HOW IT WORKS

NEW

101 Amazing FACTS you need to know

Welcome to

101 *Amazing* FACTS you need to know

What causes earthquakes? Why is Magna Carta so important? Why do we love chocolate? What is the V1 star? For the answers to these questions and many more, look no further than this new collection of conundrums and curiosities from six subject areas. Covering the environment, technology, science, space, transport and history, each section is packed with amazing facts to satisfy even the hungriest of minds.

101 Amazing FACTS you need to know

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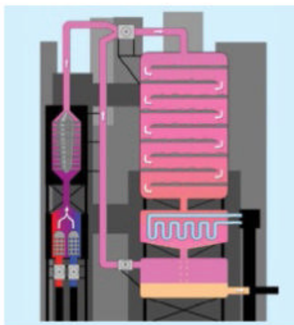

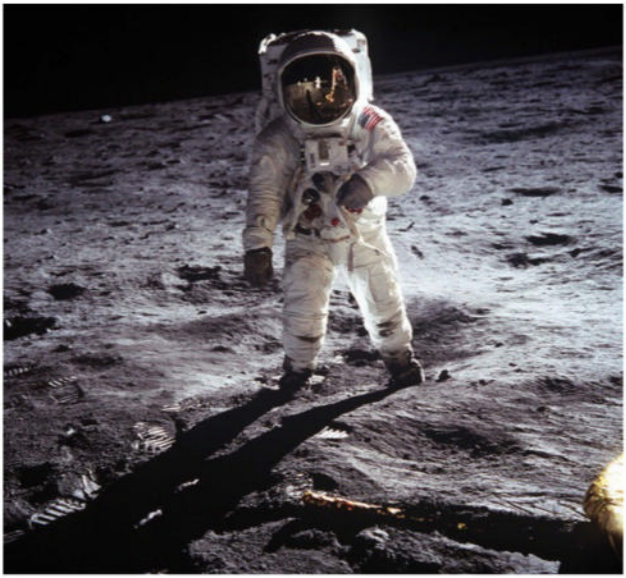

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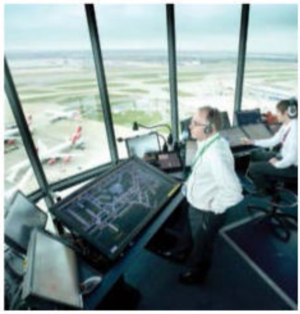


History

What causes earthquakes?

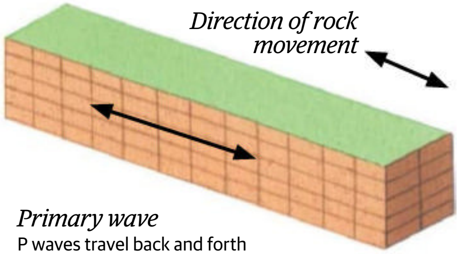
Behind the destructive phenomena that make the Earth move

Earthquakes are caused by the build-up of pressure that is created when tectonic plates collide. Eventually the plates slip past each other and a huge amount of energy is released, sending seismic waves through the ground. The point at which the fracture occurs is often several kilometres underground; it is known as the focus or hypocentre. The point directly above it on the surface is the epicentre, which is where most of the damage is caused. Earthquakes have different characteristics depending on the type of fault line, but when they occur underwater they can trigger enormous wave capable of huge devastation – these are called tsunamis.

©Thinkstock

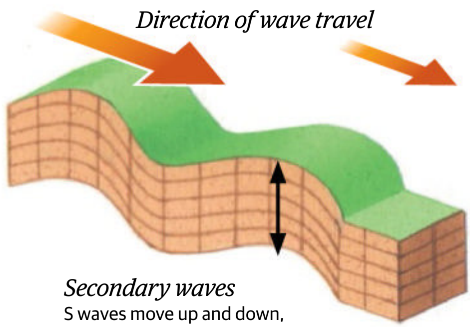
Earthquake waves

How seismic waves travel through the Earth's crust



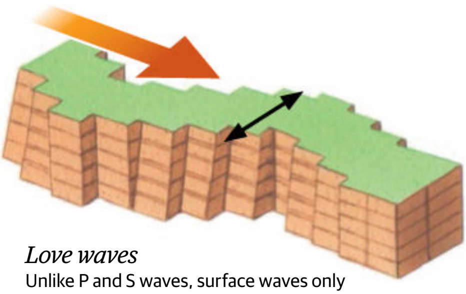
Primary wave

P waves travel back and forth through the Earth's crust, moving the ground in line with the wave. They are the fastest moving of the waves, travelling at about 6-11km/s (3.7-6.8mi/s), and typically arrive first with a sudden thud.



Secondary waves

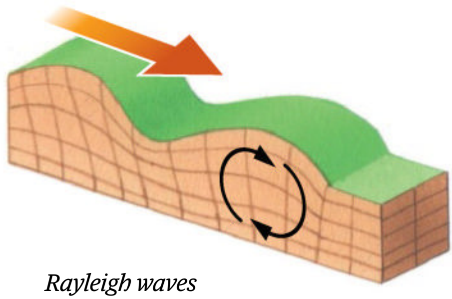
S waves move up and down, perpendicular to the direction of the wave, causing a rolling motion in the Earth's crust. They are slower than P waves, travelling at about 3.4-7.2km/s (2.1-4.5mi/s), and can only move through solid material, not liquid.



Love waves

Unlike P and S waves, surface waves only move along the surface of the Earth and are much slower. Love waves, named after the British seismologist AEH Love, are the faster of the two types and shake the ground from side to side, perpendicular to direction of the wave.

"A huge amount of energy is released, sending seismic waves through the ground"

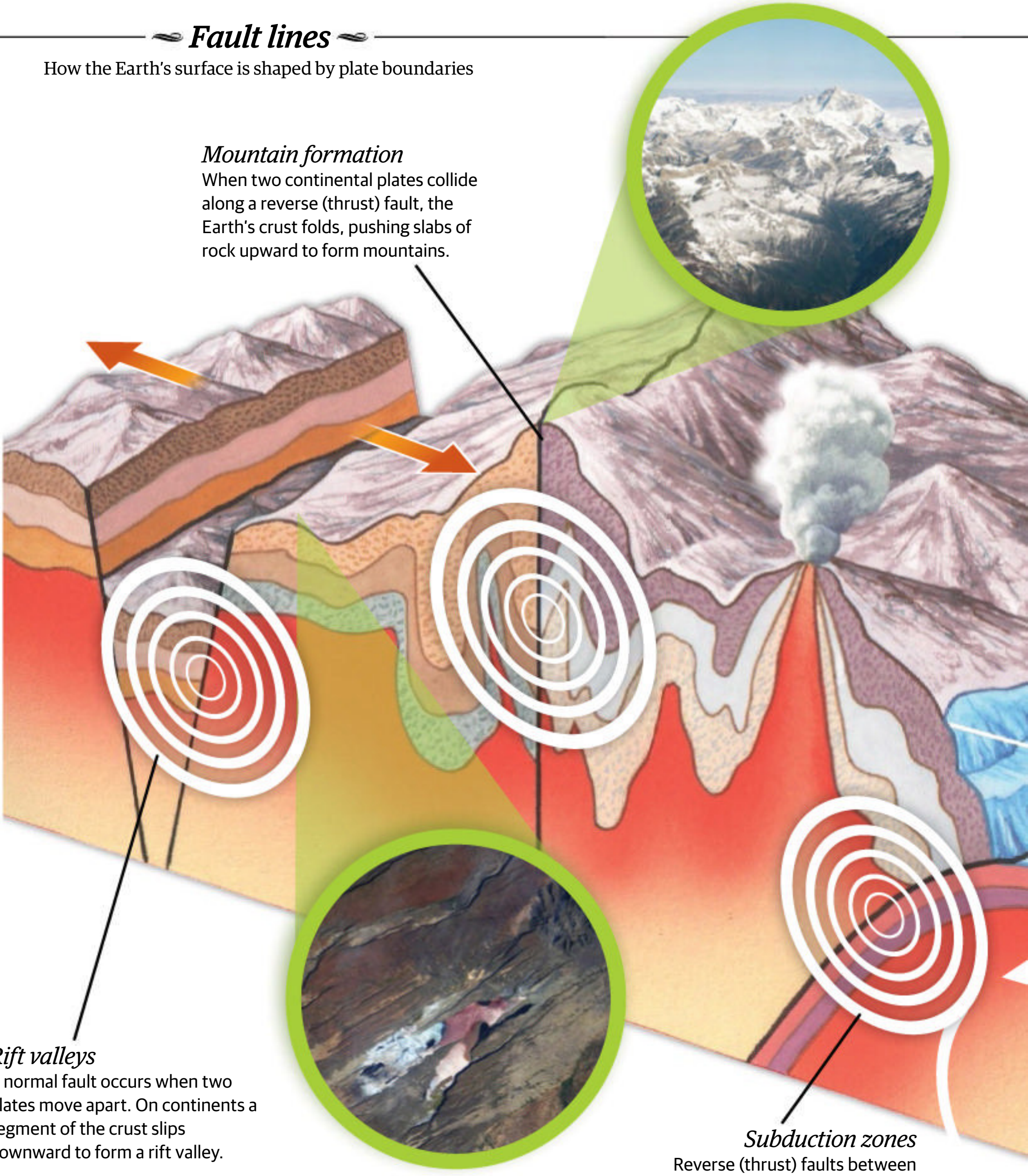


Rayleigh waves

Rayleigh waves, named after the British physicist Lord Rayleigh, are surface waves that cause the ground to shake in an elliptical motion. Surface waves arrive last during an earthquake but often cause the most damage to infrastructure due to the intense shaking they cause.

Fault lines

How the Earth's surface is shaped by plate boundaries



Mountain formation

When two continental plates collide along a reverse (thrust) fault, the Earth's crust folds, pushing slabs of rock upward to form mountains.

Rift valleys

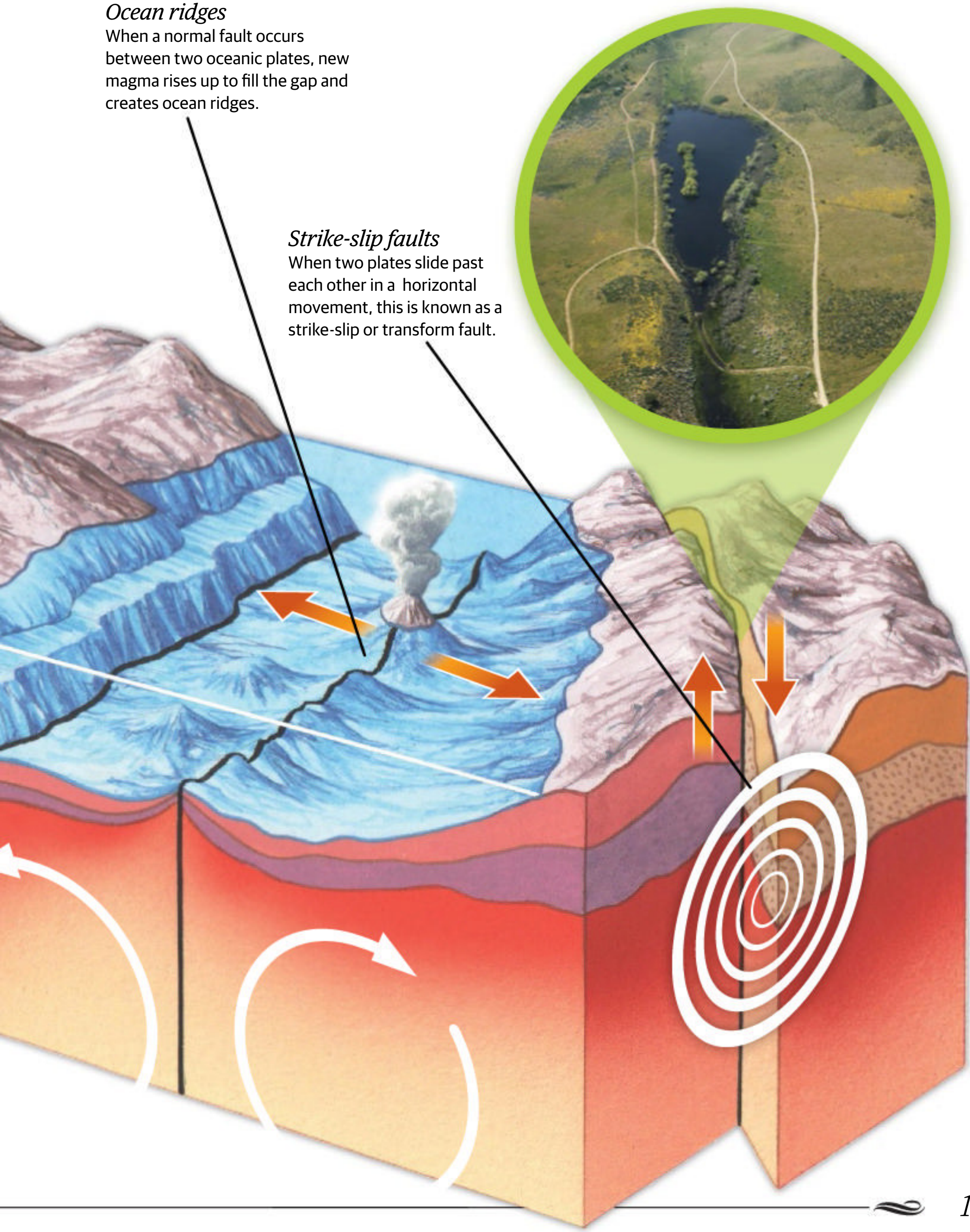
A normal fault occurs when two plates move apart. On continents a segment of the crust slips downward to form a rift valley.

Subduction zones

Reverse (thrust) faults between continental and oceanic plates cause subduction, causing the higher-density oceanic plate to sink below the continental plate.

Ocean ridges
When a normal fault occurs between two oceanic plates, new magma rises up to fill the gap and creates ocean ridges.

Strike-slip faults
When two plates slide past each other in a horizontal movement, this is known as a strike-slip or transform fault.



What do ant colonies look like?

An army of ants can construct vast underground cities in a week

Below
Ants have separate entry and exit points to their hives

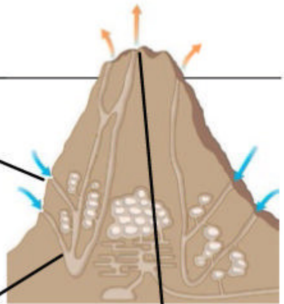
A single ant is capable of carrying up to 50 times its own weight, so working together as a colony means they're able to accomplish impressive feats. In fact, within a week, a large army of garden ants can construct an underground city large enough to house a colony of thousands of insects.

Originating deep underground, ant nests are made up of multiple chambers connected by tunnels. Each chamber has a different purpose; some are for food storage, others are nurseries for the young and resting spaces for busy worker ants. You'll find the queen ant in the central chamber, where she'll lay her eggs.

Amazing structural additions are porous turrets that are built above ground to ventilate the nest and maintain an even temperature inside.

Termite megacities

At up to five metres tall, termite mounds are made from soil, dung and termite saliva, and can take four to five years to build. Just like ants, termites are social animals and work together to erect these impressive structures. Although a mound appears solid, it's actually porous, enabling air to circulate throughout to maintain the temperature. Towers are also built facing north to south to help regulate heat. Air will enter the mound through tiny exterior holes and circulate around the structure, lowering the temperature and providing fresh oxygen to the insects. As the air warms, it will rise and exit the mound via the central chimney.



Fresh air
A termite mound is porous, which enables cool air to enter and circulate the structure.

Internal tunnels and chambers
A network of tunnels connect chambers used for living and farming fungi for food.

Rising heat
As air inside the mound warms, it rises up and exits through the central chimney within the tower.

Underground ant engineering

Take a peek inside an ant colony

Construction
Ants hollow out a network of tunnels and underground chambers grain by grain using their mandibles (insect mouthpart).

Ventilating the nest
In order to maintain an even temperature and ensure a constant flow of oxygen inside, ants build porous turrets above ground.

Entry points
There are often a few entry and exit points to an ant nest, ensuring worker ants have quick access.

Expansion
As the colony grows, worker ants will continue to expand the size of the nest. Some can be as deep as 3m (9.8ft).

Living space
Each tunnel connects to various chambers, which can be used to house food, ant eggs and the oversized queen of the colony.

How are plastic bottles recycled?

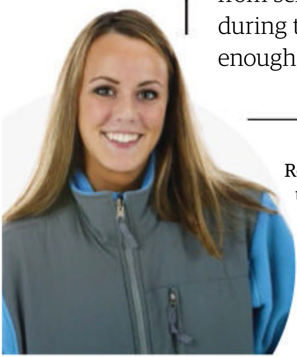
What happens when you put a plastic bottle in the recycling bin?

The average UK household throws away an estimated 500 plastic bottles every year, and a large percentage end up in landfill sites. Most plastic bottles are made from polyethylene terephthalate (PET) or high-density polyethylene (HDPE), both of which are degradable plastics. This means that when they are exposed to enough light, oxygen, heat or mechanical stress, they can break down into water, carbon dioxide, biomass and trace elements.

However, this process can take hundreds of years, during which time the plastic is taking up landfill space and can be potentially harmful to wildlife, particularly if it ends up in the sea. The best solution for disposing of plastic bottles is to recycle them to generate, among other things, brand new bottles.

As well as reducing the amount of waste going to landfill, this also helps conserve the non-renewable fossil fuels needed to make bottles from scratch and reduce greenhouse gas emissions normally created during this process. In fact, recycling one plastic bottle can save enough energy to power a 60-watt light bulb for three hours.

Below
Your empty bottle of water can be turned into a warm fleece jacket



Made from bottles

Recycled plastic bottles can be turned into all sorts of useful things. For example, the flakes made from melting plastic can be spun into a fine polyester fibre, which can be used to make fleece clothing, carpets and duvet filling. The durability of recycled plastic makes it ideal for use in drainage pipes, scaffolding boards and fences,, and it's a cheap material for making street furniture, signs and bins. The stationery in your pencil case could be made from recycled bottles too, as the plastic flakes can be reshaped into rulers, pencil sharpeners and other items.

The recycling journey

How your plastic bottle is reborn

1. Collection

Your empty plastic bottles are collected and taken to a recycling facility for sorting. If you have already separated the plastic bottles from the rest of your recycling they can be sent straight to a recycling plant.

2. Separating

The recycling is hand-checked to remove any non-recyclable material. A 'trommel' – a large perforated spinning drum – then separates plastic bottles and cans.

3. Sorting

The bottles are then cleaned and sorted by type and colour using infrared beams. The infrared light is reflected off of the plastics in different ways, allowing a sensor to detect which is which. Precision jets of air then separate the different types.

4. Shredding and melting

Next they are shredded by a machine and washed again to remove any impurities, such as remnants of paper labels or the original contents. They may also be decontaminated further using a chemical solution. The shreds of plastic are then dried and melted down.

5. Flaking

The melted plastic is reformed into flakes or pellets as it cools. These can then be melted down and used to make new products such as new plastic bottles.

What are ocean dead zones?

The biology behind these barren expanses of ocean

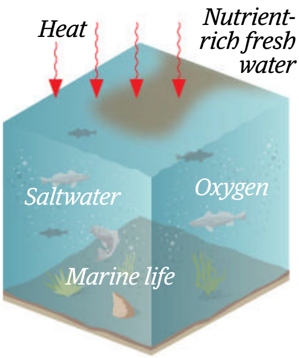
Dead zones get their name from the fact that they can support very few plants and animals. This is due to the absence of oxygen, known as 'hypoxia'. Hypoxic conditions can materialise in lakes and other standing bodies of water, but they can also occur in large areas of the ocean.

The main cause of a dead zone is eutrophication – when minerals, usually of agricultural origin, are washed into the water. The heightened nutrient levels stimulate huge blooms of algae on the surface of the water. This then restricts oxygen making its way into the water, which effectively smothers everything living beneath it.

Due to the agricultural nature of the nutrient runoff, dead zones often appear close to the shore. There are around 146 known coastal dead zones around the world, with the largest ones located in the Baltic Sea and the Gulf of Mexico.

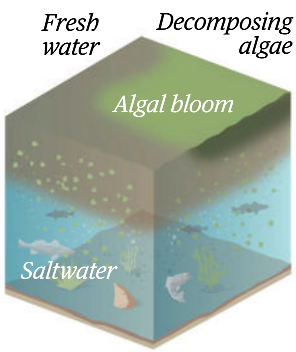
Becoming a dead zone

How a healthy patch of ocean becomes a hypoxic watery wasteland



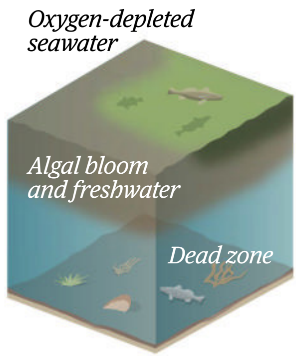
Nutrient runoff

Sun-warmed freshwater runs off the land. Nutrient-loaded water sits on top of seawater, cutting off oxygen to organisms below.



Algal bloom

The nutrients encourage algae growth on the surface. Dead algae also decomposes at depth, using up the limited oxygen levels.

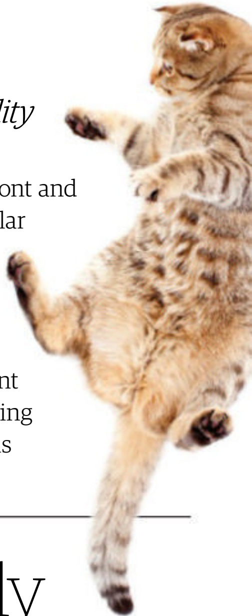


Deep-water hypoxia

Oxygen supplies dwindle and organisms living below can't survive. Fish can die in shoals and dead matter floats to the surface.

Why do cats always land on their feet?

