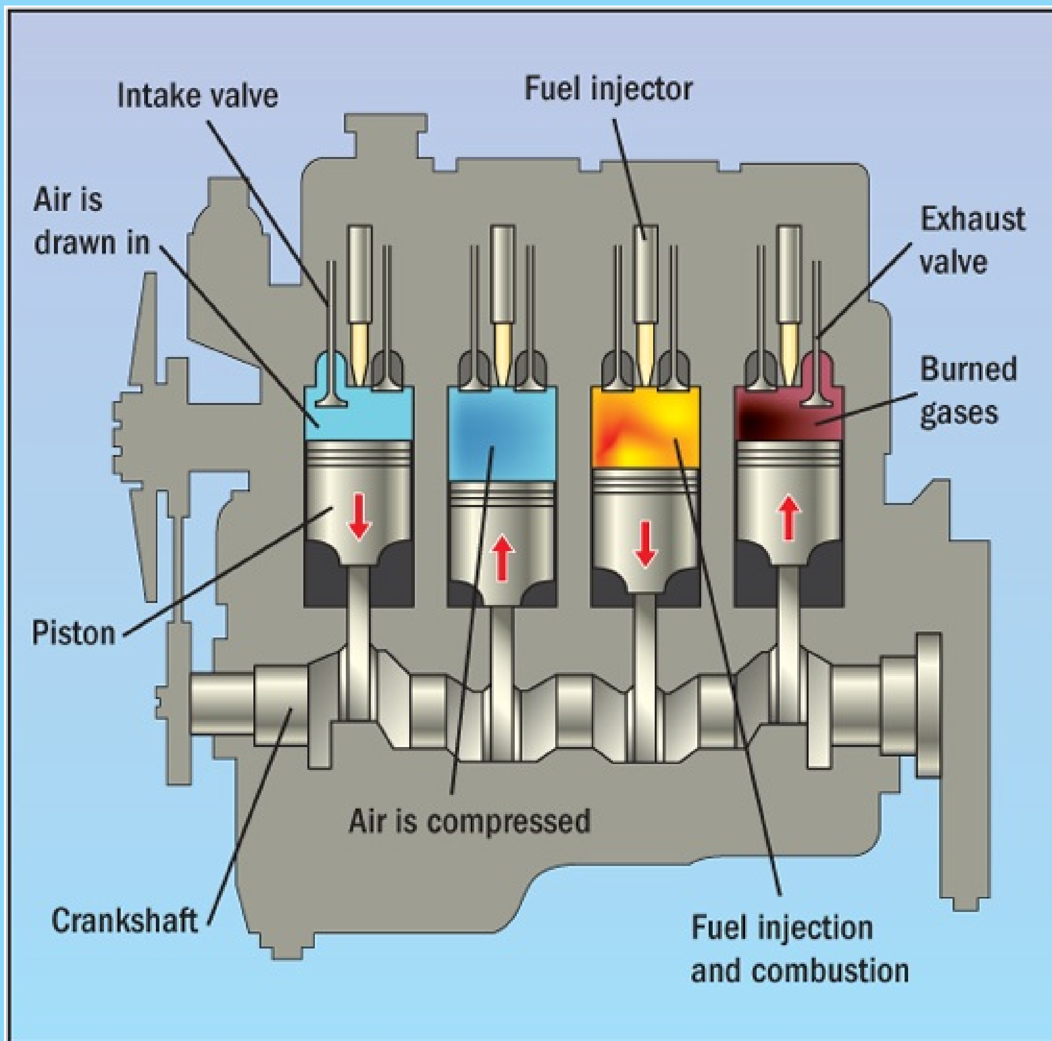
Compression engines could be dangerous. An experimental ammonia gas engine blew up and almost killed Diesel in 1893! However, by 1897, his new four-stroke compression-ignition engine worked well. It was big and heavy, and cost more to make than a gasoline engine, but it had fewer moving parts so it broke down less often. It was also cheaper to run because it burned thick fuel oil, not expensive refined gasoline. Diesel’s engine was ideal for heavy vehicles like trucks, buses, and tractors. Most trucks today have diesel engines, as do many cars. Diesel’s invention also made the internal combustion engine suitable for rail locomotives, ships, and heavy machinery.