What's the secret behind this amazing feline agility



When they take a tumble, cats move their front and back limbs separately to create spin (angular momentum) and right themselves in mid-air. First, a falling cat uses its eyes and inner ear to work out which way is down. It then stretches out its hind legs while pulling in its front legs. Turning its rear end slightly one way, it twists its front end in the other direction until its front paws are facing down. From there it tucks in its back legs and swivels them around so all four limbs meet the ground.

Do horse chestnuts really keep spiders away?

Does this autumnal trick really repel arachnids?

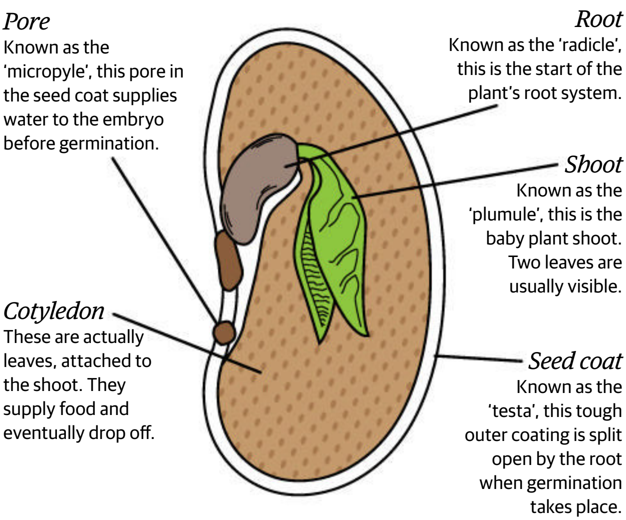
There is no evidence to back up the claim that conkers repel spiders. In 2009, the Royal Society of Chemistry (RSC) offered a prize to anyone who could provide proof of this old wives' tale. One theory was that a chemical in the horse chestnuts might smell unpleasant to the arachnids. But with nobody able to substantiate the claim, the RSC concluded that the notion was false, awarding its prize to schoolchildren who had conducted a number of experiments that suggesting spiders were indifferent to horse chestnuts. Instead, lemon juice or essential oils may be a more effective natural spider repellent.

What's inside a seed?

These tiny pods have the potential to become the largest redwood or the prettiest peony

Seeds are the reproductive body of types of plants known as 'angiosperms' - flowering plants - and 'gymnosperms' - the group that contains conifers. Every plant seed, regardless of its size or the species of its parent plant, contains three main parts: the embryo, the cotyledon and the seed coat.

The seed's embryo is the baby plant, the young root and shoot that has the potential to grow up and develop into the majestic specimen that its parent once was. The cotyledon, or 'food store', is the source of a seed's nourishment, containing enough starchy nutrients for survival during the first few weeks following germination, after which the young plant will be able to make its own food via photosynthesis. Lastly, the seed coat provides a tough layer of protection for the baby plant, enabling it to lie dormant over winters and be dispersed by animals, wind or water action. Then it can simply wait until the conditions of light, warmth, oxygen and water are perfect to initiate its growth.



What makes seawater so salty?

The natural seasoning that causes the flavour of the sea

Below
Seawater can be evaporated to harvest salt for culinary or industrial purposes

© Thinkstock

Most of the salt in the ocean comes from a process that takes place on land. Rainfall contains carbon dioxide from the atmosphere, making it acidic. As the rain erodes rocks on land, it releases ions – atomic particles that carry an electric charge. Rivers and streams eventually carry these dissolved ions out to the ocean. Some are removed from the water by various plants and animals, while other ions – mainly sodium and chloride – remain and become more concentrated. These two ions are what make seawater salty. It's estimated that if all of the oceans were evaporated and their salts were spread evenly on the entire surface of the Earth, it would form a layer 152 metres (500 feet) thick.

Why do dogs lick people?

Ever wondered what your canine companion is after?

While it's believed that dogs lick humans to show affection, there are many other theories to explain the behaviour. One is that we taste pretty good. Salty sweat and food residue not only taste great but provide information about where we have been and what we have eaten. Licking is also considered a learned behaviour. Puppies learn to lick to keep themselves clean, but also to communicate – greeting one another and strengthening bonds within the group. In adult dogs, licking is also a way of showing submissiveness to a dominant pack member, so it's likely that dogs lick us for the same reasons.

© Dreamstime

How does wind erosion work?

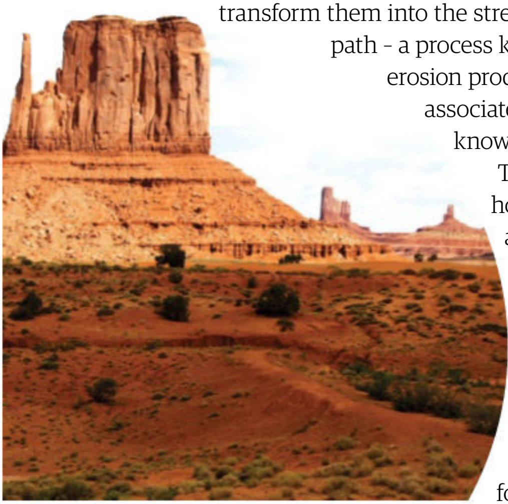
The sheer power of the wind shapes and sculpts whole landscapes over time

Ever wondered how desert stacks emerge, how huge archways appear out of the rock and how colourful stripes stretch along rocky ledges in the desert? All of these features are the result of wind erosion – the fancy term for which is Aeolian processes.

In the wide-open expanses of deserts, the sheer force of the wind can eat into softer types of rock, such as sandstone. Rock particles are removed and lifted up by the wind (a process known as deflation) and then, as the wind blusters through the arid landscape, its path governed by the rock formations that dominate the terrain, these particles act almost like sandpaper on the rocks and gradually transform them into the streamlined shapes that follow the wind's path – a process known as abrasion. Over time, this gradual erosion produces the incredible landforms we associate with the desert landscape, which are known as 'yardangs'.

The type of rock in an area greatly affects how the wind shapes it. Softer rock types are easily eroded, while harder rock is far more resistant and is more likely to be polished by the ferocity of the wind, resulting in smooth, buffed formations. Softer rock is carved out by the wind, producing much more pronounced effects, while a mixture of both hard and soft rock types can produce incredible formations such as buttes and arches.

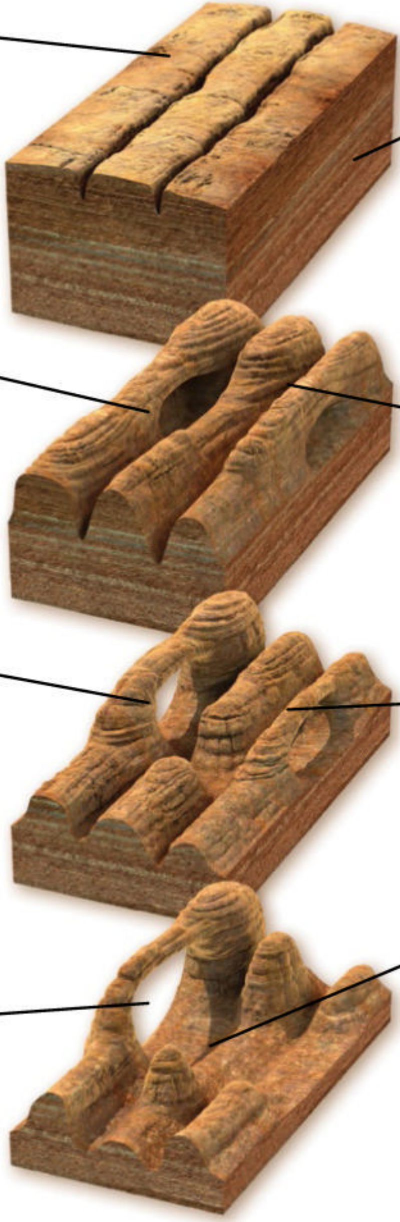
Below
Monument Valley in Utah, USA is a famous example of extreme wind erosion



© Luca Galuzzi

How rock archways are formed

Erosion by the wind helps to hollow out these incredible natural structures



Cracking
Geological processes can cause the rock to crack, creating fissures and exposing the softer layers of rock within.

Rock layers
Different types of rock with different properties form and shape the landscape in layers.

Overlying rock
The wind gradually erodes the layers of rock above the cracks.

Cracks deepen
As the wind rushes through the cracks they are gradually eroded away and begin to widen and deepen.

Rain and ice
Rainwater dissolves some of the soft rock's chemical makeup, while water in small cracks freezes and weakens the rock.

Rockfalls
The weakened softer rock begins to crumble and eventually falls away, leaving an arch of more resistant rock.

Collapse
Eventually, the arch is eroded so much that it collapses, leaving two rock pillars standing either side.

Archways widen
Wind erosion continues to wear away at every surface of the exposed archway, constantly widening it.

How do electric eels hunt?

Discover how the electric eel shocks its prey into submission

Below
The electric eel can paralyse its prey with up to 600 volts

The electric eel is a formidable freshwater predator with the ability to emit a powerful voltage of electricity underwater to immobilise passing prey. Releasing pulses of electricity has a direct effect on a fish's muscles, causing them to twitch or convulse, which gives away their position to the predator. Electric eels are capable of this feat because they have electric organs that can store power like a battery. When an eel plans to attack, thousands of specialised electrocyte cells within its organs will discharge, emitting a burst of electricity of up to 600 volts. Due to their poor eyesight, electric eels will use the same technique to ward off predators and to navigate in their gloomy freshwater surroundings.

Why are jungle birds more colourful than others?

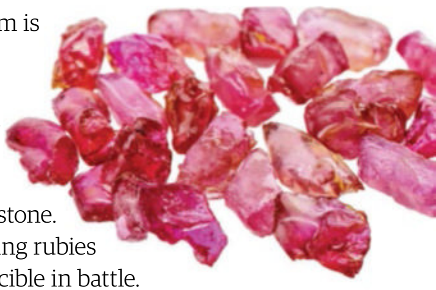
How jungle birds' bright plumage attracts female attention

Below
Among birds, the males are most often the biggest show-offs

In most species only the male is brightly coloured, which is central to understanding how this plumage evolved. Being colourful makes you more visible to predators, and females choose colourful males because they demonstrate how fit and healthy they must be to have survived so long. All her offspring, male and female, benefit from his superior genes, with the extra risk befalling the males alone. In dense forest environments full of hiding places, this mating advantage is completely worth it. In more exposed environments, predation is a bigger immediate concern, making it more advantageous for both sexes to be camouflaged.

How do rubies form?

Identifying the precise mechanism that forms these precious gems is an ongoing task



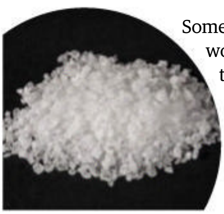
Rubies are actually a type of rare mineral called corundum. Corundum is made up of densely packed aluminium and oxygen atoms, which are colourless on their own. However, when chromium ions replace some of the aluminium, bright red hues appear in the gemstone.

Burmese warriors believed placing rubies under their skin made them invincible in battle. Although this was not the case, rubies are beaten only by diamond among the minerals, with a hardness of 9.0 on the Mohs scale.

How rubies are formed is still debated by scientists, but there are some leading theories. It is widely accepted that plate tectonics are involved, specifically where the continents of India and Asia collide to form the Himalayas. What has baffled scientists is why rubies are present only erratically within this area's marble. Geologists need access to Burma's Mogok mine to prove or disprove any theory they put forward, but owing to the country's delicate political situation, this is not currently an option.

Below/Right
Colourless corundum is turned red by the presence of the impurity chromium

Ruby formation theories

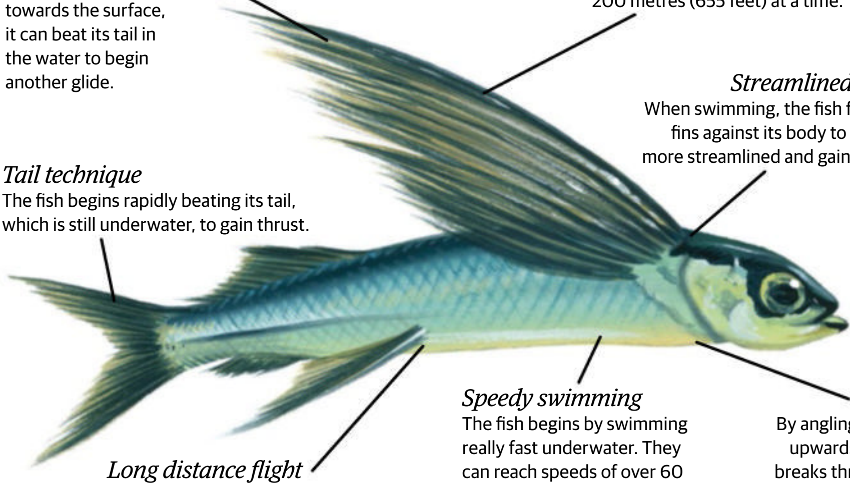


Some believe the key to ruby formation is salt's presence within the limestone. This salt would have mixed with the detritus (dead organic material) and helped form the limestone that produced rubies. Once the limestone became heated, the salt lowered the melting point of the mixture (a flux), allowing the aluminium enough mobility to mix with the chromium. Crystals of salt have been found within the ruby-containing marble, which supports this theory. Others believe the process requires a liquid to transport silica away before rubies can develop. Silica will actually stop corundum formation, so there would be no chance of rubies forming in areas with high levels of this compound.

How do flying fish fly?

Discover the clever technique that gets these aquatic creatures airborne

Is it a bird? Is it a plane? No, it's actually a fish. Strictly speaking though, flying fish don't really fly. They use their fins to help them glide through the air, but they don't flap them like wings. The fish developed this technique to help them escape predators in the water, but they can't remain airborne for long as they need to return to the water to breathe.



Gliding
By spreading its fins, the fish can glide through the air for up to 200 metres (655 feet) at a time.

Staying airborne
When it falls back towards the surface, it can beat its tail in the water to begin another glide.

Streamlined body
When swimming, the fish folds its fins against its body to make it more streamlined and gain speed.

Tail technique
The fish begins rapidly beating its tail, which is still underwater, to gain thrust.

Speedy swimming
The fish begins by swimming really fast underwater. They can reach speeds of over 60 kilometres (37 miles) per hour.

Lift off
By angling its body upwards, the fish breaks through the surface of the water to reach heights of up to six metres (20 feet).

Long distance flight
By completing successive glides, the fish can travel up to 400 metres (1,312 feet) through the air.

Do we know the number of tigers left in the wild?

Measuring the threat to Earth's remaining tiger population

Right
There are fewer than 400 Sumatran tigers left in the wild

The International Union for the Conservation of Nature (IUCN) keeps records of the population sizes of thousands of threatened species. Their figures are estimates based on surveys from lots of regional conservation bodies. This is a mixture of direct observation, cameras set up near watering holes and droppings or paw prints found on trails. The most recent figures, which are from 2011, suggest there are around 3000 tigers left in the wild.

What are light pillars?

The cause of many false UFO reports exposed

Below
Light pillars form due to the light of the Moon or street lights

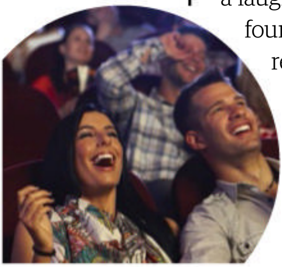
© Photo by Christoph Geisler

A rare atmospheric and optical phenomenon, light pillars are only visible under very specific conditions. They form when light from a source low in the sky – such as the setting Sun or even streetlights – reflects off millions of flat, hexagonal ice crystals in the air and into your eyes or camera. The columns of light are not physically present, but if you stand in the right spot, with the ice crystals roughly halfway between you and the light source, the optical illusion occurs. As well as being cold enough for the ice crystals to form, the weather must be very calm so that the crystals can fall gently through the air while remaining in a horizontal orientation, tilting slightly from side to side. It's these tilted crystals that elongate the reflection into a column, and the higher they are in the sky, the taller the column will be.

Why is laughter contagious?

How a trick of the brain coaxes us into sharing laughter

Below
Laughter helps us fit in and show politeness towards others



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We've long known that laughter often prompts us to laugh ourselves – or at least smile – even if a joke isn't particularly funny. Researchers have found that we actually have a laugh generator in our brains. The sound of laughter has been found to activate the premotor cortical region, an area of the brain responsible for preparing our facial muscles to react. Unpleasant sounds also activate the region, but we're still more likely to smile or laugh at the sound of laughter than, say, make a disgusted face if we hear an unpleasant noise. That's because laughter is also a social tool that we use to fit in with other groups of people. Some scientists even theorise that our ancestors may have laughed together before they could speak.

Why do some animals have whiskers?

Understand the sensory power of animal whiskers

Primarily sensory tools, whiskers help animals collect information about their environment. Dense packets of nerves at the base of each whisker feed into a specific pathway, picking up tiny vibrations. They are used to sense objects and air currents, alerting them to approaching dangers, particularly in the dark. Different species use their whiskers for slightly different purposes. Many predators, like seals and shrews, use theirs to detect prey. Rats can move their whiskers rapidly, scanning their surroundings to build up mental maps. Cats use them to judge whether they can squeeze into a small space. Whiskers can also fulfil a social function – for example, dogs show fear by flaring out their whiskers.

© Dreamstime

How do insects walk on water?

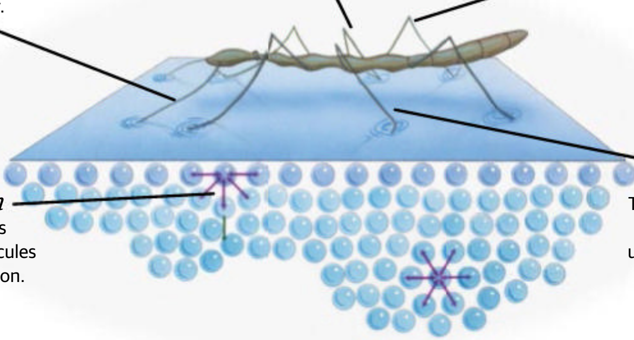
An insect's secret to staying afloat revealed

Below
Water skaters are sometimes called Jesus bugs

The water strider is classed as a true bug (a member of the Gerridae family) and lives on or around the surface of freshwater. Despite being denser than water, it can skate across the surface without breaking through. Its feet bend in such a way that the water deforms, much like elastic film thanks to tiny hairs that trap air bubbles between them and the water's surface. Its middle legs act as paddles, making movement possible, while its long rear legs enable it to steer and even brake as it glides across the water. Its front legs are also short enough to grab prey - living or dead - along the way. Thankfully, the speed at which the water strider can move means it stands a chance against its own predators.

Anatomy of a water strider

How does the water strider use its body to walk on water?



Paddle legs
Its middle legs act like paddles and enable the bug to move across the water's surface.

Short legs
Short front legs make it easy for the water strider to grab prey.

Long legs
The rear legs are long and used for steering and braking.

Surface tension
The cohesive forces among liquid molecules cause surface tension.

Hair
The water strider has hairs on its legs and underside of its body that trap air.

What is the Doomsday Seed Vault?

Welcome to the Swiss bank of the agricultural world

Deep within the Arctic Circle, on the frozen island of Spitsbergen in the Norwegian Svalbard archipelago, is a giant vault. It's something you'd half expect to find in a Bond movie: set 120 metres (394 feet) inside a mountain, it's the site of an old coal mine and boasts some formidable security features that include reinforced concrete walls, dual blast-proof doors, motion sensors and airlocks.

Just 1,300 kilometres (808 miles) from the North Pole, the island's inhospitable climate and treacherous terrain make monitoring human activity in the area relatively easy. The 1,750 banks from around the world that have made deposits to this vault can sleep easy knowing their investments are secure. But this is no safe house for cash or gold, nor is this a financial institution of any kind – it is a giant repository for the world's precious seed crops.

The project is an effort on the part of several multinational corporations and governments to protect future crop diversity. This includes the Bill and Melinda Gates Foundation along with a conglomerate of corporations with agricultural interests called the Global Crop Diversity Trust, and the Ministry of Agriculture and Food on behalf of the Norwegian government.

Below
The entrance is the only part of the Svalbard Global Seed Vault that stands above ground

Below
The vault's construction was funded entirely by Norwegian authorities

Svalbard is an ideal choice for the vault's location, making it a kind of fail-safe, should worldwide seed banks fail. The location may be remote, but it has good infrastructure and a ready supply of coal to power the facility. The sandstone the vault is set into is low in radiation and stable, plus it's very cold and dry, protecting the seeds even if the refrigeration units were to fail. So, in the event of large-scale regional or global crises, our world's diverse produce is securely backed up.

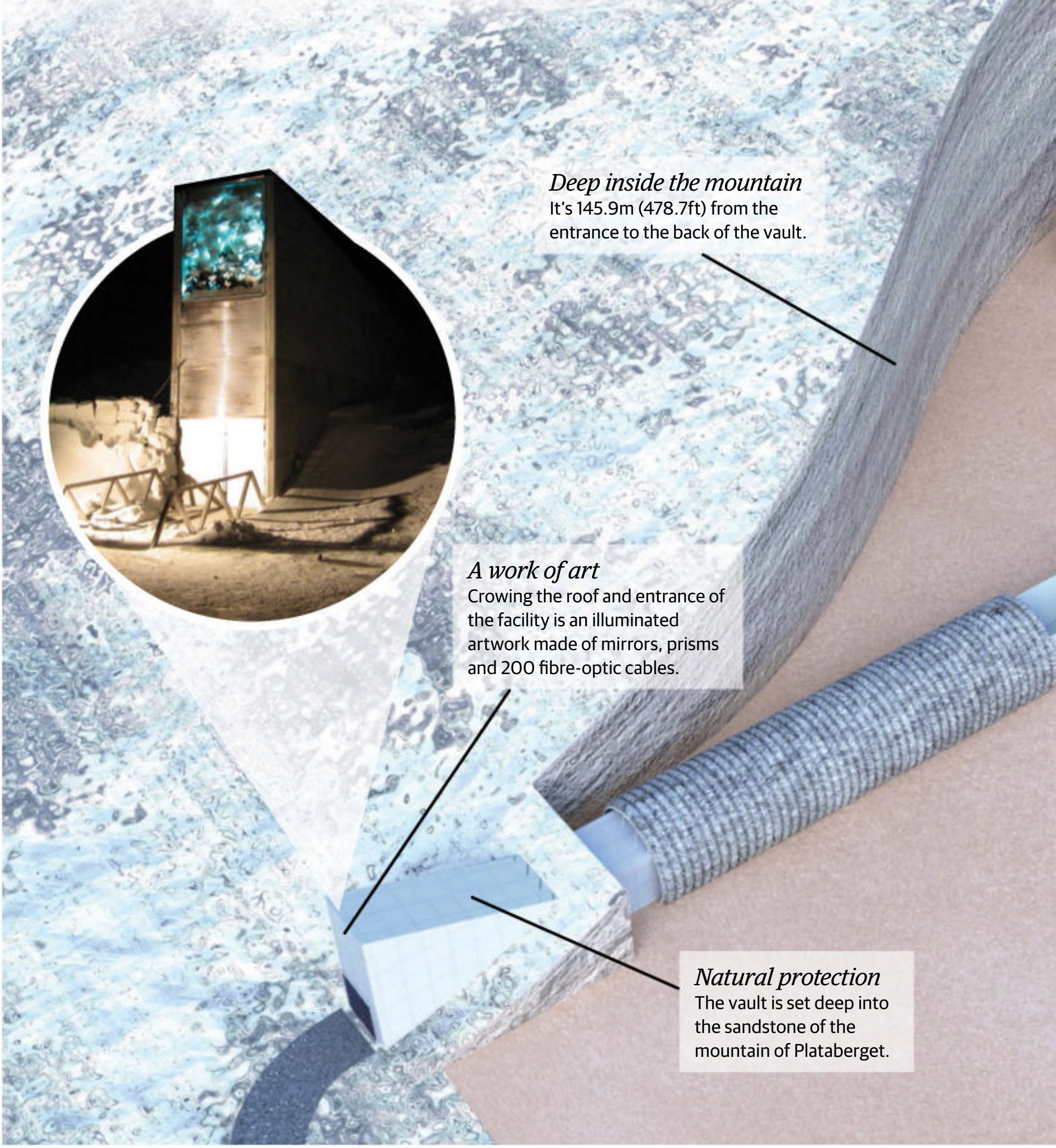
©Alamy

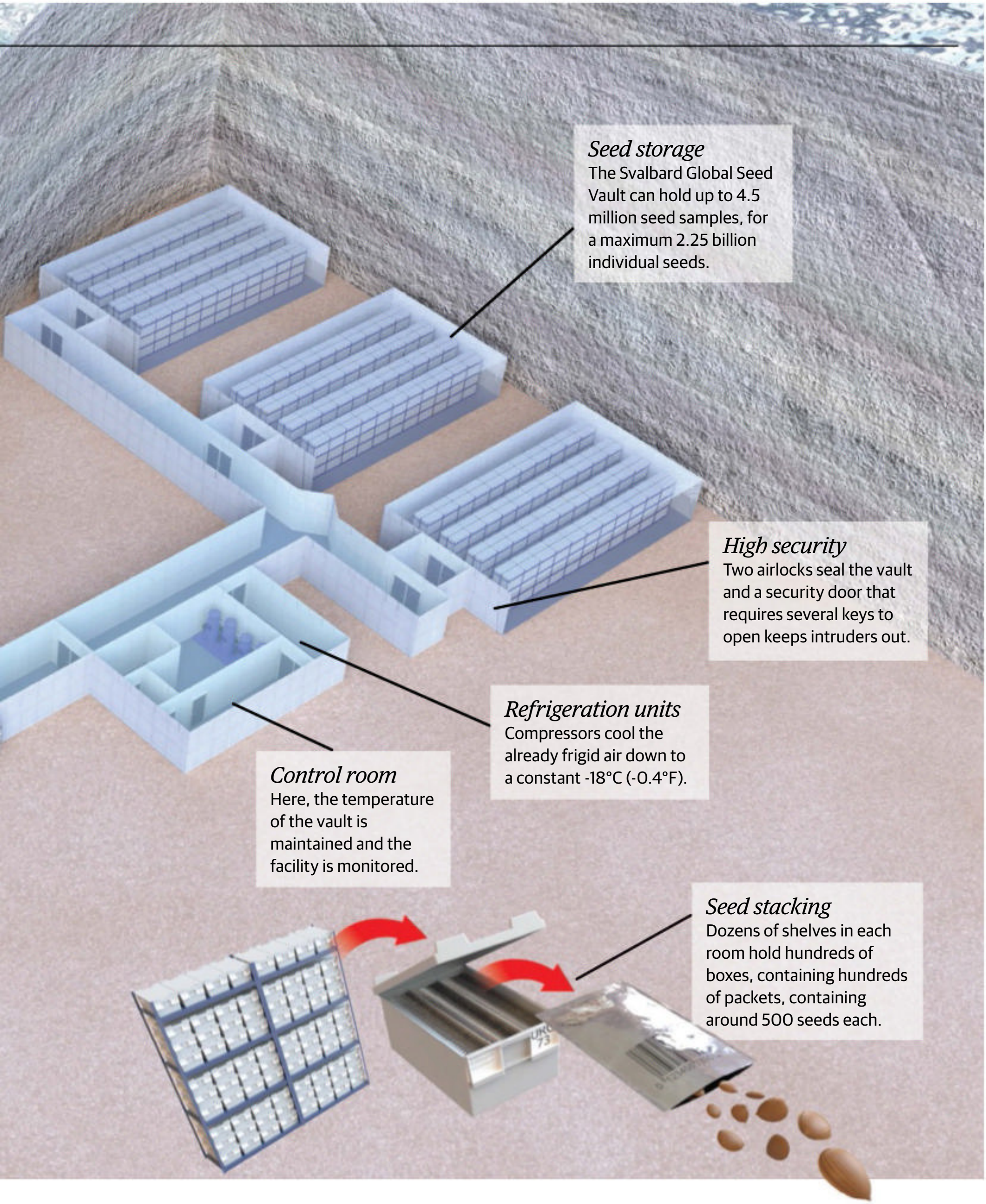
Preserving our food future

Duplicate samples of seeds from national seed banks are stored in sealed aluminium bags that exclude moisture, then shelved in itemised containers, the contents of which are recorded and held in a database maintained by the Norwegian authorities. The bedrock that surrounds the vault is a temperature of minus-three degrees Celsius (27 degrees Fahrenheit), although the facility is kept even colder by refrigeration units that chill the seeds to minus-18 degrees Celsius (minus-0.4 degrees Fahrenheit). The island of Spitsbergen is tectonically inactive and even if the ice caps melted, the site lies high enough to remain above sea level. Under these conditions, seeds will remain viable for hundreds or even thousands of years.

The world's coldest bank

In the event of the unthinkable, the Svalbard Global Seed Vault can preserve our food crop history




Seed storage
The Svalbard Global Seed Vault can hold up to 4.5 million seed samples, for a maximum 2.25 billion individual seeds.
High security
Two airlocks seal the vault and a security door that requires several keys to open keeps intruders out.
Refrigeration units
Compressors cool the already frigid air down to a constant -18°C (-0.4°F).
Control room
Here, the temperature of the vault is maintained and the facility is monitored.
Seed stacking
Dozens of shelves in each room hold hundreds of boxes, containing hundreds of packets, containing around 500 seeds each.

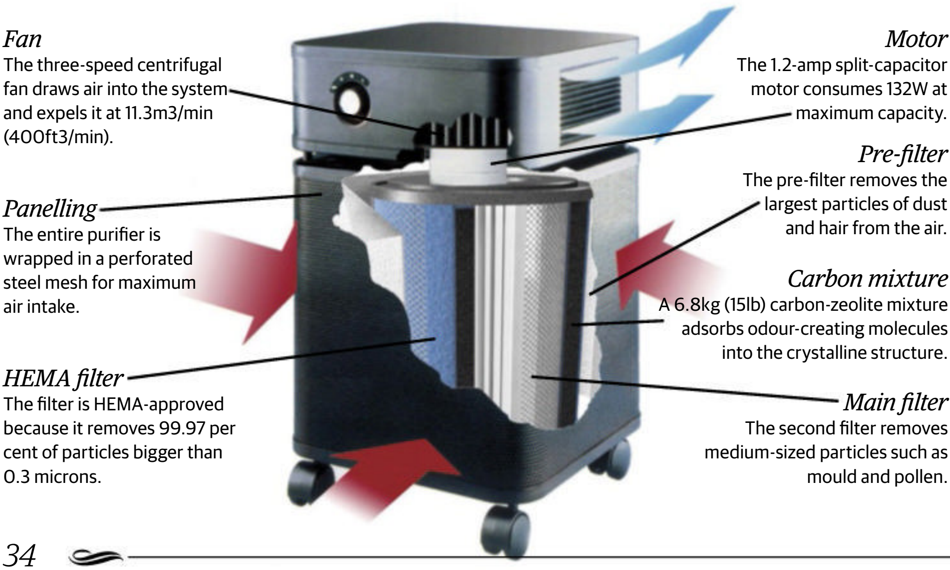
How is air purified?

How air purifiers filter out dust and odours to keep your world clean

Most air purifiers remove pollutants from the air by filtration or by ionising molecules. The filtration system uses a fan to draw air into the machine before passing it through a series of filters. These are usually foam, fibreglass or charcoal, all of which are extremely porous. This allows small air particles to pass through but catches and holds larger dust particles. Air purifiers that only let through 0.03 per cent of particles that are 0.3 micrometres or larger are given a High Efficiency Particulate Air rating from the US Department of Energy. Ionising purifiers also draw air in using a fan. Once inside, larger particles such as pollen or dust molecules pass through an electrical field called a corona discharge. This adds or removes an electron from the molecule, giving it either a positive or negative charge. The charged molecules are then attracted to one of two charged metal plates inside the purifier where they stick, allowing the clean air to pass through.

Inside Austin's HealthMate

The specs adopted by the Austin air purifier to keep your air fresh and clean



Does bulletproof glass work?

Understand the futuristic tech capable of stopping a bullet

Below
Bullet-resistant glass is made from heat-bonded layers of glass and plastic

When a normal pane of glass is struck, there is nothing to absorb the energy, and the weakly-bonded particles break apart, allowing a bullet to travel straight through. To prevent this from happening, sheets of tough, flexible plastic, often polyvinyl butyral (PVB), are sandwiched in between, and repeatedly heated and cooled to bind the two together in a process known as lamination. When a bullet hits, the layers of glass shatter as normal, but as they break, the force is absorbed and spread by the strong and flexible PVB sandwiched in between. This slows the bullet down, preventing it from passing through. The fragments of broken glass remain firmly stuck to the plastic, stopping them from flying away and causing injury.

How does wireless charging work?

The future of phone charging will rid your home of untidy wires

Most wireless chargers use electromagnetic induction. The charging pad contains a wire coil, through which an alternating electric current is passed to create a pulsing magnetic field. At the other end, your mobile phone has its own coil, which reacts to the magnetic pulses by producing a corresponding alternating electric current. This is converted into direct current to power the device. Wireless charging is less efficient than cable charging and the magnetic field strength falls off very quickly with range. But recently, a company called uBeam has demonstrated longer range wireless charging that works by beaming ultrasound waves that are converted into electricity in your phone by piezoelectric transducers.

Right
Ikea now includes wireless charging pads in some of its lights and furniture

How is water treated?

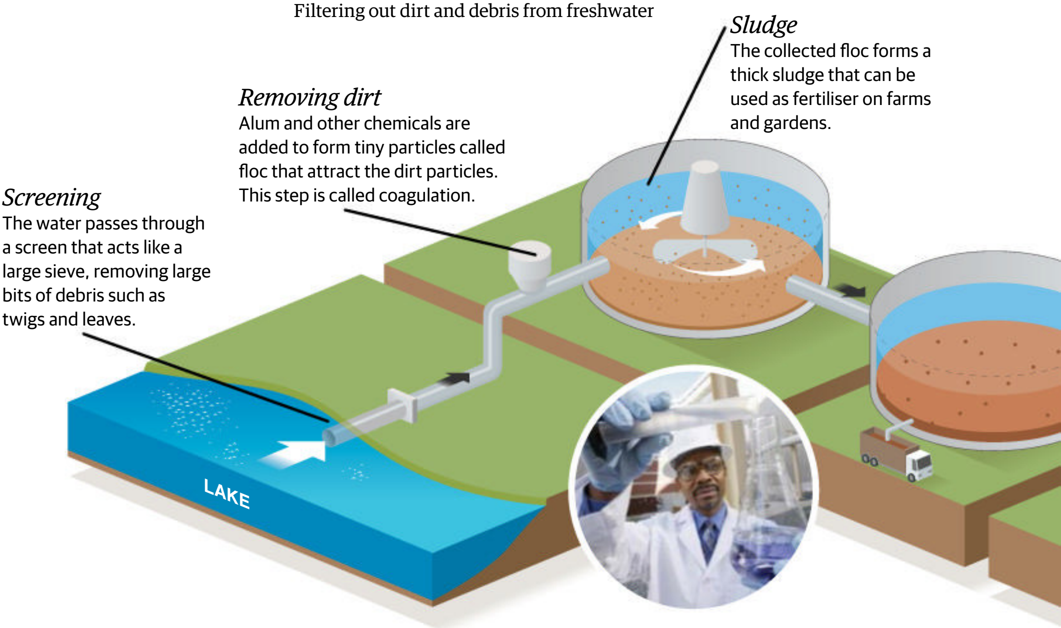
Follow the cleaning process that makes water safe to drink

Below
Constant testing of the treatment process ensures your water is safe to drink

The water that comes flowing out of your tap starts off as rain falling from the sky. It's collected in rivers and lakes as surface water, or beneath the Earth's surface as groundwater, but it would be unsafe to drink without treatment. This water contains dirt, pollutants and microorganisms that cause nasty diseases such as typhoid, cholera and dysentery. To remove these harmful impurities, drinking water is filtered and disinfected at a water treatment plant before it reaches your home.

Journey from lake to tap

Filtering out dirt and debris from freshwater



Right
Sedimentation takes place in large round tanks called clarifiers

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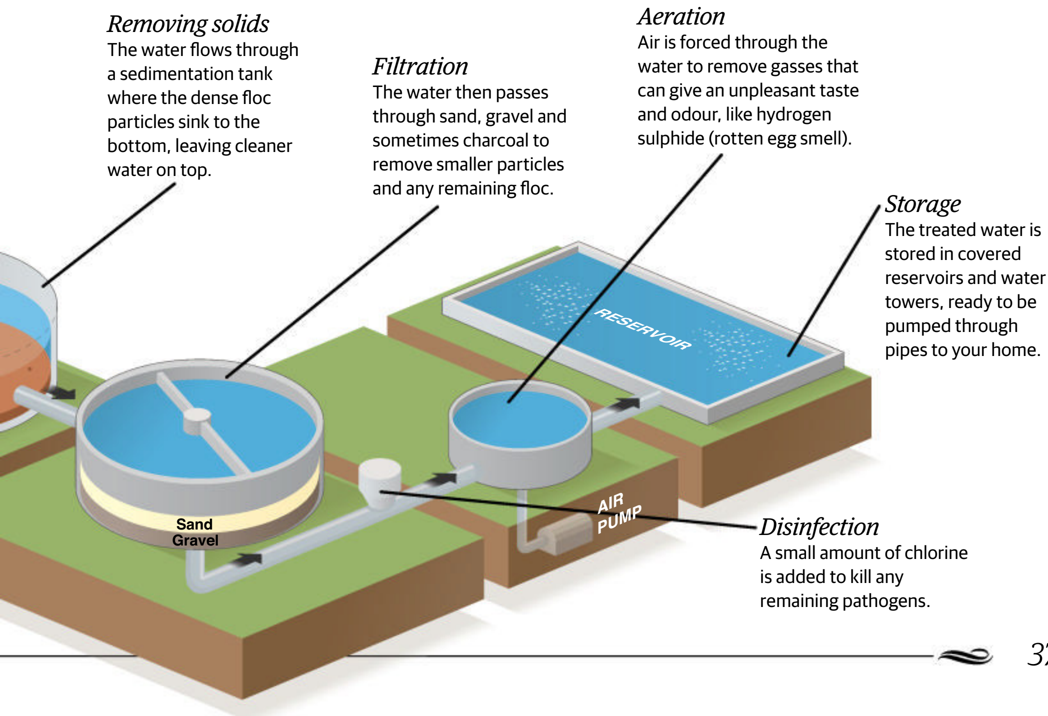
The treatment process is often tailored to each water source, as some require more cleaning than others. For example, as groundwater is partially filtered when it trickles through soil and rock in the earth, it typically requires less treatment after it is pumped out of the ground. However, surface water must go through a few more stages of cleaning to remove large debris as well as smaller impurities. Some treatment plants also add extra ingredients to water, such as fluoride to help prevent tooth decay, or lime to soften it by removing calcium compounds.

Every time you have a glass of clean drinking water, you have the engineers that develop these water treatment facilities to thank for making it safe. They are continuously testing new methods for treating water that are cheaper and more energy efficient. One such method is solar disinfection, which involves using UV radiation from the Sun to damage and kill harmful bacteria in the water.



How do record players work?

The science behind the recent vinyl revival has been sound since 1877

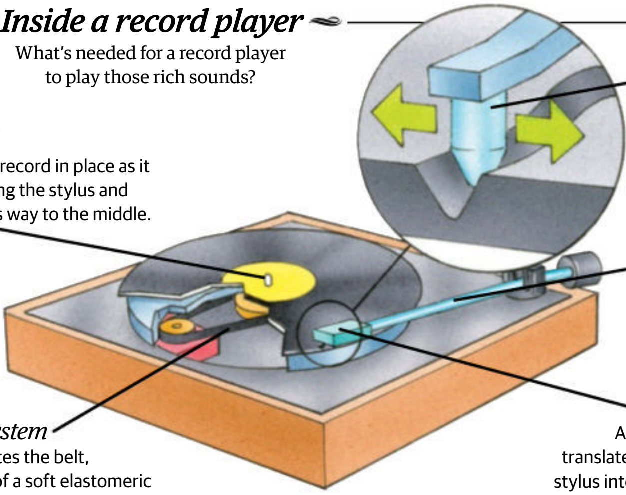
The technology of record players is all based on sound vibrations recorded physically into grooves of a vinyl disc. The delicate needle, or stylus, reads these vibrations and translates them into sound through the arm of the player.

Thomas Edison's 1877 phonograph was the earliest example of this method of recording and reproducing sound. It was the first machine to use flat disc records, initially made of rubber, which could be rotated and played on the device using a hand crank. Though records were subsequently made from shellac, then polyvinyl chloride, the basic principles remained. The turntable rotates the vinyl with either a belt-drive or direct-drive system, reducing the noise of the motor.

The etchings of the vinyl form a gradual spiral in toward the centre, which the stylus follows as the record turns, picking up the thousands of miniscule bumps and translating them into good vibrations. So, the next time you put on a Kool and the Gang record, you'll literally be hearing something groovy.

Inside a record player

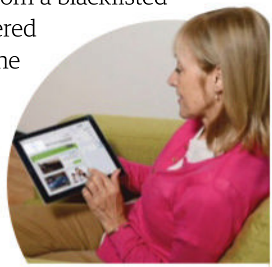
What's needed for a record player to play those rich sounds?



How do computers identify junk mail?

The science behind the service that sifts through your spam

Junk mail is detected by scanning the message for common warning signs. Was the message sent from a blacklisted network? Have the headers been tampered with to hide the sender? Does the subject line use all capital letters? All these factors are added together to give a weighted score, and anything over a certain number is deemed to be spam. If you manually mark an email as spam, it also refines the scoring system for future emails.



Right
Emails are often checked for phishing scams and labelled 'junk' to protect you

What is thermal clothing?

How can this layered fabric keep you warm in winter?

Thermal clothing is made from two-ply material, typically with layers of cotton, wool or synthetic fabrics such as polyester. The base layer's purpose is to draw moisture away from the skin in a process called capillary action or wicking. This is where the forces of adhesion, which cause water molecules to stick to other surfaces, are greater than the forces of cohesion, causing water molecules to stick together. This means that sweat is drawn into the narrow spaces between the clothing's fabric fibres, just like a paper towel absorbs water or a candlewick absorbs fuel. The moisture is then drawn to the outer layers of the fabric, where it can evaporate much faster and won't leave you feeling wet and cold. The outer layers also provide insulation, trapping heat so that you stay warm in cold temperatures.

Below
Adding a thermal underlayer will keep you warm and dry on cold winter jogs

What makes a silencer on a gun work?

How is a silencer capable of muffling a gun's boom?

When a gun is fired, explosive gunpowder is ignited. The explosive creates a high-pressure pulse of hot gases, forcing the bullet down the barrel. It exits at a supersonic speed with a bang that breaks the sound barrier. A gun silencer suppresses that sound. It consists of a tube of small chambers separated by baffles. When the gun is fired, the pressurised gas now has lots of holes to expand into, so the pressure is far lower when the bullet exits the barrel, reducing the sound.

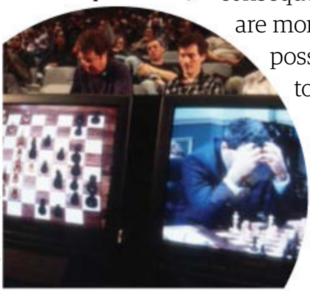
© Thinkstock

Right
A silencer is a tube of small chambers separated by baffles

How do computers play chess?

Can you beat this enviable computerised opponent?

Below
IBM's Deep Blue chess computer was the first to beat a human world champion



© Najlah Feanny

Humans and computers play chess in essentially the same way. Both start with a large selection of memorised opening gambits and then plan their move by imagining the consequences of each possible move. The difference is that computers are more methodical. On each turn, they build a tree of all the possible moves branching off. They score each move according to certain rules and focus on the sequences with the highest tactical scores. IBM's Deep Blue chess computer first beat a reigning world champion in a 1997 match against Gary Kasparov, but even today, computers aren't guaranteed to win. In particular they can be weak at assessing strategies that involve sacrificing some pieces early on, in order to gain an advantage later in the game.