The diesel engine

The modern four-stroke diesel cycle works like this.

1. **Intake**. The piston moves down, as air is drawn into the cylinder.
2. **Compression**. As the piston rises, the air is compressed, which produces great heat.
3. **Combustion**. The diesel fuel is sprayed in through a fine nozzle, and the heat ignites the fuel. The explosion pushes the piston down again.
4. **Exhaust**. On the final upstroke, an exhaust valve opens and waste gases

are pushed out.



Rudolf Diesel

Date of birth: March 18, 1858

Place of birth: Paris, France

Greatest achievement: Diesel invented the compression-ignition engine, named after him, and now widely used in industry and transportation.

Interesting fact: Diesel died mysteriously in 1913. His body was found in the English Channel, after he apparently fell from a steamship. No one knows whether it was an accident or suicide, or if he was murdered by business enemies.

Date of death: September 29, 1913


PATENT-URKUNDE

№ 67207

AUF GRUND DER ANGEHEFTETEN BESCHREIBUNG UND ZEICHNUNG IST DURCH BESCHLUSS DES KAISERLICHEN PATENTAMTES

an Rudolf Diesel, Ingenieur, in Berlin

EIN PATENT ERTHEILT WORDEN.

GEGENSTAND DES PATENTES IST:

Arbeitsverfahren und Ausführungsart für Verbrennungskraftmaschinen.

ANFANG DES PATENTES: 28. Februar 1892.

DIE RECHTE UND PFLICHTEN DES PATENTINHABERS SIND DURCH DAS PATENTGESETZ VOM 7. APRIL 1891 [illegible] BESTIMMT.

ZU URKUND DER ERTHEILUNG DES PATENTES IST DIESE AUSFERTIGUNG ERFOLGT.

Berlin, den 23. Februar 1893.

KAISERLICHES PATENTAMT.

Beglaubigt durch [illegible]

Bureau-Vorsteher des Kaiserlichen Patentamtes.

Diesel's first German patent for "working processes for internal combustion engines." A second patent was granted in 1893, and his new Diesel engine appeared in 1897.

"The diesel engine can be fed with vegetable oils and would help considerably in the development of agriculture of the countries which use it."

Rudolf Diesel in 1911. Today we are starting to use **biofuels** made from plants (see page 41).

Breakthrough

Rudolf Diesel invented the first compression-ignition engine. By the early 1900s, vehicles with diesel engines were replacing horse-drawn wagons and buses. Today most trucks and buses, and many cars, have diesel engines.

America goes car crazy

Gasoline buggies

By the 1890s, the United States was catching up with Europe. Inventors made "gasoline buggies," inspired by what they read in newspapers and magazines of car progress in Europe.

The Duryea brothers sell cars

In Illinois, two brothers, Charles and Frank Duryea, fitted a single-cylinder gasoline engine to a horse-buggy and in 1893 drove it at a speed of 7 mph (12 km/h). They went on to make a better car, and in 1895, a Duryea car made headlines by winning a race sponsored by the *Chicago Times-Herald* newspaper, traveling 53 miles (86 km) without breaking down. This attracted so much interest that the brothers set up a Motor Wagon Company, and a year later made 13 cars of the same design. Though small-scale, this was America's first carmaking plant.

THAT'S A FACT!

The Duryea brothers soon went their separate ways. They argued bitterly over which brother was the real inventor of their 1893 car.

Drivers look for improvements

By the early 1900s, gas-driven cars were becoming more popular than steam and electric cars. Diesel trucks and buses were taking to the roads, but there were still more horses than motorized vehicles. In Europe, cars were still expensive toys for the rich. Few car owners understood how the engine worked or learned to drive; most hired drivers (chauffeurs), just as they had paid coachmen to drive their horses. In the United States, however, cars became more affordable, and carmakers began selling cars that were more reliable, with "extras" to attract customers. These extras included important technical improvements, such as the universal joint and devices to make the car ride less bumpy. Bouncing along on metal springs was spine-jarring until the invention and introduction of **shock absorbers** in 1906.