How are mirrors made?

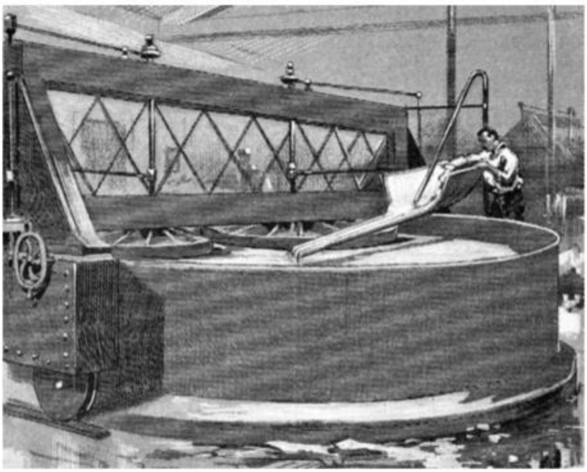
Understand the historic process that allows you to look yourself in the eye

Throughout the ages, a great number of different materials have been used to create mirrors. Obsidian was used originally, with gold, silver, aluminium and bronze also being implemented at various times through history. At first, the stones were highly polished to create a reflective surface, but today the process is a bit more advanced and streamlined.

First, a reflective coating – usually silver or aluminium – is applied to a sheet of glass, which has to be polished to the highest possible standard, since any blemishes can cause distortions in the mirror image. The remaining solution is then poured off and the glass is dried. The back of the mirror is covered with a protective substance to safeguard the coating.

Depending on the type of mirror, they are created in different ways. Heavy-duty mirrors are created with thicker layers of glass in order to be sturdier, while in mass production, highly polished metal can be used. Some optical instruments use different coatings that better reflect certain types of light. For example, aluminium is better than silver at reflecting ultraviolet light.

Below
Mirror-making is a process that has remained relatively consistent over time



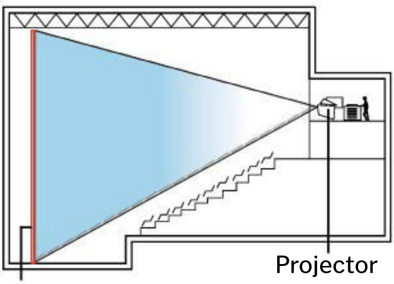
What makes IMAX so special?

The tech behind this immersive cinematic experience

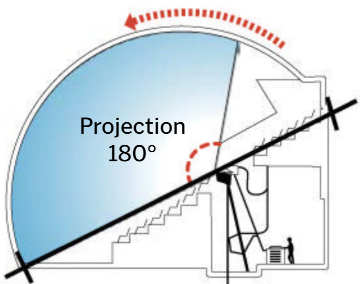
Watching an IMAX movie is without question one of the most arresting film experiences in the world. Invented in Canada in 1970, by the end of 2013 there were 837 IMAX theatres in 57 countries around the world. Their defining feature is humongous screens – so large that the images completely fill the viewer's field of vision, giving them a feeling of immersion so strong that some even feel motion sickness during especially dynamic scenes.

Maximising IMAX technology

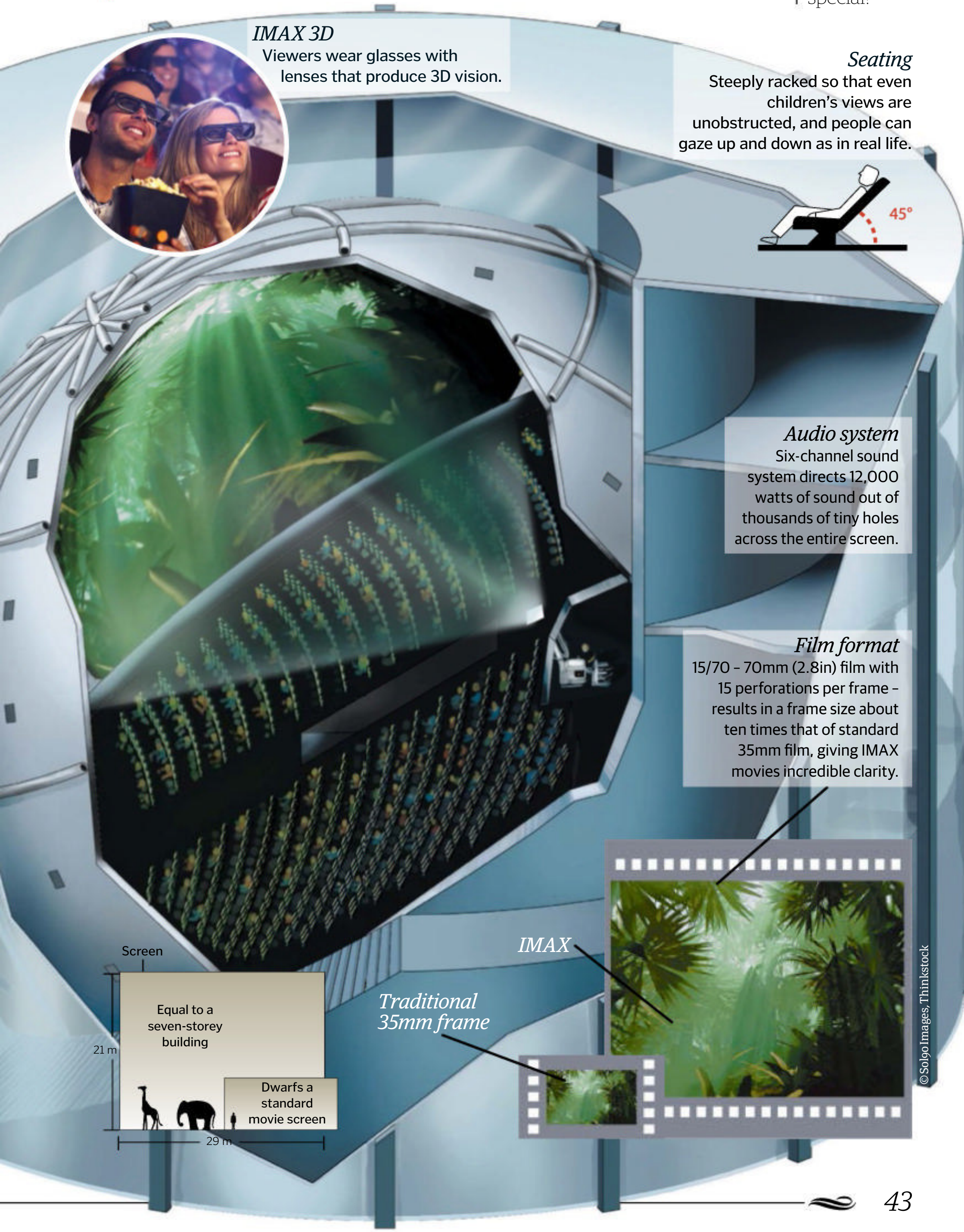
Gigantic images with incredible resolution make for a completely immersive experience



Flat IMAX
Uses a silver-coated flat screen that reflects light more intensely than a white screen.



OMNIMAX dome
Hemispherical dome made of metal and coated with highly reflective white paint wraps the entire audience in larger-than-life images.


IMAX 3D
Viewers wear glasses with lenses that produce 3D vision.
Seating
Steeply racked so that even children's views are unobstructed, and people can gaze up and down as in real life.
45°
Audio system
Six-channel sound system directs 12,000 watts of sound out of thousands of tiny holes across the entire screen.
Film format
15/70 – 70mm (2.8in) film with 15 perforations per frame – results in a frame size about ten times that of standard 35mm film, giving IMAX movies incredible clarity.
IMAX
Traditional 35mm frame
Screen
Equal to a seven-storey building
21 m
Dwarfs a standard movie screen
29 m

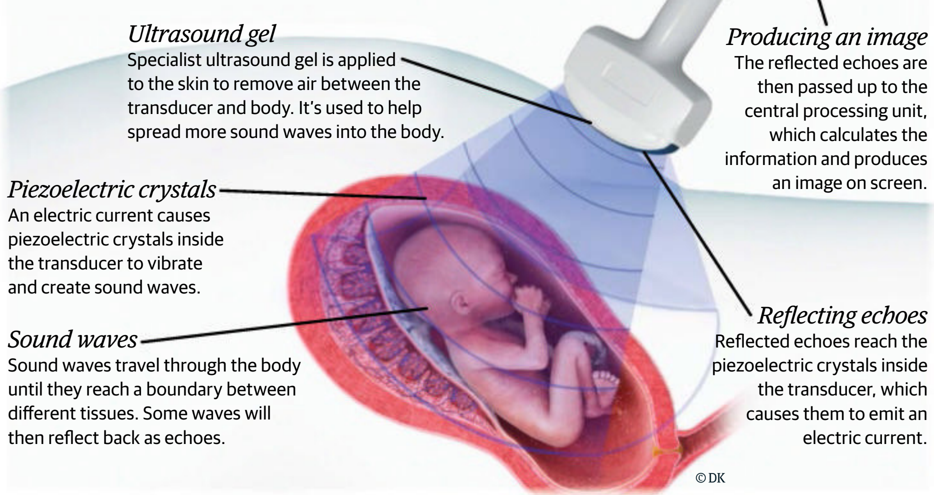
How do ultrasound scans work?

Take a closer look at the science inside this medical machine

Ultrasound procedures are used for a number of medical reasons, most commonly to monitor the development of a foetus. Ultrasonography sends high-frequency sound waves through the body and measures their reflected echoes to create a 2D image of internal structures. The transducer probe, which is placed on the skin, is specially designed to create and receive these waves. It does this using a principle called the piezoelectric effect. Quartz crystals – piezoelectric crystals – inside the transducer probe rapidly change shape and vibrate when an electric current passes through them. This causes sound waves to be produced, which travel freely through fluid and soft tissue inside the body. However, once they reach a denser structure they will bounce back to the transducer as an echo. As a result, the crystals inside the probe emit electrical currents, which pass up to the central processing unit (CPU). The information gathered then forms an image on screen.

Ultrasound imaging

Discover how ultrasound is used to look inside the human body



Why don't touchscreen phones work with gloves on?

What causes this infuriating winter frustration?

Most touchscreens use capacitive sensing, which uses two glass layers, coated on their inside surfaces with stripes of a transparent conducting material called indium tin oxide. On one layer the stripes run horizontally and on the other layer they run vertically. Each intersection acts as a tiny capacitor that stores an electric charge. When your finger touches the glass, it distorts the electric field and changes the amount of charge the capacitors underneath it can hold. But this only works because your finger conducts electricity, but gloves don't. Special touchscreen gloves work by using electrically conductive thread woven into the fingertips.

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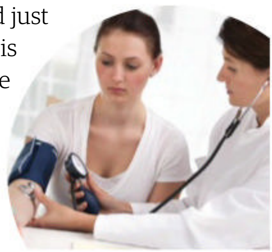
How is blood pressure measured?

An insight into how we can better monitor our health

The most common method for measuring blood pressure uses a sphygmomanometer – an inflatable armband with a pressure gauge and hand pump. The doctor pumps the armband up enough to squeeze the brachial artery in your arm shut. They then gently let a little air out and listen with a stethoscope at the crook of your elbow, until they hear the blood just start to flow again. The pressure reading at this moment is your systolic pressure, which is the maximum pressure during each heartbeat. Releasing more air until there is no more sound through the stethoscope, gives the minimum pressure for the heartbeat, which is the diastolic pressure.



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Right
Blood pressure is expressed as systolic pressure over diastolic pressure

How does a smartphone tell up from down?

The secret lies in a tiny device called an accelerometer

Have you ever wondered how your phone's compass knows which direction you're headed in? It's all down to the accelerometer, which is built into the circuitry of all modern smartphones. This gadget can detect changes in orientation and tell the phone to respond accordingly by rotating its screen.

Accelerometers are made up of two fundamental parts. The first is the housing, which attaches to the object in question. The second is some form of mass, which is capable of moving when the object's orientation changes. This movement is the key to how it works, and is what the device measures in order to identify whether the phone is facing up, down or sideways.

Below
Apple has included an accelerometer in each generation of iPhone, iPad and iPod Touch

The accelerometer fitted inside a smartphone is an incredible piece of engineering. It is only 500 microns across, and is made by etching into a piece of silicon using potassium hydroxide. This clever device can be used for more than just identifying the orientation. It can be employed in gaming technology, particularly for driving games, where the user steers a vehicle by tilting their smartphone. They can also be used like a pedometer to track your daily steps, or even to detect tremors as part of an earthquake early warning system.

What are exploding manhole covers?

A cast-iron way to keep the smell of the sewers off the streets

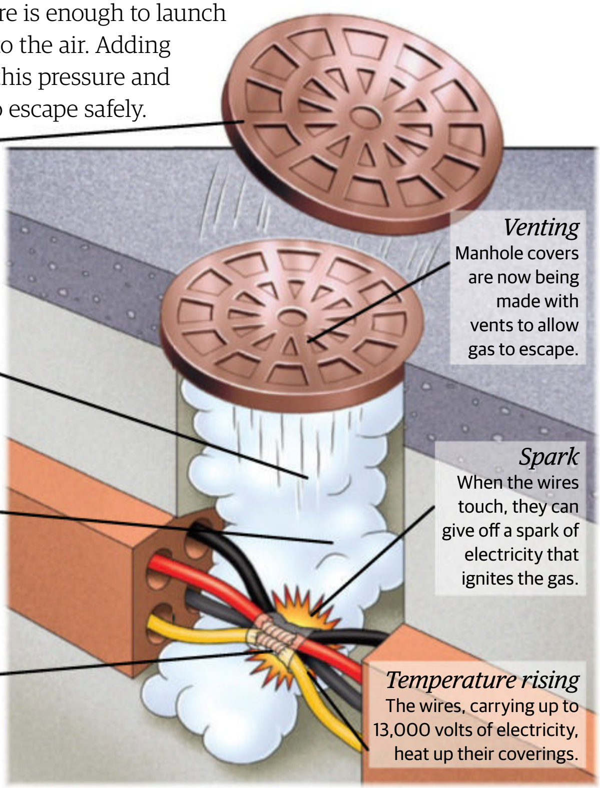
Manhole covers prevent people and vehicles from falling into sewer-access pipes. They can weigh as much as 136 kilograms (300 pounds), but it's possible for them to be blasted up to 15 metres (50 feet) into the air by gas explosions. These occur when frayed or gnawed cables heat up and begin to smoulder. The combination of gas, an ignition spark from the wires and a build-up of pressure is enough to launch the cover into the air. Adding vents stops this pressure and allows gas to escape safely.

Lift-off
The resulting explosion can lift the manhole cover up to 15m (50ft) in the air.

Under pressure
The pressure begins to build up as more gas fills the available space.

Smouldering
The smouldering wires emit gases that have nowhere to go, trapped between pipe and iron cover.

A frayed knot
Wires in the pipework get frayed from wear and tear or rats gnawing on them.



Why do we love chocolate?

Discover why your favourite chocolate bar is so irresistible

There's no doubt that chocolate is one of our favourite indulgences, with over 7.2 million tons of it consumed worldwide each year. What you may not realise is that it's the hundreds of complex chemicals found in chocolate that keep us coming back for more. Not only do they give chocolate its delicious taste and smooth texture, but they also have powerful effects on the human brain to make us feel happy and alert. It's no wonder that the plant genus from which this tasty substance comes from is called theobroma, derived from the Greek for 'food of the gods'.

Right
Dark chocolate that is over 70 per cent cocoa solids is the healthiest

Is chocolate good for you?

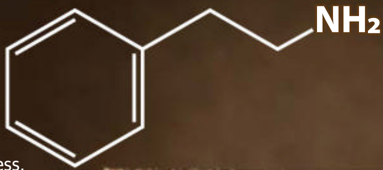
Although it is typically considered an unhealthy treat, some chocolate does actually have some health benefits. Cocoa beans are rich in natural antioxidants called flavonols. One such flavonol, called epicatechin, can increase the levels of nitric oxide in your blood to relax your blood vessels. This helps to improve blood flow, lower your blood pressure, and can also prevent atherosclerosis, a condition where the arteries harden after becoming clogged with plaque. Epicatechin can also improve your body's insulin sensitivity, helping to keep your blood sugar levels under control and reduce the risk of diabetes. However, not all chocolate is rich in flavonols. White chocolate is not a good source of these antioxidants as it does not contain cocoa solids, and milk chocolate has a higher proportion of milk and sugar rather than beneficial cocoa. Therefore, dark chocolate is the best option, and the higher the percentage of cocoa solids the better.

©Thinkstock

Why your brains love chocolate

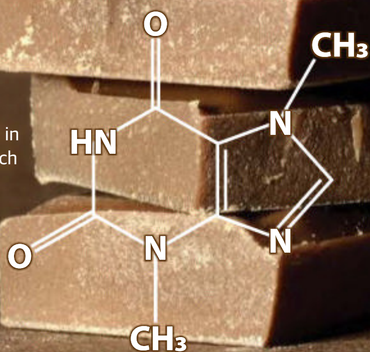
The chemical effects of your favourite sweet treat explained

Pleasurable

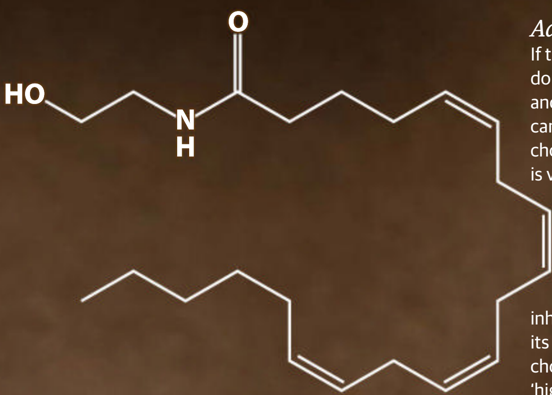


As well as being tasty and sweet, chocolate also contains several mood-enhancing chemicals. One such chemical is the amino acid tryptophan, which is used by the brain to produce serotonin, the hormone that boosts your happiness. Another is the alkaloid phenylethylamine (PEA - shown in the diagram here), which encourages the brain to release dopamine, the hormone that creates feelings of pleasure. PEA is responsible for chocolate's reputation as an aphrodisiac, as it also occurs naturally in the brain to release dopamine when you fall in love. However, as there are only very small quantities of tryptophan and PEA in chocolate, there is some debate as to whether they have any effect on the brain at all.

Stimulating



Like coffee beans, cocoa beans contain a small amount of caffeine which is a natural stimulant. This alkaloid helps you feel more alert by blocking the adenosine molecules, responsible for causing drowsiness, from binding to their receptors in your brain. Another alkaloid found in chocolate is theobromine (the structure of which is shown here), which has a similar stimulating effect to caffeine, but is also the reason why chocolate is poisonous to some animals. Theobromine is actually toxic to humans too, but the average adult would have to eat approximately five kilograms (11 pounds) of it to feel the effects. Small mammals have a much lower tolerance, meaning that just 50 grams (1.8 ounces) of chocolate could be lethal to a small dog.



Addictive

If the mood-enhancing chemicals in chocolate don't have you reaching for another piece, then another ingredient might. Anandamide is a cannabinoid neurotransmitter that is found in chocolate and also occurs naturally in the brain. It is very similar to tetrahydrocannibol (THC), the ingredient in marijuana that makes people feel 'high', and therefore creates a similar blissful feeling that we all crave. In addition, chocolate also contains the chemicals N-oleoyletha-nolamine and N-linoleoylethanolamine, which inhibit the breakdown of anandamide to prolong its effects. Anandamide is only present in chocolate in very small amounts though, so the 'high' you get from it is very mild.

Why is chocolate so tasty?

The shine, snap and smooth texture are the main characteristics that make chocolate so appealing, and they are all achieved through clever chemistry. To form solid chocolate, a liquid cocoa butter mix is cooled so that its fat molecules join together in crystal structures called polymorphs. If the cocoa butter cools and hardens too quickly, the fat molecules form a loose and disordered polymorph that makes the chocolate soft and dull-looking with an unappealing white coating called a fat bloom. To avoid this, manufacturers use a technique called tempering, controlling the temperature and rate at which the chocolate cools, to create a tight crystal structure. This particular polymorph is called Form V and gives the chocolate a melting point of around 33.8 degrees Celsius (92.8 degrees Fahrenheit), just slightly cooler than our body temperature. This means that when you put chocolate into your mouth, it slowly melts on your tongue, creating yet another appealing characteristic. The smooth texture of the melted cocoa butter creates a pleasant 'mouthfeel', a word used by the food industry to describe the way a substance feels in the mouth, and a main contributor to its overall enjoyment.

Soft, dull untempered chocolate

Hard, shiny tempered chocolate

How do suntans develop?

Find out how our skin reacts to being exposed to the Sun

Medical professionals continue to warn us about the dangers of exposing our skin to too much sunlight. In spite of this, many of us still spend too long sunbathing in the hope of achieving the evenly bronzed skin tone that's commonly desired.