Winner of America's first car race, the 1895 Duryea. It battled three Benzs, two electric cars, and winter snow. Sitting with Frank Duryea (right) is an umpire, to make sure the driver did not cheat.

A 1908 Renault. The French carmaker set up business in New York City in 1906, selling to rich Americans attracted by Renault's reputation for racing and reliability.

Universal joint drive

In 1676, Irish scientist Robert Hooke made a universal joint for a telescope. It allowed free movement along a jointed shaft in any direction. Clarence Spicer, an engineering student at Cornell University in New York State, first applied the joint to a car in 1903. The universal joint reduced noise, protected against dust and dirt, and was easy to **lubricate** (oil). It made cars more reliable.

Weatherproofing

By 1903, cars still had soft tops, but they had windshields to keep off the wind. When it rained, the driver had to use one hand to work the manual wipers. In 1905, California rancher Mary Anderson drove through New York City in a snowstorm. After watching her driver struggling to wipe away the snow, she designed a spring-operated wiper. By 1917, this had evolved into an electrically operated, rubber-blade windshield wiper operated at the flick of a switch—similar to those on cars today.

Breakthrough

Frank and Charles Duryea put the automobile in U.S. news, by racing cars, and then by setting up America's first car factory. Innovations such as the universal joint, shock absorber, and electric wipers made journeys more comfortable.

The production line

Cars for a few, or cars for all?

As the 20th century began, more than 50 companies were making cars, but only one at a time, by hand. Many European carmakers were building luxury cars for the rich, such as the Rolls-Royce Silver Ghost. In the United States, some carmakers were more interested in selling cheap cars by the thousand to anyone. After huge oilfields were found in Texas in 1901, the United States had what seemed to be a limitless fuel supply for as many cars as people would buy. To supply the masses, factory **assembly-line** techniques would have to be applied to car manufacture.

The rise of Detroit

Assembly-line techniques had been used before in U.S. factories making rifles and farm machinery from ready-made parts. Detroit, a major engineering center, became the car capital of the United States using this industrial method. The breakthrough was made by Ransom E. Olds. His cars were not technically advanced, but by using factory production methods, Olds could build them fast and sell them cheap. In 1901, he sold 600, and the Oldsmobile became the big-selling car in the United States. By 1904, Olds was selling 5,000 a year. New customers demanded, and got, refinements, such as the rearview mirror (1906) and the electric horn (1908).

Ford’s revolution

No carmaker matched the success of Henry Ford. His 1903 Ford Motor Company sold 1,700 cars in its first year. Ford’s bright idea was to build just one model (design), without frills, to cut costs. In 1908, his first Model T car, nicknamed the “Tin Lizzie,” cost $825. In 1913, the Ford assembly-line system started up; as each car frame moved through the factory, workers added parts from moving conveyor belts. New cars rolled off the end of the line, one after the other, cutting production time from 13 hours to less than 2 hours. Ford also brought in parts from other companies, such as the Dodge brothers, to start the auto-supply industry. Ford kept his customers happy by training mechanics to fix their cars. By 1916, the price of a Model T had dropped to $345, and by 1924, this top-selling car cost just $290. Even people with modest incomes could afford a Ford, and as many more people bought cars, garages and filling stations opened across the country.

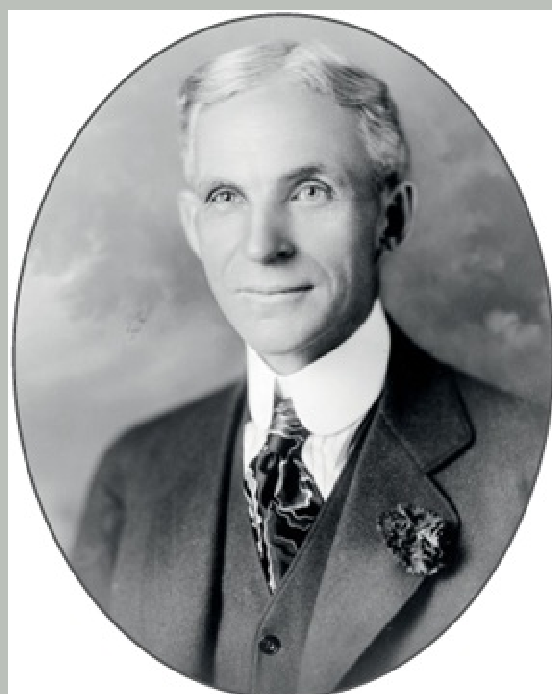
Henry Ford

Date of birth: July 30, 1863

Place of birth: Wayne County, Michigan **Greatest achievement**: Henry Ford revolutionized car production with his assembly-line methods.