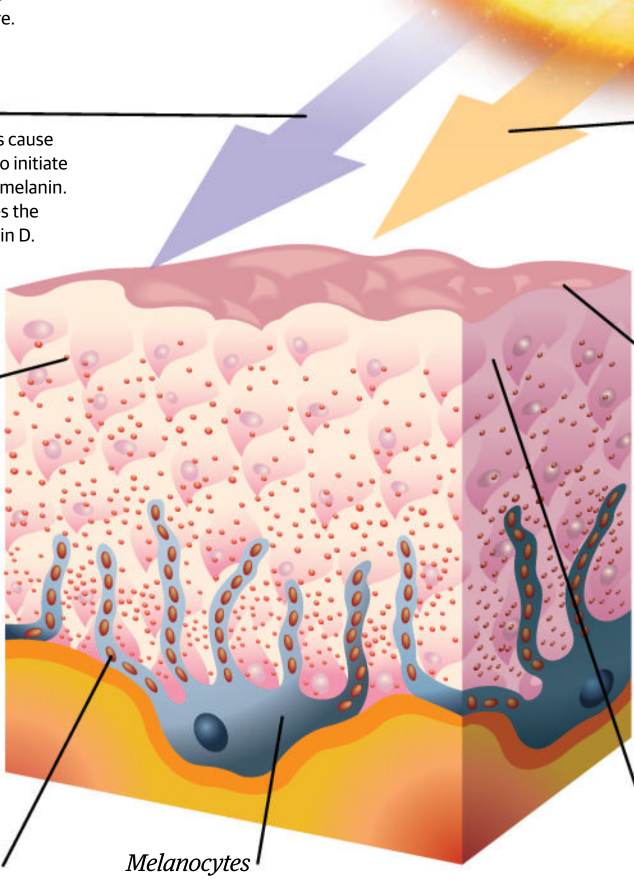
When we expose our skin to strong sunlight or a sunbed, the ultraviolet radiation we absorb prompts melanocytes in our skin to react by producing more melanin. Melanin is the pigment responsible for our skin's colour and it protects the cells by absorbing UV radiation that would otherwise cause damage to our skin cells. People with naturally darker skin have more melanin, so are inherently better protected against sunlight. Nevertheless, excessive UV exposure damages melanoyctes' DNA, which can lead to a deadly form of skin cancer that's known as melanoma.

Recent science suggests the process of tanning has addictive qualities. An experiment using mice showed that as well as producing melanin, UV radiation produced pleasure chemicals called endorphins, which are also produced after a person ingests addictive drugs.

Below
Your risk of melanoma doubles after five or more sunburns

The tanning process

Learn about the important structures within the skin that play a role in creating a tan



The Sun

The Sun produces UVA, UVB and UVC light, but the UVC is mostly blocked out by the Earth's atmosphere.

UVB

These short waves cause the melanocytes to initiate the production of melanin. UVB also promotes the synthesis of vitamin D.

UVA

The long waves have a direct effect on our skin's melanin, creating a natural tan by oxidising it brown.

Melanin

This pigment browns when it absorbs UVA light. It also increases in size and then surrounds each skin cell.

Horny layer

This layer of dead skin cells is thickened when exposed to UV light, helping form a protective layer.

Melanosomes

These are produced within the melanocytes and contain the enzyme tyrosinase, which synthesises melanin.

Melanocytes

These are specialised skin cells. They are responsible for the production of melanosomes and can send them to the surrounding skin cells.

The epidermis

Our skin cells are in a continuous 30-day cycle, in which they are constantly produced and replaced. This is why suntans eventually fade.

How do we keep our balance?

What factors are at play to keep us standing upright?

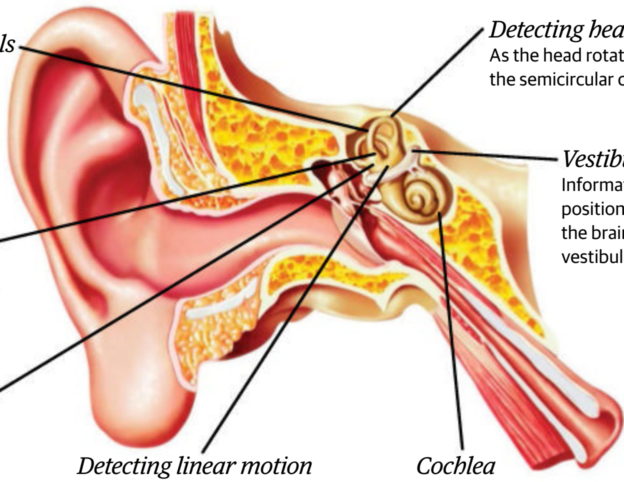
Our sense of balance is handled by the vestibular system in the inner ear, and provides vital feedback about head position and movement. Inside the ear there are three semicircular canals; each is filled with fluid. At one end of each canal is a bulge supporting a series of sensitive hairs. As you move your head, the fluid moves too, bending the tiny hairs and sending information about head rotation to the brain. There are also two organs called otoliths on each side of the head. These contain sensory hairs weighed down by calcium crystals that help to tell which way is up.

Right
Without the balance sensors in the inner ear, we would be constantly dizzy and disorientated

© Thinkstock

The sense of balance

The inner ear contains specialised structures that detect head movements



Semicircular canals
Three fluid-filled rings are positioned at 90-degree angles to one another in the inner ear.

Otolithic organs
The two otolithic organs contain sensory hairs weighed down by calcium crystals.

Calcium crystals
The calcium in the otoliths is heavier than the surrounding tissue, and is pulled by the force of gravity as the head moves.

Detecting linear motion
As the head accelerates in a straight line, the otoliths are able to detect the movement.

Cochlea
This part of the ear is responsible for detecting sound, and is located just below the semicircular canals.

Detecting head rotation
As the head rotates, the fluid in the semicircular canals moves.

Vestibular nerve
Information about head position is transferred to the brain by the vestibular nerve.

© Alamy

What is déjá vu?

Do you feel like you've been here before?

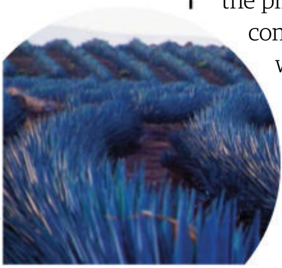
Below
Déjá vu may be the product of neural misfiring in the brain

Déjá vu affects 70 per cent of people, but scientists have no definitive explanation for its cause. The phenomenon involves a feeling of familiarity in a situation where you are in fact experiencing something new. Most commonly seen in young adults, experts suggest a link to dopamine levels, which are generally higher in 15-to-25-year-olds. Episodes of déjá vu also occur very consistently before a certain type of epileptic seizure, implying that déjá vu could be caused by brain cells misfiring, transmitting electric signals at random to generate a false sense of familiarity. Another theory is that familiar features, like the layout of a shop, may be recognised by the brain without us realising, triggering feelings of familiarity in a new situation.

How is tequila made?

Follow the process from blue agave plant to bar

Tequila is produced in the region of Tequila in Mexico. It originates from the blue agave plant, which can take between eight and ten years to fully mature. When ready for harvesting, the agave's core, known as the piña, is extracted. At the distillery stage, the piña hearts are split open and roasted in large ovens to break their complex starches into sugars. The released liquid is then sealed within large steel vats for fermentation where yeast is added. The fermented juice – or mosto – will have a low alcohol content at this stage. To increase the volume of alcohol, the mosto is distilled twice by heating the liquid to alcohol's vaporisation point before cooling and condensing it. Purified water is then added to dilute the tequila to 40 per cent alcohol content, then it is bottled up or transferred to wooden barrels for ageing.



How are calories calculated?

A bomb calorimeter can tell us how much energy is in our food

Calories measure energy and can be used to describe any fuel, from petrol to bread. One calorie is the amount of energy required to raise the temperature of one gram (0.035 ounces) of water by one degree Celsius (1.8 degrees Fahrenheit). Food labels often quote energy content in kilocalories (kcal), because food is so rich in energy that it makes more sense to label 1,000 calories at a time.

The number of calories in any given item of food is calculated by measuring how much energy is released when a substance is burned. Inside our bodies, molecular machinery is responsible for burning the fuel we eat, but in the lab, using a spark gives the same result. The traditional method of calorie calculation is to put the food inside a sealed unit known as a bomb calorimeter. The food is surrounded by an atmosphere of oxygen to ensure it will burn well, and the container is sealed and surrounded by a known volume of water. A spark ignites the food inside and allows it to burn until it is reduced to charcoal, releasing all of the energy contained inside. The energy is converted to heat, which in turn raises the temperature of the water. By measuring the water's temperature change, you can then find out exactly how much energy has been released and calculate the calories from there.

Today, many food manufacturers use a different system to create nutritional labels; instead of burning the food item whole, they simply add up the calories of the different components, such as fats, carbohydrates and proteins.

Below
Calculating the calories in food is more explosive than we first thought

Calculating calories

Take a look inside a bomb calorimeter and find out how calories are calculated

1. Setting up the calorimeter

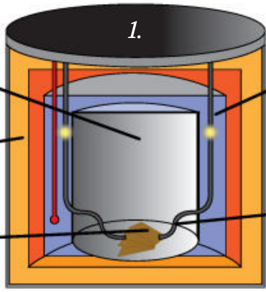
The first step in measuring the calorie content of our food is to place the item inside a bomb calorimeter. The food is then sealed in a container that's filled with flammable oxygen gas, and is placed inside a second container containing a known quantity of water.

2. Burning the food

Food is fuel, and it is burnt inside our bodies using oxygen; the calorimeter simulates this in the lab. An ignition wire is used to set light to the food, and as it burns, the energy released is transferred into the water surrounding the chamber, causing the temperature to rise.

3. Calculating the calories

When the food has been reduced to ashes, all the energy has been released. The difference between the start and end water temperature is determined and multiplied by the number of grams of water that were contained within the calorimeter. This gives the number of calories.



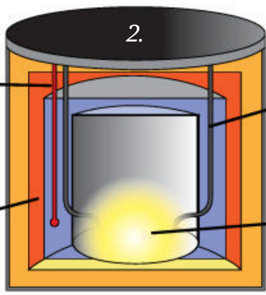
Food chamber
The bomb is sealed and filled with oxygen.

Thermometer
The initial water temperature is recorded before beginning.

Test food
The food is crushed into a pellet and placed inside.

Water
The bomb is surrounded by a fixed volume of water.

Ignition wire
A length of wire is pressed into the food pellet and connected to a circuit outside the bomb.

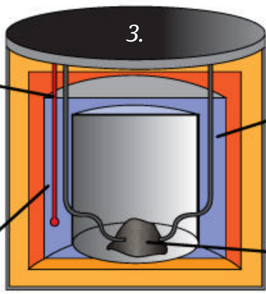


Temperature change
The water temperature begins to rise as the food releases its energy.

Insulation
Insulation and a vacuum gap around the water chamber prevent heat from escaping into the atmosphere.

Ignition
The food is ignited by passing a current through a wire inside the bomb.

Energy release
As the food burns, the energy released heats the water surrounding the bomb chamber.



Final temperature
The temperature of the water is recorded and compared against the original temperature.

Calorie content
The calorie content of the food is calculated using the change in water temperature.

Total calories
This food has raised 5kg (11lb) of water by 45°C (81°F), giving a total calorie content of 225kcal.

Ashes
The experiment ends when the food has completely burnt away.

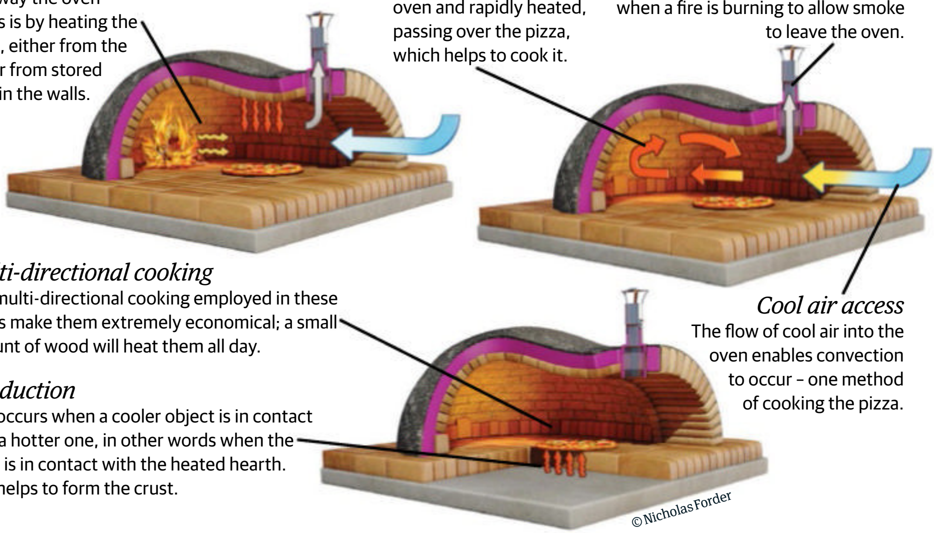
What happens in a brick oven?

Find out why these ancient ovens are still the best way to cook pizza

It's impossible to replicate the unique taste wood-burning brick ovens give to pizzas. It is thought that this form of cooking has been around for at least 3,000 years, and was once the only means of baking bread. Examples of this type of oven have even been excavated in ancient Pompeii.

To cook a pizza, the first thing you need is a fire within the oven. While this burns, it's important to keep the door and chimney flue open. The oven's interior absorbs and retains the heat created by the fire, and should be left to do so until the oven chamber is white hot. The fire can then be left to die down, and the door and chimney can be closed so the oven reaches an even temperature.

The oven is now ready and cooking a pizza should take less than two and a half minutes. Because they are able to retain heat for a long time, brick ovens can be one of the most efficient and economical methods of cooking.



Do truth serums work?

Understand the science behind this bottle of liquid truth

Below
No known drug can force someone to speak nothing but the truth

© Thinkstock

Various drugs have been used as 'truth serums', although none can reliably make their victims speak the truth. Many examples are barbiturates, such as sodium thiopental, originally used as anaesthetics or sedatives. Similar to alcohol, they depress the central nervous system and impair judgement and cognitive function. Doctors observed that these drugs reduced inhibitions in patients, causing them to talk more freely. One theory is that by disrupting brain function, such drugs might make it more difficult for someone to concentrate enough to lie convincingly. But these drugs also tend to make people extremely suggestible and downright incoherent, meaning they are just as likely to say whatever their interrogator wants to hear, or to babble complete nonsense, as to tell the truth.

How does fluoride work?

How this mineral works to protect your pearly whites

Fluoride is a mineral found naturally in water, soil, and in trace amounts in tea and fish. Its main use is to help prevent the formation of tooth decay by encouraging a stronger enamel to form that's more resistant to acid attack. It also reduces plaque bacteria's ability to produce acid – the primary cause of tooth decay. However, it seems that you can have too much of a good thing. Recently in the US, the fluoride in water has been found to cause white splotches on children's teeth – a condition known as dental fluorosis. As long as the standard guidelines are followed, fluoride can be beneficial to your dental health.

© Thinkstock

Right
Fluoride is used in toothpaste to help fight decay

How does the body burn fat?

How we shed the pounds and transform fat into useful energy

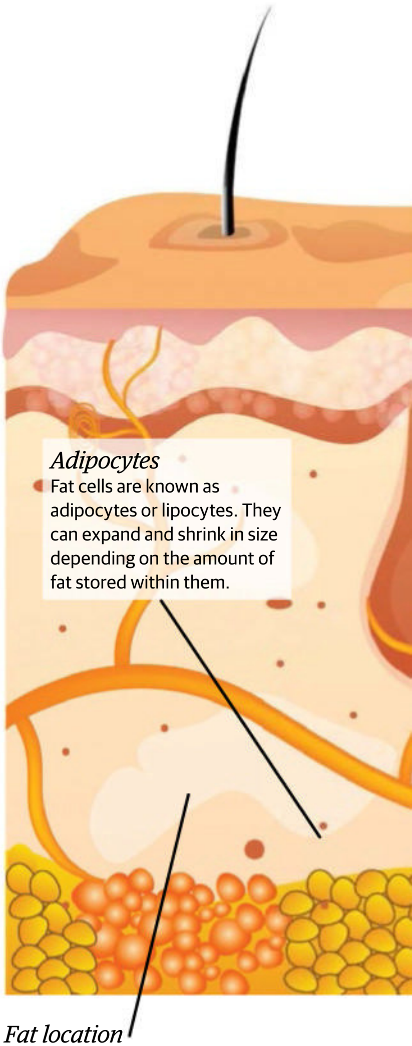
Billions of fat cells exist in all body types, sandwiched between the skin and muscle tissue, and it's the size of these fat cells that determine a person's weight. So how does this build up of fatty deposits get broken down when you're working on losing weight? Put simply, it involves a biochemical process that converts these space-demanding molecules in fat cells into usable energy.

The entire process begins when you increase activity levels and reduce calorie intake. By consuming fewer calories than you're burning, the body will react to the reduction of available energy by producing fat-mobilising hormones, which in turn signal important enzymes, which help break down fat reserves for more energy.

The key enzyme in this process is lipase. Lipase stimulates fat cells so that they release triglycerides (the form of fat within the fat cell). Each triglyceride molecule is then broken down into glycerol and three fatty acids. The glycerol is broken down further by the liver to release energy, while the free fatty acids are transported directly to muscles via the bloodstream. The enzyme lipoprotein lipase helps the muscle cells absorb the fatty acids, which can be burned for extra energy.

Fat-cell biology

Discover where fat is stored within the body



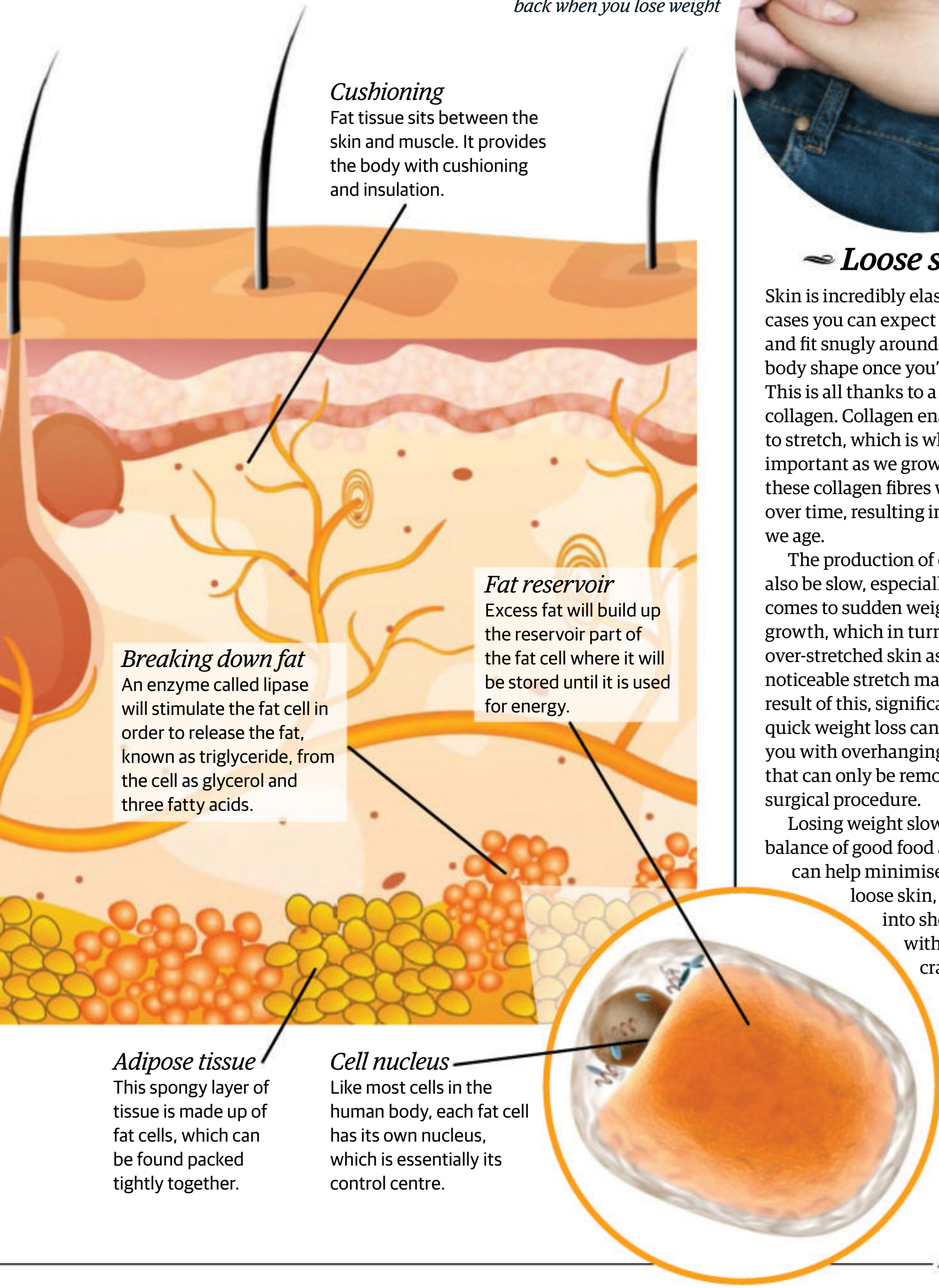
Right
Collagen helps to keep skin stretchy and enables it to ping back when you lose weight

Loose skin

Skin is incredibly elastic, so in most cases you can expect it to ping back and fit snugly around your new body shape once you've lost weight. This is all thanks to a protein called collagen. Collagen enables the skin to stretch, which is why it's so important as we grow. However, these collagen fibres will weaken over time, resulting in wrinkles as we age.

The production of collagen can also be slow, especially when it comes to sudden weight gain or growth, which in turn leads to over-stretched skin as well as noticeable stretch marks. As a result of this, significant or very quick weight loss can often leave you with overhanging, excess skin that can only be removed through a surgical procedure.

Losing weight slowly, with a balance of good food and exercise, can help minimise the risk of loose skin, so don't rush into shedding stones with a quick-fix crash diet.



Why are bubbles colourful?

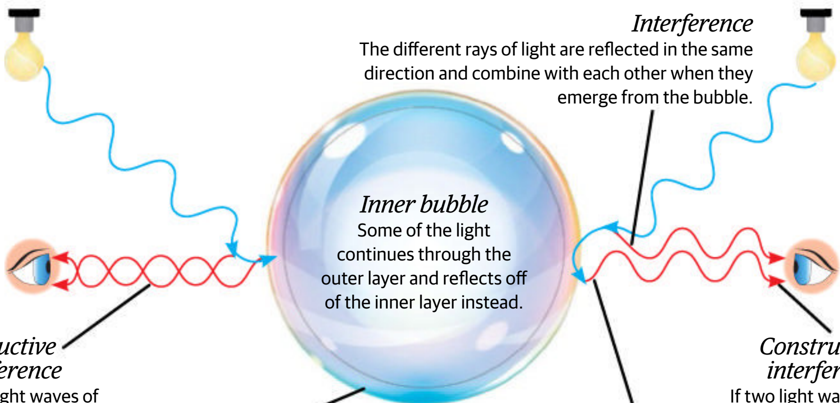
Discover how bubbles put on their multicoloured display

Below
As a bubble moves, light hits it from different angles, causing it to change colour constantly

Bubbles are actually colourless, but their amazing structure and the properties of light make an entire rainbow visible. To understand how this works, you first need to know what a bubble is. The outer film that traps the air inside is made of a thin sheet of water sandwiched between two equally thin layers of soap molecules. The way that light interacts with these layers is what creates the colours you see. Light is made up of light waves that vibrate several times a second. The number of times a wave vibrates is called its frequency or wavelength, and different wavelengths of light have different colours. When light hits a bubble, these individual wavelengths are reflected back into our eyes so that we see them as separate colours. It's this very same process that causes oil slicks floating on water to appear multicoloured and the surface of CDs and DVDs to reflect a rainbow pattern.

Bubbles and light

How bubbles reflect light to produce amazing colours



How does chewing gum work?

And does it really linger in the body for seven years if swallowed?

Chewing gum tends to be made up of either synthetic rubber or chicle, both of which give the gum its chewiness. The reason why it doesn't break down after repeated chewing is due to the qualities of its base material. Both chicle and synthetic rubber are extremely malleable; it's possible to impact them repeatedly without damaging their structure. But don't worry - the rumours that chewing gum stays in our digestive system for seven years aren't true. When the body recognises that the synthetic components of chewing gum can't be used, they are sent down the same route as any other waste product.

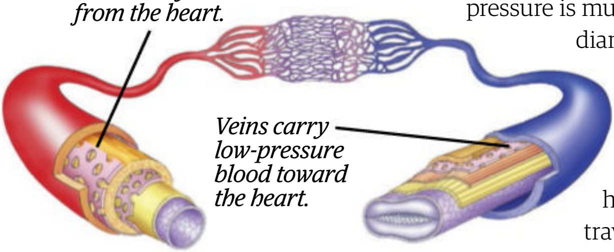
© Dreamstime

Right
Chewing gum comes in many forms; the pillow-shaped coated pellets are known as dragée gum

How do veins and arteries differ?

Remember the rule: a-away, v-towards

In order to withstand the high pressure created by the heart's beats, arteries need to be thick and muscular. They resist stretching, helping to maintain enough pressure to push blood around the body without bursting under the strain. However, by the time the blood has travelled through the capillaries and into the veins, that pressure is much lower. Veins are wider in internal diameter than arteries, and their walls are thinner, allowing them to accommodate up to 70 per cent of the blood in the body as it makes its way back to the heart. One-way valves help to keep the low-pressure blood travelling in the right direction.



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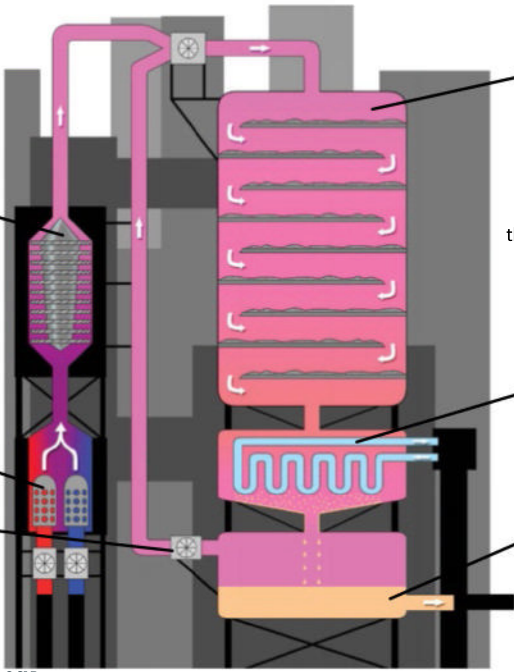
What is the Haber process?

Producing fertiliser to help us grow food more efficiently

The Haber process is an efficient way of producing ammonia for use in fertilisers and household products. Ammonia has helped to sustain food production for billions of people, but its use in explosives has reportedly resulted in the death of 150 million. It's for this reason that some scientists say ammonia changed the course of the 20th Century more than the advent of electricity or television.

Industrial production of ammonia

The ins and outs of the Haber process



Gas compression
The clean hydrogen and nitrogen are mixed and compressed at a pressure of 200 atmospheres.

Nitrogen and hydrogen cleaning
Before the process can begin, the nitrogen and hydrogen need to be cleaned and purified.

Gas recycling
The process doesn't react all the hydrogen and nitrogen together; therefore any leftover gas can be recycled back into the reaction tower.

Reaction tower
The mixture of nitrogen and hydrogen passes through the reaction tower, where iron and high temperatures of 450°C (842°F) catalyse the formation of ammonia.

Cooling loop
The ammonia produced in the reaction tower is gaseous. The cooling loop works to condense it into a liquid.

Ammonia collection
Once condensed, the liquid ammonia is piped off for collection, and can be stored in a refrigerator.

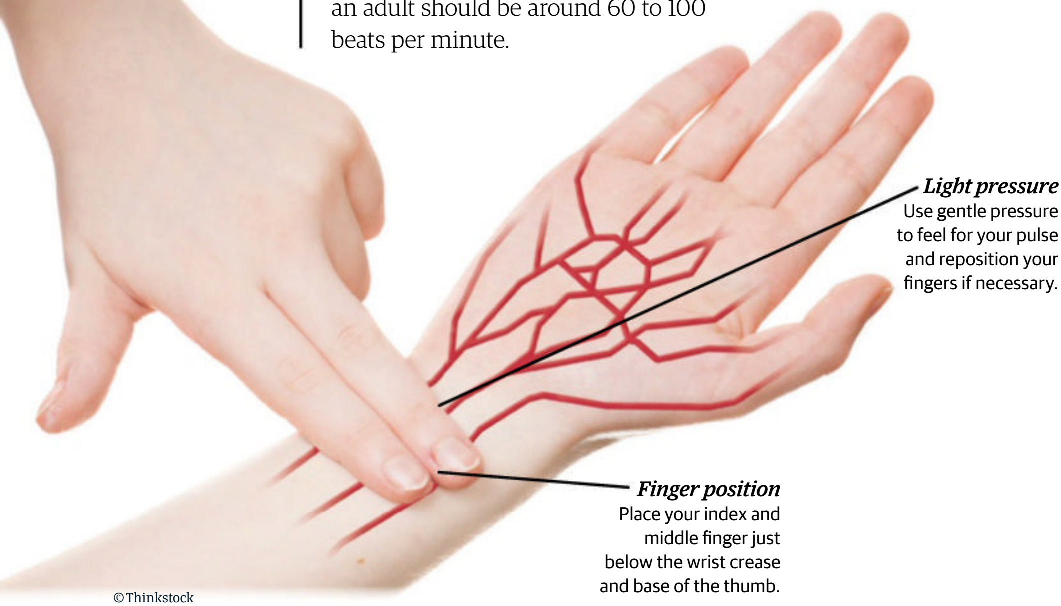
How do you check your pulse?

See whether you have a regular or irregular heart rate

Checking your own pulse is a good way to keep track of your heart rate. Monitoring it while you're resting is the best way to get an accurate reading, as rhythm can increase at different times during the day, especially when you're exercising.

It's possible to check your radial pulse on your wrist or on your neck. This is because arteries pass close to the skin in these areas. To take your wrist pulse, simply turn over one of your hands so that the palm is facing up. Now place the index and middle finger from your other hand below the crease of the wrist, in line with the base of your thumb and next to the tendon. Use gentle pressure and feel carefully for a beating pulse. If you're checking your pulse in your neck, place the same two fingers just below the jawline next to your windpipe.

Once you've located your pulse, use the second hand on a watch to count the number of beats per minute. A normal resting heart rate for an adult should be around 60 to 100 beats per minute.



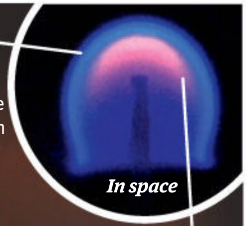
What makes a candle burn?

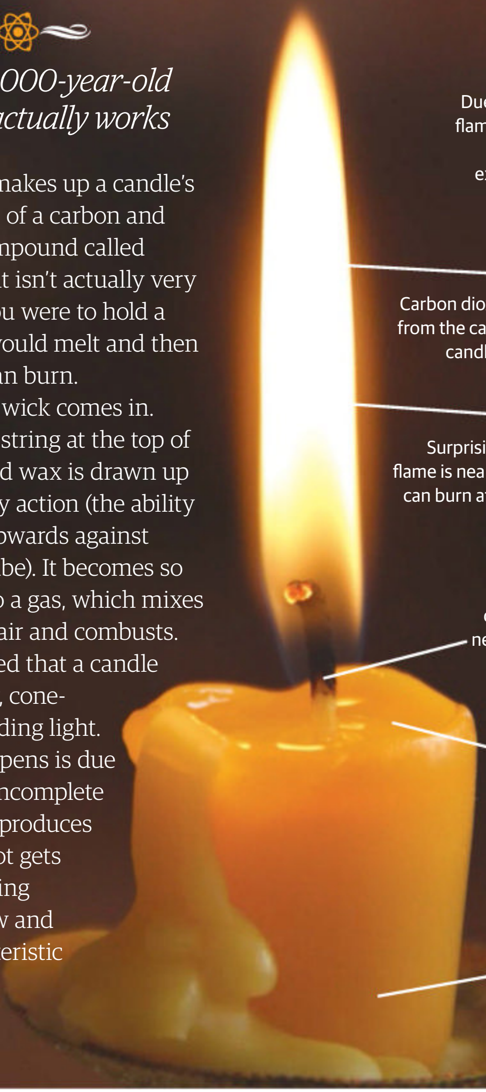
How this 2,000-year-old invention actually works

The wax that makes up a candle's body is made of a carbon and hydrogen compound called paraffin. As a solid, it isn't actually very flammable and if you were to hold a flame against it, it would melt and then evaporate rather than burn.

This is where the wick comes in. When you light the string at the top of the candle, the liquid wax is drawn up the wick by capillary action (the ability of a liquid to flow upwards against gravity in a small tube). It becomes so hot that it turns into a gas, which mixes with oxygen in the air and combusts.

We take for granted that a candle burns with a yellow, cone-shaped flame, providing light. The reason this happens is due to a process called incomplete combustion, which produces bits of soot. This soot gets extremely hot, causing each particle to glow and produce the characteristic yellow colour.





©Thinkstock; NASA

How does bleach kill germs?

A chemical reaction vanquishes bacteria and stains

Below
Sodium hypochlorite in bleach oxidises molecules, which helps remove stains and kill bacteria

© Thinkstock

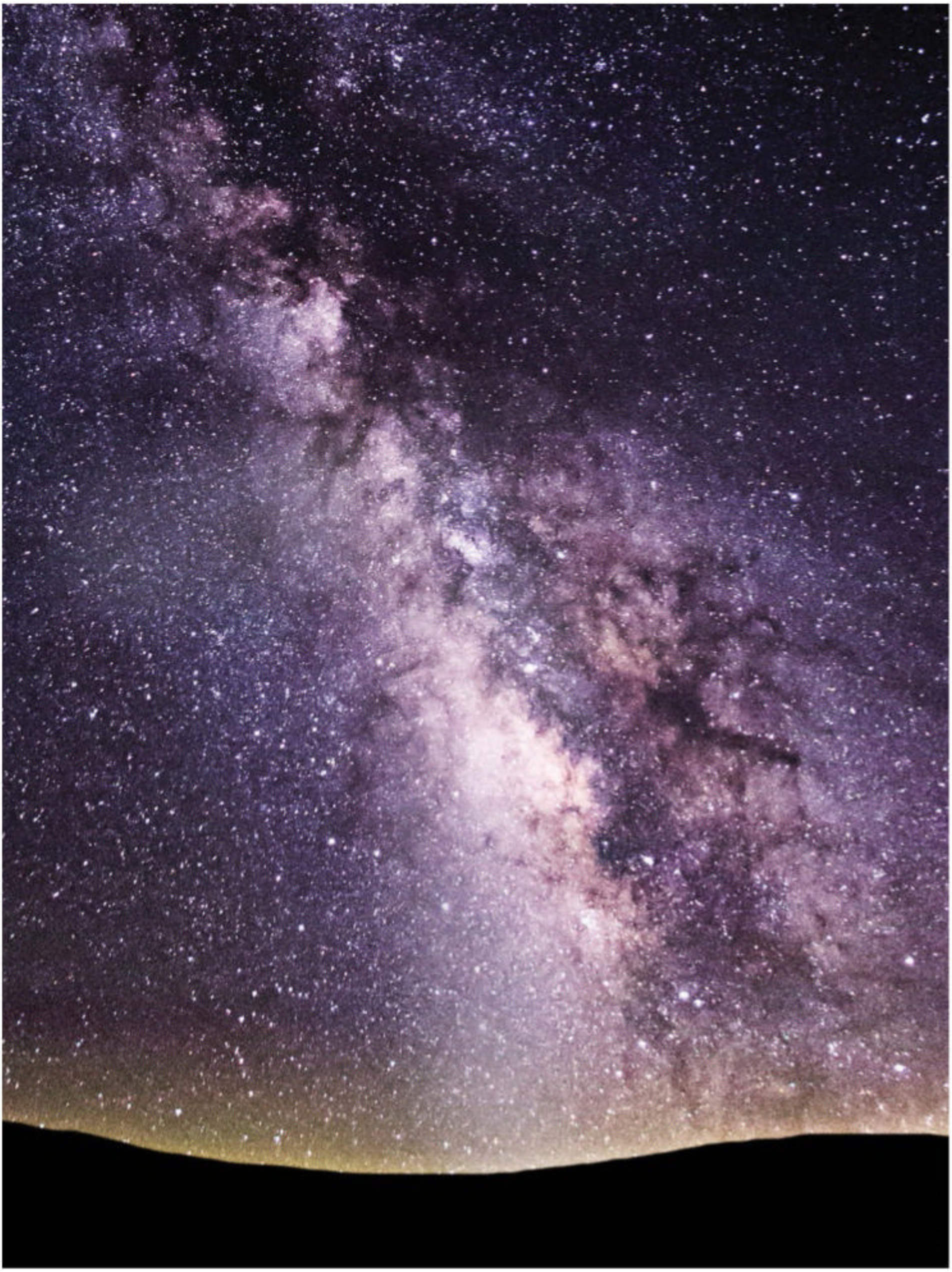
Household bleach can be used to disinfect surfaces, remove stains and even whiten clothing. There are two main types: chlorine bleach and non-chlorine bleach, but all bleaches are in a class of chemicals called oxidative agents. This means a chemical reaction called oxidation occurs when bleach comes into contact with certain germs and stains. When removing a stain from white clothing, for example, bleach will oxidise and break the chemical bonds of a chromophore, which is part of a molecule that has colour. This essentially prevents the stain from being able to absorb light, so the area will appear white, too. The active ingredient in chlorine bleach, sodium hypochlorite can also oxidise and kill molecules in germ cells, which is why bleach is also used as an effective disinfectant.

Why do mosquitos bite you?

How do mosquitos select their victims?

Many insects are attracted to certain smells in their 'prey' – and mosquitoes are no exception to that rule. In 2015, researchers at the London School of Hygiene and Tropical Medicine proved a genetic link between scent and mosquito bites. They looked at 18 sets of identical twins and 19 sets of non-identical twins and measured how attracted mosquitoes were to each individual's scent. With identical twins, the mosquitoes preferred both equally, but with non-identical twins they tended to prefer one to the other. This indicated that some people carry the genes for a natural insect repellent.

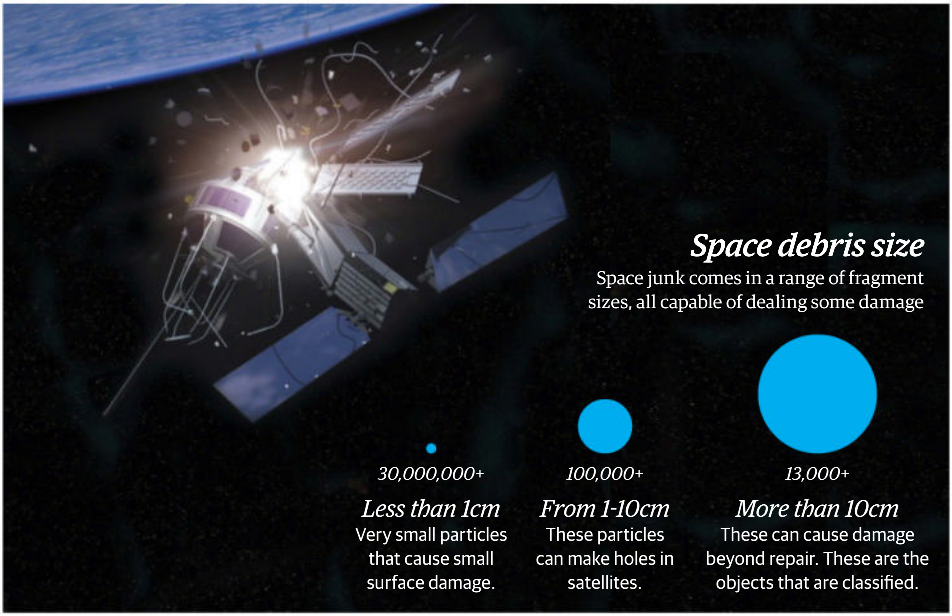
Right
Some people have a more attractive scent to mosquitoes compared to others



What is space junk?

Hurtling above us are thousands of pieces of space junk

Since the launch of the first satellite, Sputnik 1, in 1957, the area of space near the Earth has been populated with countless pieces of debris. Fragments from satellites that have been damaged or destroyed, and parts of rockets and spacecraft remain in orbit, forming a true cosmic dump. The danger of these objects is due to the risk of collision: they can travel at speeds of up to 70,000 kilometres (43,496 miles) per hour. Even tiny chunks of debris can have a devastating effect on anything in their path when travelling at such speeds, as depicted in the 2013 blockbuster Gravity.

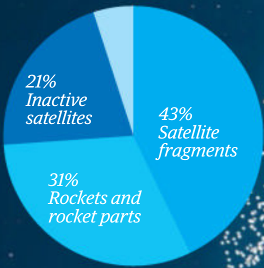


Space debris

Any artificial object without use that's orbiting the Earth is considered to be space debris. Single-use rockets can remain in orbit, just like spaceship parts or machines removed unintentionally to prevent them from entering the wrong orbit. There is a wide range of objects out there; for instance, in 1965, astronaut Edward White lost a glove that kept orbiting at 28,000 kilometres (17,398 miles) per hour for a month!

Origin and location

Approximately 95 per cent of the objects shown orbiting Earth in this graphic are space debris, only five per cent are functioning satellites. Space agencies and private companies are developing reusable rockets to avoid generating more debris.



Classified objects in space by countries

There are over 25,000 objects that have been launched to the low Earth orbit since 1957. The United States and Russia have launched the most.

What can be done?

There are different methods of dealing with space junk. One could be that debris ends up on Earth and not orbiting around it, but the most effective way is to send satellite remains out of Earth's orbit.

Sail

Like ships, the sail is unfurled when the satellite stops working and solar wind diverts it.

Cable

A cable drags the satellite into a lower orbit. It disintegrates when entering the atmosphere.

Space probe

A probe is set on a collision course with the satellite to propel it out of orbit.

Polar orbit

1,000km (621mi) This orbit is where weather and Earth-mapping satellites are found.

Geostationary orbit (GEO)

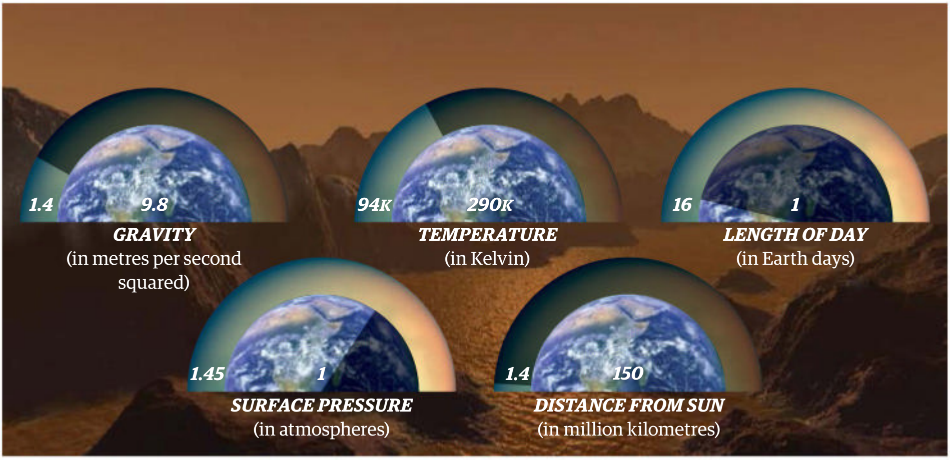
36,000km (22,369mi) Although not as crowded as LEO, GEO still contains many decommissioned broadcast and communication satellites.

High Earth orbit

Above 36,000km (22,369mi) Astronomic satellites function in higher orbits.

Low Earth orbit (LEO)

160-2,000km (99-1,243mi) The ISS and the Hubble telescope operate in LEO. There is also a residual panel that belongs to the Hubble.



Could we survive on Titan?

Could Saturn's largest moon be our new mother Earth?

It's fair to say that Saturn's largest moon is one of the most Earth-like worlds we've visited, which raises the question of whether humans could colonise it. There are a number of possible benefits, none of which are greater than the potential use of Titan's natural resources. In fact, data from Cassini suggests that Titan has more liquid hydrocarbons than all the known natural gas and oil resources on Earth.

If there is a large volume of water trapped beneath this moon's surface, it could be used to generate breathable oxygen. Furthermore, by combining Titan's water and methane, it would be possible to create rocket fuel that could be used as a power supply. While nitrogen, methane and ammonia - all thought to be present on Titntn - could be used to produce fertiliser to help grow food.