Interesting fact: Before the Model T, Ford had made eight other cars: the A, B, C, F, K, N, R and S. Ford went on building the Model T until 1927.

Date of death: April 7, 1947



"There is one rule for the industrialist and that is: Make the best quality of goods possible at the lowest cost possible, paying the highest wages possible."

Henry Ford

The shape of streets to come. Main Street in Savanna, a small town in Illinois, is lined with Model T Fords—the car for everyone.

Breakthrough

Ford's assembly line cut car-production time, and his methods started the modern car industry. The assembly-line technique was adopted by other industries, changing factory systems around the world and creating the consumer culture we have today.

The auto industry grows

The changing look

Factory production changed the look of the car and other motor vehicles. Production sped up during World War I (1914–18), when thousands of trucks and cars were built to move supplies and troops. Then, too, manufacturers switched from mostly wood to mostly metal. Power tools could hammer and bend sheet steel and aluminum into curves not possible in a car body made from wood. Cars began to look more streamlined. Dodge in the United States was among the first to sell steel cars, made by fixing metal panels on to a frame. Most cars by now had hard roofs, instead of folding soft tops—though open cars were still popular.

New body strength

In 1915, an American engineer, H. Jay Hayes, suggested a better way to make cars—the “unit body.” Hayes had made his own all-metal electric car in 1898. Now he suggested replacing the heavy frame with a “platform” of tube-steel (strong but much lighter) on which the engine, suspension, and bodywork rested. The first unit body car was the 1916 Ruler Frameless. Soon most cars were made in this way, from steel panels **welded** together. Easy to assemble in a factory, the unit body had another advantage—the body could be lifted off the platform (now called the chassis) for repairs. The change made cars stronger, safer, and lighter, with fewer rattles and squeaks. By the 1930s, U.S. carmakers were buying 20 percent of all U.S. steel.

The Fisher Body Company supplied many U.S. carmakers with car bodies. This 1936 General Motors ad praises the new "turret top," offering solid steel safety with style.

Easy starting

While the bodies were becoming lighter and more streamlined, starting the cars was still exhausting. Early motorists had to swing a metal handle to turn the **crankshaft** and start the engine. This all changed after a tragic incident in the winter of 1910. A Cadillac driver was stranded in Michigan, when her car's engine stopped. She wasn't strong enough to swing the handle so another motorist, Byron T. Carter, stopped to help. Unfortunately, as he was turning the handle, the engine "backfired"—the shaft spun and the handle flew off, smashing his jaw. Carter died as a result of this accident. Cadillac boss Henry M. Leland, a friend of Carter, was so shocked by the tragedy he asked engineer

Charles Kettering to improve on the starting handle. By 1912, Kettering invented the electrical starter, powered by a battery and generator, and by the 1920s almost all American cars had push-button starters. This innovation encouraged more women to become drivers.

THAT'S A FACT!

Before quick-drying paint was invented in 1924, newly painted cars took hours, even days, to dry. If you looked closely, you could see dust and insects stuck to the paint.

Starting cars could be exhausting. A London driver in 1916 tries to start her car by cranking the engine with a metal starting handle. The invention of the electric starter made driving easier for everyone.

Breakthrough

Hayes unit body design of 1915 was the shape of things to come. It moved car making from traditional methods to factory production of all-metal body shells, like those of cars today.

Car comforts

A golden age

From the 1930s to the 1950s, the car industry grew worldwide. The U.S. led the way, followed in the 1950s by Japan. A golden age of motoring and car technology had begun. As more people took to the roads, many drove cheap, “popular” cars: Fords, the French 2CV, the British Austin 7, and the German Volkswagen (meaning “people’s car” in German). Customers had to pay more for luxuries such as a heater.