Humans on Titan would face extreme temperatures, meaning that we would need large heat generators and insulation units just to stop ourselves from freezing. The effects of living in lower gravity might also cause long-term issues. In spite of these problems, Titan may still be a better choice than Mars!

What is a meteor shower?

Discover how falling comet debris becomes shooting stars

Below
Meteor showers are named after the constellations they appear to fall from

© Getty

A meteor shower occurs when lots of meteoroids enter the Earth's atmosphere. Meteoroids are bits of dust and rock from comets that are released when their orbit brings them close to the Sun. The Sun's heat boils off some of the comet's icy surface and the resulting debris then trails it in orbit. Meteoroids that enter the Earth's atmosphere are known as meteors, and can regularly be seen travelling across the night sky. However, several times each year, the Earth's orbit crosses with the orbit of a comet causing it to collide with a bunch of meteoroids all at once.

As they are usually very small, most meteors burn up in the atmosphere before they reach the Earth's surface, but those that do occasionally hit the ground are known as meteorites.

What happens if the Sun dies?

What will remain when the Sun commits suicide?

As the Sun dies, it will swell before exploding into a planetary nebula. In the coming few billion years, the Sun will gradually run out of hydrogen fuel and begin to fuse heavier elements. Its core will become denser while its outer layers grow hotter, expanding outward and evaporating all of Earth's water. Eventually the Sun will be a hundred times bigger than it is now, engulfing Mercury, Venus and possibly Earth. When it eventually runs out of fuel, it will eject its material outward in an expanding shell of gas, leaving behind a superdense but dim white dwarf star.

Right
The Sun will eventually leave behind a cloud of dust and gas

What will it be like to go to Mars?

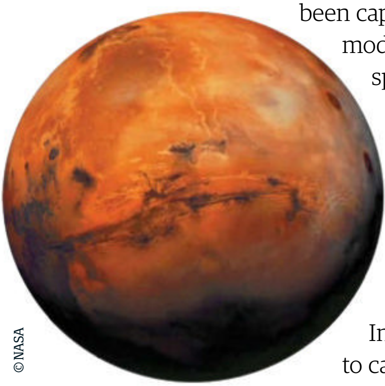
What will astronauts face during their journey?

NASA is aiming to land astronauts on Mars within the next decade thanks to the development of its latest spaceflight system – the Orion capsule and the Space Launch System (SLS). Although not suitable for a long journey to Mars alone, Orion could hook up with a habitation module in orbit around Earth to provide the living space before heading for Mars.

To get Orion and the habitation module to their destination will require a giant rocket – the biggest since the Saturn V. The Space Launch System will come in a couple of varieties. The first, called Block I, will be able to launch 70 tons into low Earth orbit using Space Shuttle-derived booster rockets. The next version, Block II, will dispense with the shuttle boosters for more advanced rockets capable of launching 130 tons into space. No other rocket in history has ever been capable of launching such a large payload. The habitat module could be launched in segments and assembled in space before being launched to Mars by the SLS.

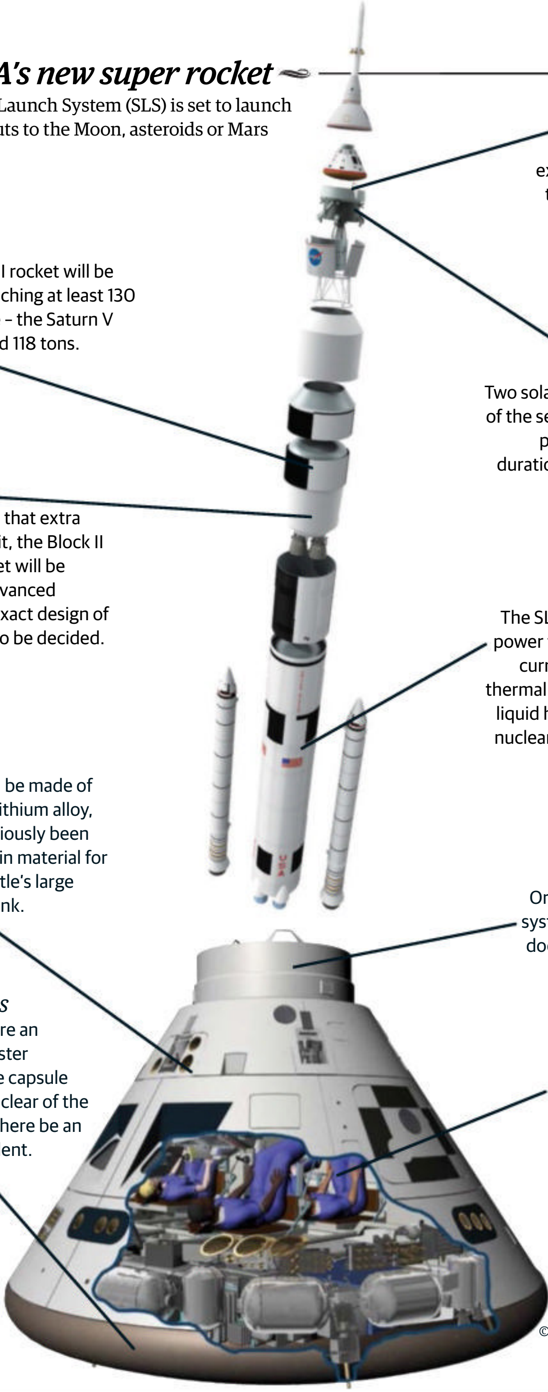
The private space company SpaceX is also keen to get in on the act. Owner of SpaceX, Elon Musk, has said that he wants to start a colony on Mars, and is developing a Mars Colonial Transporter, which Musk says will be capable of launching 100 tons into space. The mission may involve some variation of SpaceX's Dragon capsule that's already ferrying cargo to the International Space Station and could one day be outfitted to carry astronauts too.

Right
Development of the SLS rocket alone will cost an estimated £12 billion ($18 billion)



NASA's new super rocket

The Space Launch System (SLS) is set to launch astronauts to the Moon, asteroids or Mars



Service module

This section of the exploration vehicle is home to Orion's engine, fuel and oxygen supplies.

Payload

The SLS Block II rocket will be capable of launching at least 130 tons into space – the Saturn V rocket managed 118 tons.

Solar panels

Two solar panels on either side of the service module will help provide power for long-duration missions into space.

Rockets

To give the SLS that extra punch into orbit, the Block II heavy-lift rocket will be powered by advanced boosters, the exact design of which has yet to be decided.

Nuclear power

The SLS will need even more power to reach Mars. NASA is currently studying nuclear thermal rocket engines, where liquid hydrogen is heated in a nuclear reactor and then spat out to provide thrust.

Hard shell

Orion's hull will be made of an aluminium-lithium alloy, which has previously been used as the main material for the Space Shuttle's large external fuel tank.

Docking

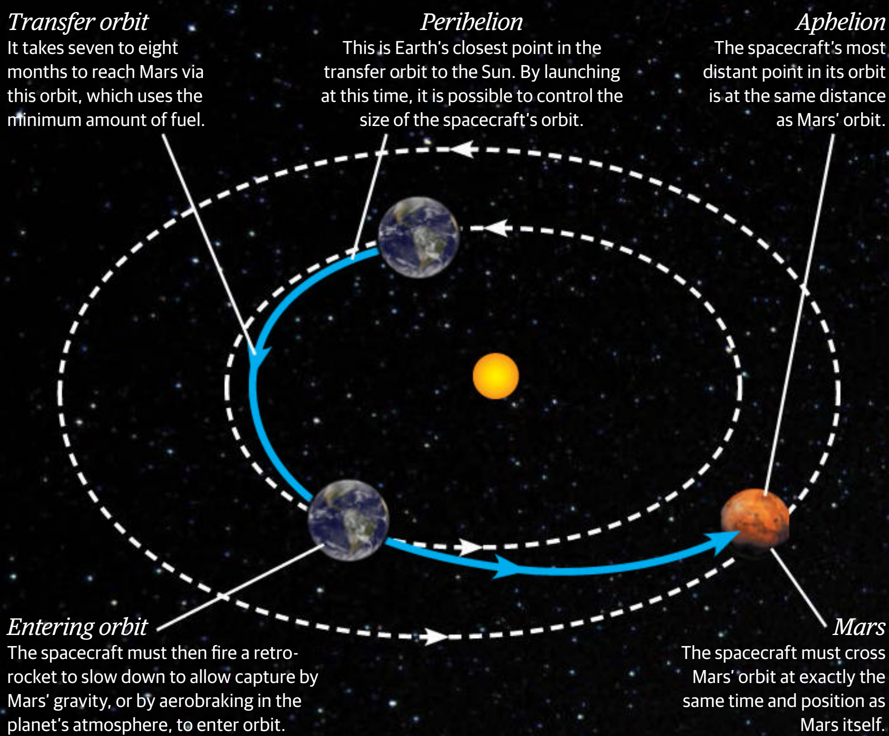
Orion will have a docking system that will allow it to dock with the ISS and the habitation module.

Emergencies

The crew can fire an additional thruster underneath the capsule that will take it clear of the rocket should there be an explosive accident.

Crew

Orion contains 50 per cent more volume inside than the Apollo capsule, able to house up to four astronauts.



> "Using current space technology, it takes about seven or eight months to reach Mars"

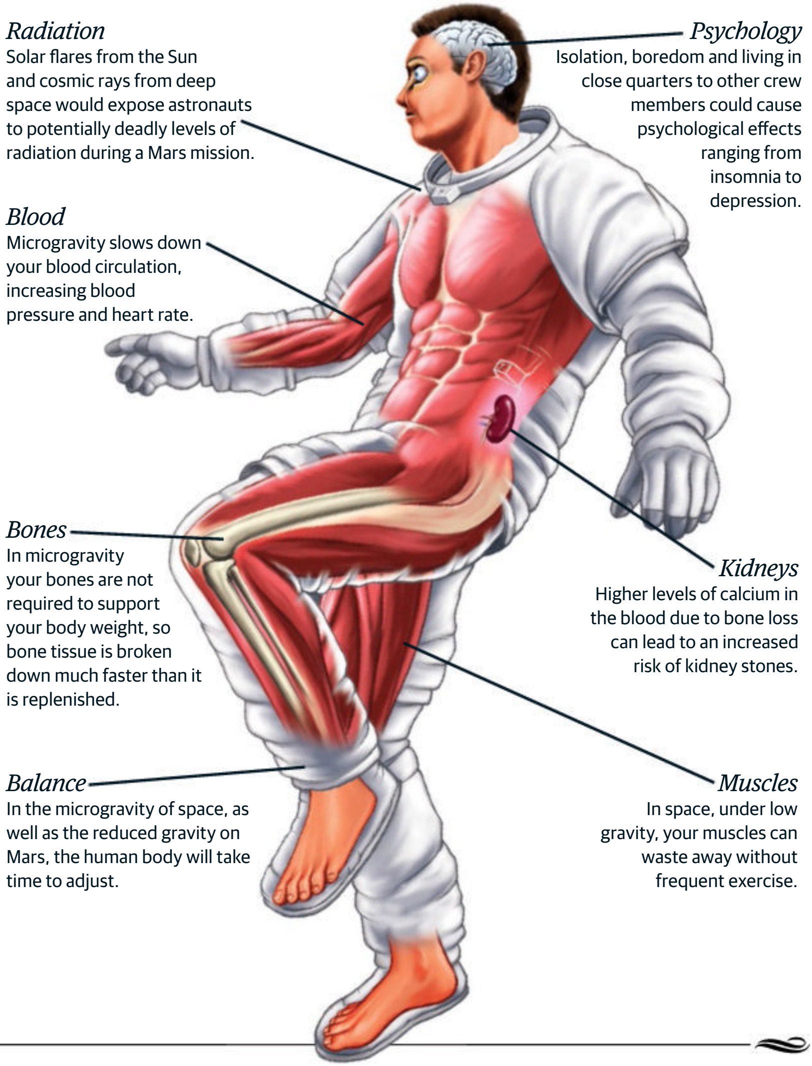
The right trajectory

Using current space technology, it takes about seven or eight months to reach Mars. You have to leave at just the right time, when the Earth is at what's called perihelion – the closest point to the Sun, of the orbital path to Mars. Spacecraft to the Red Planet then use a special trajectory called a Hohmann transfer orbit. This works thanks to a law of orbital mechanics, which says that if you can increase the spacecraft's energy at perihelion, you can increase the aphelion of its orbit, which is how far it gets from the Sun. However, you also need to make sure you arrive in position within Mars' orbit around the Sun at the same time that Mars itself does. The correct alignment occurs only once every two years, meaning that if you miss it, you have a long wait for the next one.

How will the astronauts cope?

Astronauts heading to Mars will face an uphill battle to stay healthy because space travel impacts the body in various ways. Microgravity affects the blood circulation, causing bone loss and muscle atrophy, meaning the astronauts must constantly exercise to combat muscle wastage. While the gravity on Mars is just 38 per cent of Earth's gravity, many of these problems will be alleviated once the astronauts land.

More deadly is radiation, from both the Sun and from cosmic rays coming from deep space. Because Mars does not have a magnetic field to deflect space radiation and keep it from the surface, astronauts will have to live inside shielded habitats. Then there is the additional worry of psychological effects, which can result from the experience, namely the strange environment and isolation from everyone on Earth.



What are space volcanoes?

Volcanoes can be much cooler elsewhere in our Solar System

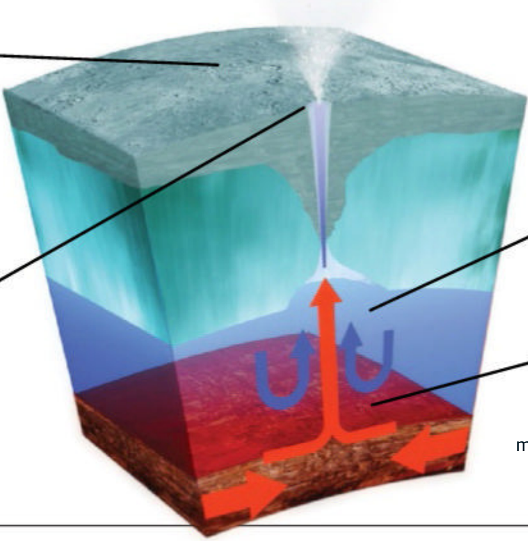
It's not just Earth that has volcanoes, they can be found on several other celestial bodies too. The volcanoes on other terrestrial planets like Venus and Mars, and moons such as Jupiter's Io, are very similar to those on Earth, spewing out hot molten rock from below. However, those found on icy moons such as Enceladus and Titan, which orbit Saturn, eject something much colder. They are called cryovolcanoes, or ice volcanoes, and work in a very different way to their hotter cousins.

How do cold volcanoes work?

This type of volcano is the opposite of what you would expect

Cryomagma
The cryomagma solidifies after eruption in the cooler temperatures, and some even escapes the moon's orbit due to low gravity.

Melted ice
The heated core melts the ice above it, and as pressure builds, it is forced up between ice sheets on the surface.



Icy eruption
A plume of cryomagma; ice particles and water vapour, mixed with methane and ammonia, spews out from the moon's surface.

Tidal friction
Gravity from a nearby planet generates tidal friction that heats the moon's core of silicate rock.

Is the Moon always visible?

Why do we sometimes spot the Moon during daylight hours?

The Moon is the second-brightest object in the sky and incredibly reflective of the Sun's rays. This means the reflected light can even penetrate the scattered blue light of the sky. Though it may seem that the Sun rises in the east while the Moon sets in the west, the Sun and the Moon are only opposite each other in the sky when the Moon is at its full stage. In theory, the Moon is almost always visible in daytime, except when it's too close to the Sun (during a new moon) or too far away (during a full moon).

Right
The Moon seen during the daytime over Colorado National Monument

What do Landsat satellites do?

Observing an orbital space programme that observes Earth

Launched in 1972, Landsat's mission is to photograph the planet and create an archive of hi-resolution aerial images for people working in different fields, including agriculture, forestry, geology, mapping, conservation and emergency response. Landsat also measures light reflected by Earth from the Sun, which tells us a lot about our planet's surface. The most recent satellite, Landsat 8, can collect images in multiple bands of visible and infrared light. It has two new spectral bands that can make specific observations of coastal regions and of high-altitude cirrus clouds, so measurements can be taken of air and water quality. Landsat 8 takes 400 images a day and returns them to the United States Geological Survey (USGS).

Below
The Landsat programme has recorded Earth over the last 40 years

© NASA

How long could you survive on the Moon?

What would happen if an astronaut became stranded?

© Alamy

How long a stranded astronaut could survive on the Moon would depend very much on the supplies they had with them, particularly oxygen. While the average human can survive for a few weeks without food and about three days without water, just 16 minutes of oxygen deprivation typically leads to irreparable damage to the brain and ultimately death within 30 minutes. The longest Moon mission to date was Apollo 17, during which astronauts spent 75 hours on the lunar surface. Had their lander been unable to return into orbit, they would only have had enough oxygen to last them a few days.

What's the core-mantle boundary?

What's it like where Earth's core and mantle meet?

There seems to be a very definite transition at a depth of around 2,900 kilometres (1,802 miles), known as the core-mantle boundary. We don't know for sure what is going inside our planet, but by looking at how seismic waves travel through the Earth, scientists have a pretty good idea. Secondary seismic waves (known as S-waves) can't travel through liquids, and at the core-mantle boundary they abruptly disappear, indicating they have moved from a solid (the mantle) into a liquid (the core). The boundary region contains patches known as ultra-low velocity zones, which are thought to contain high levels of iron that make them very compressible, giving them their strange wave-slowing properties.

© Thinkstock

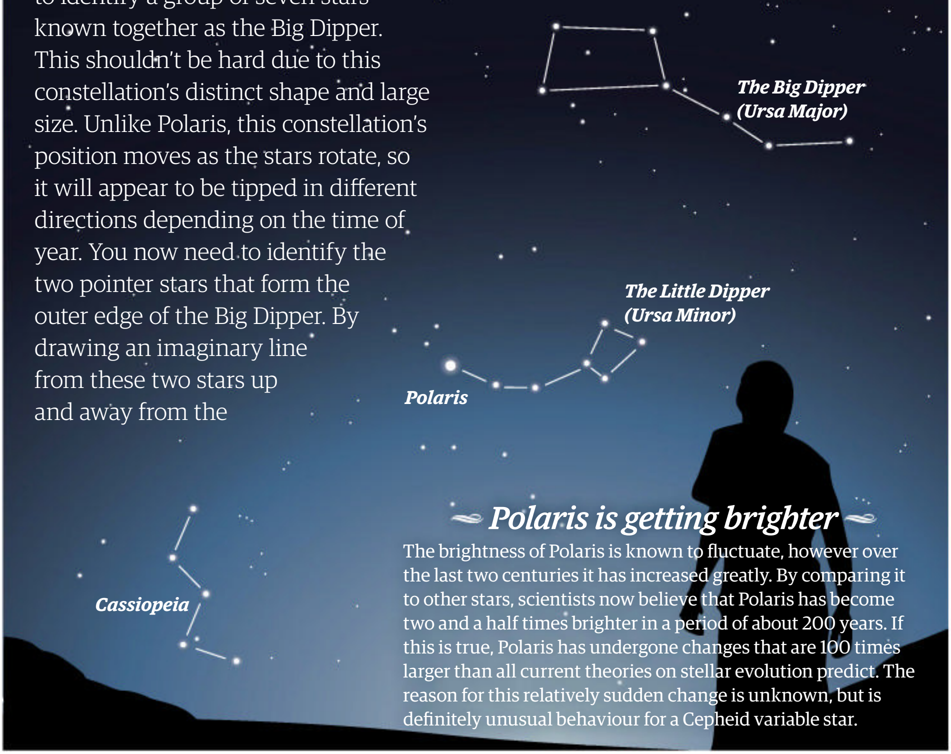
Right
The boundary is marked by a change the movement of seismic waves

How do you find Polaris?

This star has been used as a navigation aid for centuries

Since the 5th Century, Polaris has been used to help people navigate at night. This is because Earth's axis points almost directly at it, meaning that Polaris remains stationary above the northern horizon all year round, while other stars appear to circle around it. It therefore represents true north.

To find the North Star, you need to identify a group of seven stars known together as the Big Dipper. This shouldn't be hard due to this constellation's distinct shape and large size. Unlike Polaris, this constellation's position moves as the stars rotate, so it will appear to be tipped in different directions depending on the time of year. You now need to identify the two pointer stars that form the outer edge of the Big Dipper. By drawing an imaginary line from these two stars up and away from the saucepan shape of the Big Dipper, you will eventually hit the handle of the Little Dipper. The brightest star on the constellation's handle is Polaris. Knowing the location of Cassiopeia will also help identify the North Star, as it will always lie between this constellation and the Big Dipper, no matter what time of year it is.



Polaris is getting brighter

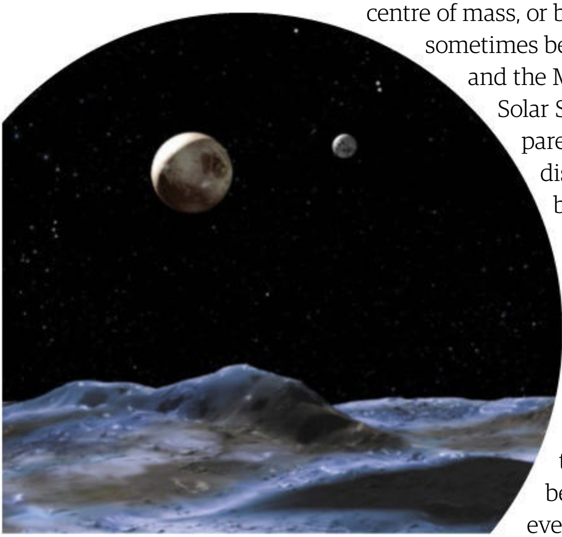
The brightness of Polaris is known to fluctuate, however over the last two centuries it has increased greatly. By comparing it to other stars, scientists now believe that Polaris has become two and a half times brighter in a period of about 200 years. If this is true, Polaris has undergone changes that are 100 times larger than all current theories on stellar evolution predict. The reason for this relatively sudden change is unknown, but is definitely unusual behaviour for a Cepheid variable star.