Entertainment and refinements

Car driving became simpler. Early gears came together with harsh grating sounds but by the 1940s, drivers could choose an automatic transmission, where the car changes gear by itself. The German firm Porsche brought in a smooth-changing “cone” synchromesh transmission in 1951, making manual gear changing easier. Other innovations at this time were power steering, the car radio, and electric windows. Electric headlights were tried as early as 1898, but modern “sealed beam” lights date from the 1940s. Drivers indicated a turn using hand signals until 1938, when powered indicators appeared on Buick cars. Most early turn-signals were little mechanical arms, later replaced by flashing electric lights.

THAT’S A FACT!

A Bugatti was the car of choice for the super rich. These were very exclusive and very expensive. At a time when many workers earned less than $300 a year, a 1920s Bugatti Royale cost $30,000!

In 1935, Rolls-Royce launched the Phantom III—the most advanced car in the world at the time. This 1947 model—the "Vutotal"—has unique bodywork by Labourdette of France, making it one of the most luxurious and distinctive cars anywhere.

A 1940s motorcycle cop reminds a motorist that U.S. roads have speed limits. By the 1940s, cars were capable of traveling at high speeds, and speed restrictions were in force on many city roads.

Road safety

With more cars on the road going at higher speeds, there were more accidents, so inventors brought in safety devices, too. Disc brakes, first suggested in 1902, were introduced on fast cars, such as the 1954 Austin Healey 100 sports car. Today, many cars have antilock brake systems (ABS)—electronic sensors on each wheel that stop the wheels from locking and skidding on slippery roads. Passenger safety improved with the introduction of seat belts in the late 1950s. Surprisingly, these were patented in 1895, and some doctors were encouraging their use in the 1930s, but Volvo introduced them as standard in 1959. Airbags, which inflate in a collision, were a 1980s innovation.

Hydraulic brakes

Disc brakes are operated by hydraulic (fluid) pressure. When a driver presses the brake pedal, brake fluid is pushed through brake lines to each wheel. The pressure of fluid inside a cylinder exerts a strong force, pressing a friction pad against a metal disc attached to the wheel. Friction (rubbing) slows the wheel; it also makes heat, released into the air. Early brakes depended on mechanical pressure—the driver had to press hard on the foot pedal. In a modern hydraulic braking system, energy from the engine forces the fluid through the brake system, so the driver does not have to press on the brake pedal so hard.

Breakthrough

Hydraulic braking and steering systems took a lot of the effort out of driving, and helped make cars safer. Seat belts and other safety features reduced the risk of injury or death in accidents.

Designing for economy

Cars get compact

By the 1960s, carmakers faced a new challenge. As gas prices rose, and oilfields dried up, fuel economy became important. For millions of people in developed countries, driving was a necessity—to get to work and school and to go shopping. People in developing countries wanted cars, too—affordable ones. So the new cars were “compact” (smaller and lighter). The lighter the car, the smaller the engine (and the less fuel) needed to move it. New materials were introduced. The 1953 Chevy Corvette was made of light but strong **fiberglass** to reduce weight. Plastic replaced leather for seat covers to cut costs. And in 1959 along came a new concept: the front-wheel drive Mini.

The Mini

At the time, most family cars had engines at the front, with drive wheels at the rear. The 1959 Mini had its engine mounted “transversely” (sideways) over the front wheels, and drove the front wheels directly. This design meant the car was half the length of most other cars but had room for four people. The Mini was the brainchild of British designer Alec Issigonis, perhaps the last inventor to create a breakthrough car on his own. By the 1980s, most production cars had this combination of transversely mounted engines with front-wheel drive.

Filling up in the 1960s: fuel was cheap, and most big, American cars burned lots of it. The push for fuel economy began in the 1970s as energy shortages became a possibility.

The rotary engine

In 1957, Germany's Felix Wankel made a rotary engine with a triangular rotor instead of a piston. It produced power on all four strokes (not just one as in a conventional four-stroke engine). Some carmakers adopted the Wankel engine. The Japanese company Mazda first used it in the Cosmo in 1968. However, most rejected it because of poor fuel economy, a short working life, and high exhaust pollution.

Robotic efficiency

To drive down prices and make their businesses more efficient, car factories began using electronic robots alongside human workers on the production line. Unimate robots were first used in the United States by General Motors in 1961. Japanese carmakers were quick to see the advantages of robot-assisted assembly, and by the 1980s, Japan had become the world's leading carmaker.

THAT'S A FACT!

In 1964, the fastest speed by a wheel-driven car was 403 mph (648 km/h), by Donald Campbell's *Bluebird*. The jet-engined car *Thrust SSC* now holds this land-speed record, topping 763 mph (1,228 km/h) in 1997.

From the 1950s, car-assembly robots began to take over some tasks from people. Smaller workforces meant lower costs. Modern cars are designed to be easy and quick to assemble, using parts made by specialty suppliers.

Breakthrough

From the 1950s, efficiency and economy became the driving factors in car manufacture. Robots worked beside people in car plants, and compact cars became popular because they were cheap to buy, economical to run, and easy to park on crowded streets.

New developments

A team challenge

Today, major car companies such as BMW, Toyota, and Fiat rely on teams of engineers and scientists to design new cars and car systems using computer-aided design programs. No inventor is likely to design a new car like Benz and Daimler did in the 1880s. The challenge for carmakers in the 21st century is to make cars cleaner and greener and find alternatives to gasoline and diesel.

Cut the gases

By the 1970s, scientists knew gas fumes were bad for health. Car exhausts give off poisonous **emissions** of carbon monoxide gas and hydrocarbons. To cut down on these harmful emissions, governments brought in laws to make engines cleaner, forcing carmakers to reduce exhaust pipe pollutants. One way they did this was with “catalytic converters,” devices in the exhaust system that change the poisonous chemicals into water and carbon dioxide. The lead added to petrol to make engines run smoothly was also harmful to health, so most cars now run on unleaded fuel.

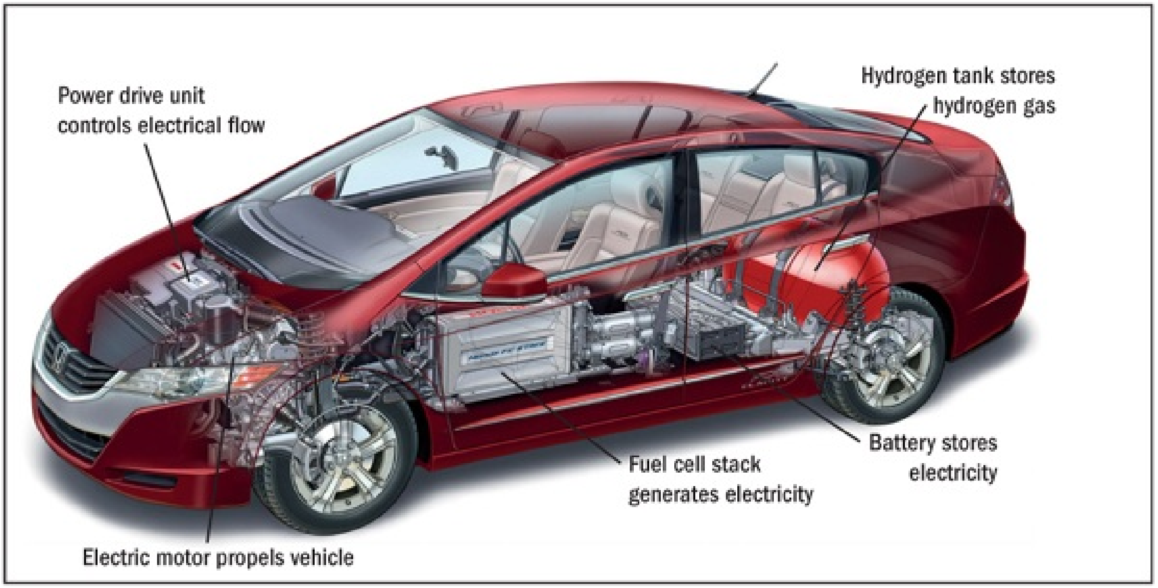
Too many cars?

Car ownership continues to grow around the world, but scientists warn that the earth’s oil will run out some time this century. Scientists also warn of dangers to the earth’s environment. Cars contribute to pollution and **global warming**, so carmakers are always looking for ways to reduce car pollution. Some cars already on the roads are hybrid cars with two engines: gas for speed and long distance, electric for town driving (although the distance the car can travel in electric-only mode is limited). The gasoline engine and the car’s brakes generate the electric power. Running on electricity, hybrids produce no emissions, but when they burn gas they are just like a regular car, so the race continues to design the “eco-cars” of tomorrow.

Many drivers now use satellite navigation devices instead of paper maps to find their way around. The devices use GPS (global positioning system) data to plot a route to a destination.

Fuel options

Possible alternative energy sources for cars include compressed natural gas (CNG); hydrogen or other gases, such as methane (from cow manure); electricity from fuel cells, batteries, or **solar panels** (turning the energy in sunlight into electrical power); and biofuels made from plants, such as sugar cane, soybeans, and corn. These biofuels can be mixed with petroleum to make a fuel that runs a conventional car engine. Many farmers are already growing biofuel crops. The question is how much farmland should we give over to fuel when we also need to grow more food to feed the world's



Honda's Clarity (2008) runs on hydrogen gas, which combines with oxygen to power a stack of fuel cells to drive its electric motor. The by-product from the system is water not harmful exhaust gases. Cars like this road test new technology for the clean, green cars of the future.

Fuel cell technology

A fuel cell turns chemical energy into electrical energy, so cars with this technology produce their own electricity and don't need charging. For example, a hydrogen fuel cell mixes hydrogen gas, stored in a tank in the car, with oxygen in the air to make electricity and water. The electricity powers the car's motor and the harmless water is released into the air.

Breakthrough

Car emissions proved to be a danger to health and the environment, so catalytic converters and unleaded gasoline were introduced to reduce harmful pollutants. Now the challenge is to find cleaner, greener alternatives to fossil fuels.

The automobile of tomorrow

Back to electric?

Tomorrow’s car may be very different from the cars of today and may well be electric. Some innovators have made solar-powered cars, like the French-made Venturi Astrolab. However solar power may not be as practical as batteries, which are improving all the time. One problem is that the source of energy for electric car batteries still mostly comes from old-fashioned power plants, which burn fossil fuels. However, there are already some “solar filling stations,” where drivers can recharge electric car batteries with solar-generated power.

Future cars

The car of tomorrow might be recycled when it wears out, or just rot away if it is made of biodegradable plant materials. It will use energy more efficiently. At present, much of a car engine’s power is lost by the time it gets to the wheels. A more efficient system is to have each wheel powered by a separate electric wheel motor; a throwback to an idea tried on early electric cars. On long journeys, the driver may pass over control to the car’s computer, which will steer the car along an electronic track.

The French-made Venturi Astrolab is an electric–solar hybrid car. It runs

on batteries (rechargeable while the car is moving) and solar cells (using sunlight). The car has a top speed of 75 mph (120 km/h).

Cars from carrots and chocolates

The World First F3 is a racing car made by a team of engineers and scientists at the University of Warwick, England. It is made from sustainable and renewable materials—the steering wheel is made from carrots, the seat from soybeans, and its **biodiesel** engine can run on vegetable oil and chocolate! An exhaust catalyst cleans the air as the car speeds along.

The Nissan Pivo 2 is an electric concept car (not yet in production). The cabin can rotate, so the driver can face forward, backward, and sideways. The Pivo 2 also has a friendly little robot that talks and listens to you as you drive!

Its interactive communication system will “talk” to other cars, exchanging data about traffic jams, bad weather, and ice on the road, and it will navigate with the aid of advanced satellite navigation systems.

Transportation into tomorrow

Long ago, a few people with cars enjoyed the “freedom of the road.” Today, many roads are jammed with cars. Even so, people like their personal transportation systems, and the demand for cars is still rising, especially in growing nations such as China. The car of tomorrow has to fit into our changing world: it must be safe, non-polluting, and electronically smart, and it must run on new forms of energy. The cars of the future will be the inventions of designers and engineers experimenting with electric cars, solar-powered vehicles, and even cars that run on chocolate!

“It is an idle dream to imagine that the automobile will take the place of railways in the long distance movement of passengers,” **declared the American Railroad Congress in 1913. How wrong the rail men were!**

Glossary

alternative fuels fuels other than gasoline and diesel that can run a car **assembly line** a production system where workers add parts to the product as it passes them **axle** a rod that attaches the wheels of a car to the chassis

biodiesel a biofuel made from vegetable oil or animal fat

biofuel any fuel made from plants

camshaft the shaft in the engine that is driven by gears, belts, or chain from the crankshaft **carburetor** the part of an engine in which air and fuel are mixed to form a flammable mixture **clutch** a friction plate that is moved to disconnect the engine from a car's wheels, so that the driver can change gear smoothly **coal gas** a gaseous fuel made from coal

crank a handle or the part of a shaft turned to start motion

crankshaft the main shaft of an internal combustion engine to which the connecting rods are attached **current** the flow of electricity along a wire

cylinder a chamber within which a piston moves up and down

differential gear a gear on the axle that allows two shafts to rotate at different rates, allowing the wheels to turn at different speeds rounding a corner **driveshaft** a rod that turns, linking the engine to the wheels

emissions the waste gases or chemicals that are produced by cars

fiberglass a light material made from extremely thin fibers of glass

flywheel a spinning wheel attached to the crankshaft, used to store energy during the power stroke to drive the crankshaft through the other three non-power strokes **fossil fuel** fuels such as coal, natural gas, and oil formed millions of years ago from organic material (plants and animals) and found under the ground **four-stroke** an internal combustion engine in which the piston makes four movements, or strokes, in each cycle **gear** a wheel with teeth (cogs) around the rim that interlocks with other toothed wheels to change speed **global warming** climate change and temperature rises, thought by many scientists to be caused by too much burning of fossil fuels **induction coil** an electrical device that uses two coils of wire of different lengths to change a low-voltage current into a more powerful, high-voltage current **Industrial Revolution** a period of social and industrial change brought about by the use of machines, steam power, and other new technologies **internal combustion** burning fuel inside the workings of an engine

lubricate to grease or oil machinery, to reduce friction (rubbing wear) between moving parts **magneto** a small electricity generator with magnets, for making a spark **patent** to get legal protection for a new invention or idea

perforated covered in small holes

petroleum oil (a fossil fuel) found in the ground, which can be refined, or processed, to make gasoline, paraffin, and other products **piston** a metal drum that slides snugly up and down inside a cylinder; used in both steam and internal combustion engines **shock absorbers** piston and cylinder devices (filled with air or oil) in a car's suspension; the pressure of the piston inside the cylinder helps to cushion bumps and jolts **solar panel** a group of special solar cells that collect energy from the sun **transmission** a system in a car that links the engine to the driving wheels **two-stroke** an engine in which power is produced on both the upstroke and downstroke of the piston **valve** a mechanical device that opens and closes to let a substance flow in one direction only. Car engines have inlet valves (letting fuel into the cylinder), and exhaust valves (to release spent gases).

weld to use extreme heat to fuse two pieces of metal together

Further information

Books

Goodbye, Gasoline by Laura Lewandowski. Compass Point Books, 2009.

Car Science by Richard Hammond. Dorling Kindersley, 2008.

Transportation: The Impact of Science and Technology by Joseph Harris. Gareth Stevens, 2010.

Road and Rail Transportation by Harriet Williams. Facts on File, 2004.

Some useful web sites

About.com: Inventors

http://inventors.about.com/od/cstartinventions/a/Car_History.htm

An introduction to automobile history, including timelines, biographies of early inventors, and more.

How Stuff Works

www.howstuffworks.com/engine.htm

A clear description of how an internal combustion engine works, with animations and links about other car systems.

Discovery Channel

www.yourdiscovery.com/cars/index.shtml

A site with an illustrated timeline, a review of auto pioneers, and a look at the cars of today and tomorrow.

Technology Review

www.technologyreview.com/special/transportation

A report on the car of tomorrow, new technologies, and alternative fuels.

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