What are binary planets?

Double planets aren't just the stuff of science fiction – they exist in our Solar System

A double or binary planet is an informal classification to describe a binary system containing two planetary-mass objects. Also called planemos, these are objects with enough mass to round under their own gravity but don't have star-like core fusion. Planemos can be objects we don't actually consider 'true' planets, like moons and dwarf planets.

Because there isn't a formal definition, exactly what makes a binary planet system is up for debate. Many are so close together that their gravitational interaction causes them to orbit around a common centre of mass, or barycentre. The Earth and Moon have sometimes been called a binary planet system, and the Moon is the largest moon in the Solar System in relation to the size of its parent planet. However, some make the distinction that the barycentre must be located outside the planets, and with the Earth-Moon system, the barycentre is found 1,700 kilometres (1,050 miles) below the Earth's surface. Pluto and its satellite Charon fit this definition better as Charon's diameter is about half that of Pluto's and their barycentre lies in the space between them. There may be distant binary exoplanets as well – even habitable ones...



Below
Pluto and Charon orbit each other around a point in space between them

What shape is the Milky Way?

We've never been outside our galaxy, so how do we know what it looks like?

Measuring roughly 100,000 light years across, the Milky Way is mankind's home. Without leaving our galaxy and viewing it from afar, we can't be absolutely certain of its shape, however there is significant evidence that points to it being a sprial. This is just one of four main galaxy shapes that have been observed in the universe, including elliptical, lenticular and irregular.

Looking towards the Milky Way's galactic centre, we're able to see a long, thin strip that suggests we're looking at a disc seen from the edge-on. A central bulge can also be detected, which can be seen in other spiral-shaped galaxies. Furthermore, by measuring the velocity of the stars and gas within the Milky Way, it's possible to observe an overall rotational motion that is greater than random motions, which is indicative of a spiral galaxy.

The final clue lies with the amount of gas and dust and their respective colours, which is similar to the other spiral galaxies we've observed. By combining all this proof, we have fairly conclusive evidence that our galaxy is a spiral.

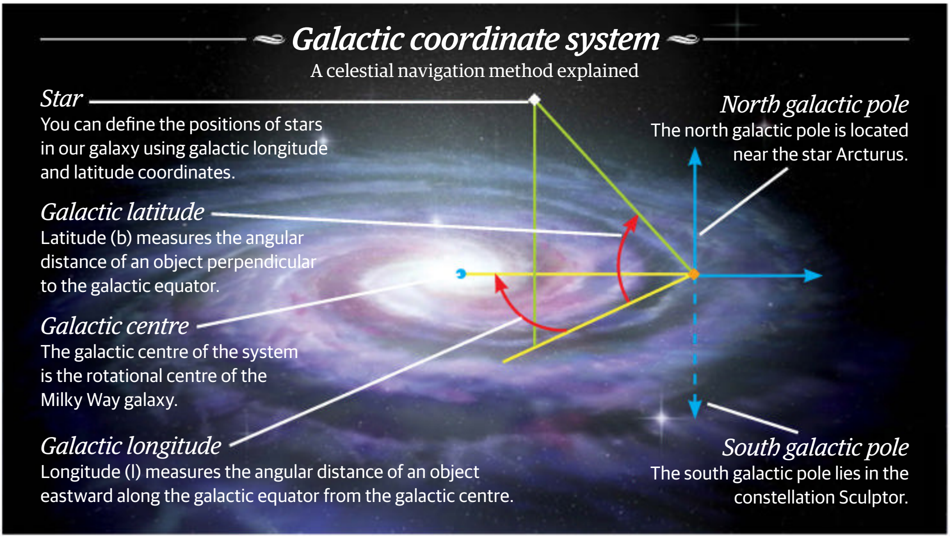
What is a galactic plane?

Find out everything about our galaxy's equator

The galactic plane is the plane in which the majority of a disc-shaped galaxy lies. It essentially slices the galaxy in half from one side to the other, and the directions perpendicular to the plane are known as the galactic poles. Typically scientists are talking about the Milky Way when referring to the galactic plane and poles.

The galactic plane is not always easy to define; even in the Milky Way, which is a barred spiral galaxy and fairly regular, not all of its stars lie precisely within the plane. The International Astronomical Union defined the locations of the north and south galactic poles as part of the galactic coordinate system, a spherical coordinate system used to specify the location of objects relative to the Sun and the centre of the galactic plane. The galactic coordinate system works similarly to the geographic coordinate system that we used to specify locations on Earth, with locations given in degrees latitude (b) and longitude (l).

Below
Most often the galactic plane is discussed in relation to our own galaxy



Why do stars twinkle?

What's behind that mysterious glint in the sky?

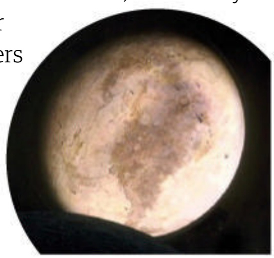

© NASA

Stars twinkle when there appear to be variations in their brightness. Astronomers call this phenomenon atmospheric scintillation, and it's caused by motion in the atmosphere. Specifically, changes in atmospheric temperature cause small fluctuations in the air's density. As starlight passes through the atmosphere, it's refracted or slightly alters direction, creating a twinkling effect. This is more obvious when viewing stars closer to the horizon because there's a thicker layer of atmosphere. Astronomers compensate for atmospheric scintillation by using special adaptive optics on the most sophisticated telescopes. Space-based observatories like the Hubble also allow us to view stars and other objects without atmospheric scintillation.

How are planet names chosen?

Who gets to decide on the names of newly discovered planets?

Planetary names in our Solar System are derived from mythology - except for Earth, which comes from Middle English. Since five of the planets can be seen by the naked eye, they have been called many things over the centuries before their names became standard. Uranus (previously thought to have been a star) is the only planet whose name comes from Greek rather than Roman mythology. Neptune's discoverers argued about its name, while former planet Pluto's name was suggested by an 11-year-old in the UK. In 1919 the International Astronomical Union (IAU) was formed, and it is currently in charge of naming all celestial objects.



Right
Ex-planet Pluto could have been called Atlas, Constance, Cronus, Minerva, Percival among others

How do you locate dark matter?

Does it have to be seen to be believed?

Dark matter has mass but does not emit or absorb electromagnetic radiation, so it is invisible to telescopes. Astronomers detect its presence from the gravitational pull it exerts on other objects, such as stars or galaxies. The movements of distant galaxies suggest that something with a very large mass is altering their paths by exerting a gravitational force on them. We know relatively little about dark matter, but some believe it could be made up of a new type of subatomic particle called a WIMP (weakly interacting massive particle), although its existence has yet to be proved.

©Dreamstime

What is the V1 star?

The V1's discovery expanded our universe's horizons

Below
The Andromeda galaxy (M31) is home to Cepheid variable star V1

© NASA

In a galaxy, not too far away, resides a star that changed how we saw the universe back in the early-20th century. Its name is Hubble variable number one, or V1 for short, and it told us that there were more galaxies beyond our own. At first it highlighted Andromeda – the star's home and the closest spiral galaxy to ours. Because of its predictable brightening, caused by stellar gas heating and expanding before cooling and contracting in a cycle, this object was soon dubbed a Cepheid variable. These stars help us to measure distances further and further out into the universe. By working out how long it takes for a variable star to brighten and dim, we can work out how bright the star would be if we were up close to it.

What is the difference between an asteroid and a comet?

Both are essentially space debris, right?

Asteroids and comets both orbit the Sun, and are the remains of objects formed in our Solar System. Sometimes their unusual orbits bring them close to planets and moons.

The difference is in their composition. Asteroids typically comprise rocks and metals, while comets also have ice, dust and organic matter in addition to the rocky material. Asteroids stay stable and solid, but if a comet gets close to the Sun, some of its ice melts off. That's what gives comets their characteristic 'tails' – fuzzy trails pointing away from the Sun that contain ice and compounds such as ammonia.

It's likely that Asteroids would have formed closer to the Sun, while comets formed further away in the Solar System, making them able to retain ice. Some astronomers theorise that comets could have formed closer to the Sun, before being flung out by gravitational forces from gas giants like Jupiter. Another difference between comets and asteroids is that the former can have huge, elliptical orbits, while asteroids usually have circular, shorter orbits.

Comet Lovejoy near the Earth's horizon, as photographed from the ISS by NASA astronaut Dan Burbank

What happens at air traffic control?

Inside the control centres responsible for keeping the UK's skies safe

When you think of air traffic control, you probably think of big control towers at airports, but the majority of the work is actually done at the two NATS control centres at Swanwick and Prestwick in Ayrshire, Scotland. Before each flight, an airline will file a flight plan, which is then evaluated by NATS. The aircraft's fuelling needs, traffic patterns and weather conditions are all considered to ensure a safe and efficient route. Controllers in the airport towers are then responsible for clearing the aircraft for take off and coordinating its movements on the ground. But once your flight is airborne, it is handed over to the air traffic controllers at Swanwick or Prestwick, depending on its route.

Controlled airspace is made up of a network of corridors called airways, which are a bit like roads. Each one is 16 kilometres (ten miles) wide and 1,524 metres (5,000 feet) high and they crisscross through the skies between the UK's major airports. Although ground-based radar systems and satellite links are used to keep track of all aircraft, it is still down to the controllers themselves to organise flights in the air and give direct instructions to the pilots.

One of the most important systems used is the interim Future Area Control Tool Support (iFacts). This gives the controllers a 15-minute look into the future, alerting them if two planes are going to come within the required separation distance from each other. An automated arrival manager system can calculate an optimal landing sequence for aircraft, but a controller is still needed to monitor and tweak this to make sure it is as safe and efficient as possible, and redirect aircraft if long delays are likely to cause them to run out of fuel. The job of a controller seems complicated to the untrained eye, but each person can manage up to ten aircraft at a time in peak demand.

Right
Controllers have 30-minute breaks every 90-120 minutes to ensure accuracy

© Thinkstock

A relay race in the skies

Your flight is passed between several different air traffic controllers as it travels from A to B

Controllers in the airport control tower manage the initial takeoff and final landing

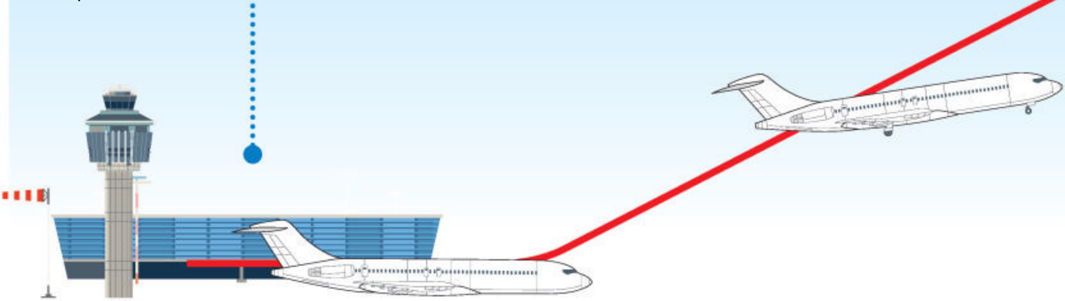
A terminal controller manages about five to ten aircraft in their sector of airspace. Each one is represented by a strip of paper

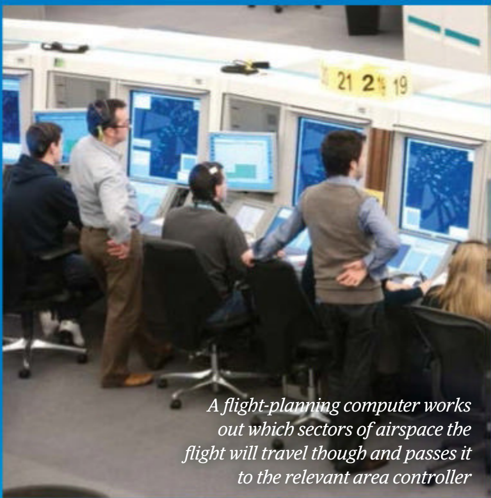
Taking off

Once all of the passengers are on the aircraft and it is ready to go, the pilot contacts the delivery controller in the airport control tower. They will give the pilot air traffic control clearance, before passing them on to the ground movement controller, located elsewhere in the tower. It's their job to tell the pilot when they can push back and taxi toward the runway. They are then transferred to the tower's air controller, who lines up the aircraft on the runway and provides final clearance for take-off. When the aircraft is above 914 metres (3,000 feet), the air controller in the tower hands the pilot over to a terminal controller at the LTCC.

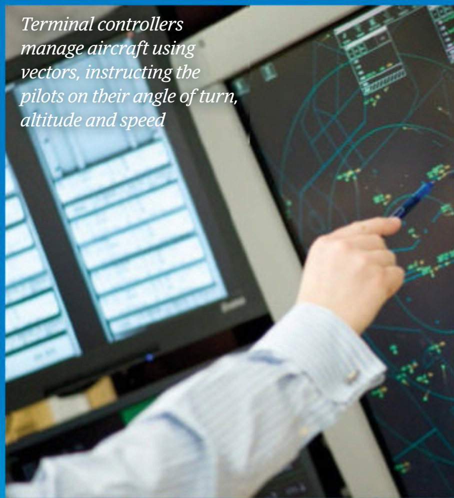
Ascending

The flight details of the aircraft are printed onto a strip of paper and handed to the terminal controller in charge of outbound flights for that airport. That controller then checks in with the pilot via radio link and guides them though their sector of airspace before passing the aircraft, and its strip of paper, to the next sector's controller. A pilot has to speak to many different controllers throughout a flight, and it's the job of each controller to tell them which radio frequency to switch to when they hand them over. LTCC helps the aircraft navigate London's busy airspace until it reaches 7,467 metres (24,500 feet).





A flight-planning computer works out which sectors of airspace the flight will travel though and passes it to the relevant area controller



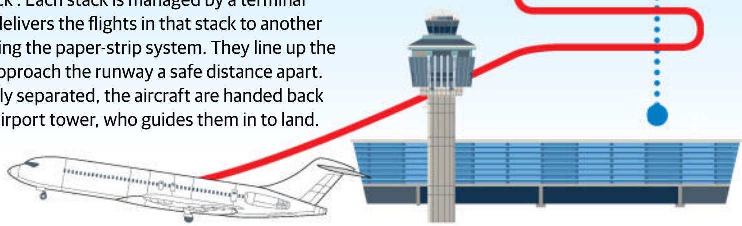
Terminal controllers manage aircraft using vectors, instructing the pilots on their angle of turn, altitude and speed

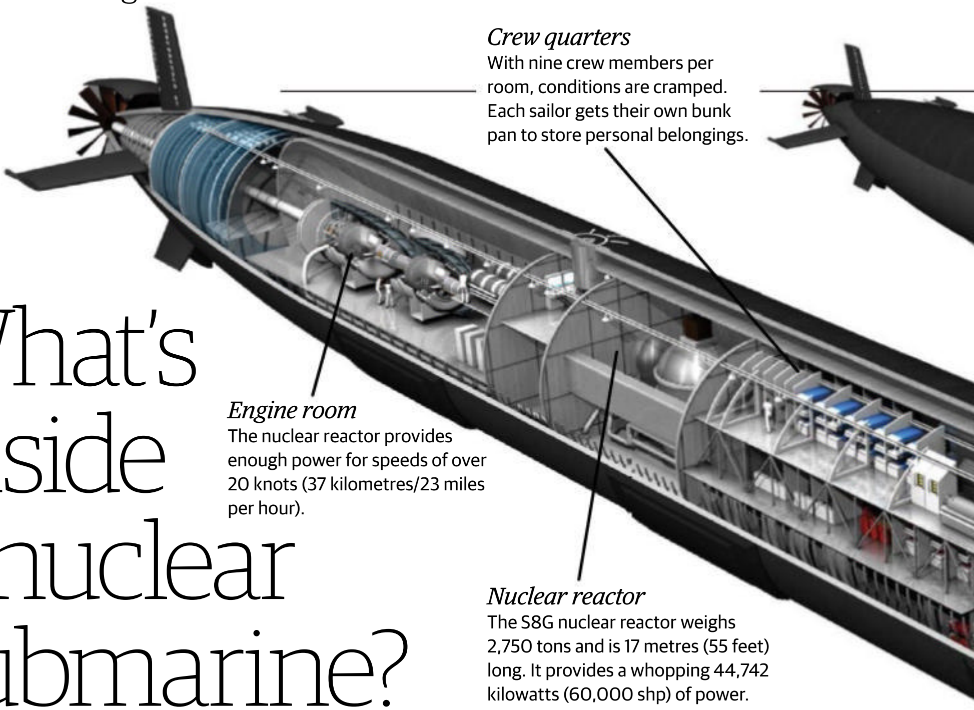
In the air

Next the pilot is handed over to the LACC, which manages all en route traffic travelling through the airspace over England and Wales. This airspace is divided into several sectors, with each sector managed by a different team of area controllers. However, when demand is low, some sectors are 'band-boxed' together so that each team is in control of several sectors at once. As the aircraft enters a different sector, it is passed on to that sector's controller. This is done electronically on computers in the LACC, as opposed to the manual system using strips of paper in the LTCC.

Landing

When the aircraft is preparing to land, it descends to below 7,467 metres (24,500 feet) and is handed back to the LTCC. When an aircraft approaches a major airport, it often circles overhead in a so-called 'holding stack'. Each stack is managed by a terminal controller, who then delivers the flights in that stack to another terminal controller using the paper-strip system. They line up the aircraft so that they approach the runway a safe distance apart. Once they are correctly separated, the aircraft are handed back to a controller in the airport tower, who guides them in to land.





What's inside a nuclear submarine?

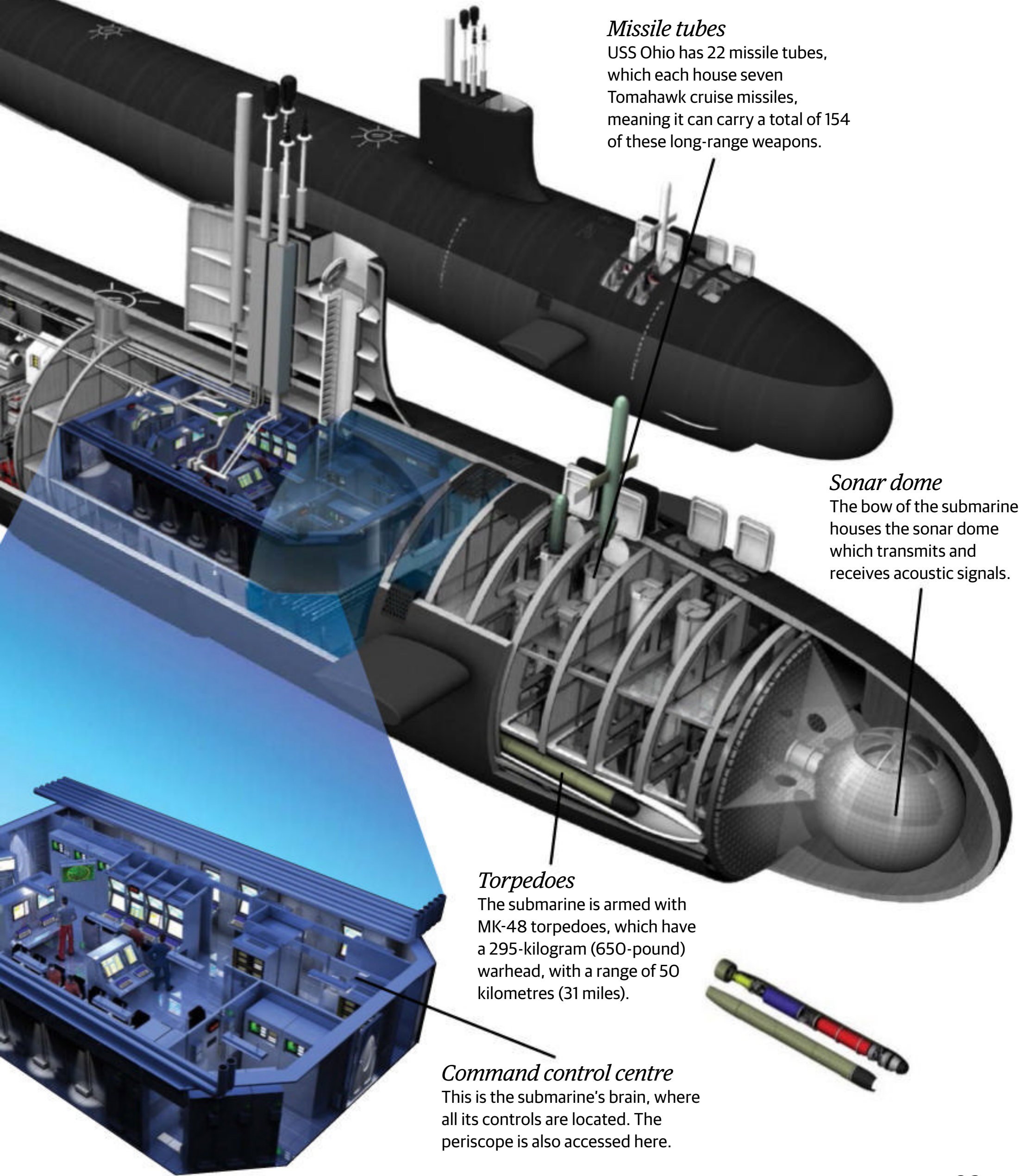
The secrets of the United States' powerful underwater weaponry

USS Ohio is the lead submarine of the Ohio class, the United States Army's largest nuclear-powered submarines. This class is made up of 18 submarines, all of which were originally equipped with a full nuclear armament of ballistic missiles. Between 2002 and 2008, the US Navy modified the four oldest Ohio-class submarines (including USS Ohio) into guided-missile submarines (SSGN), which carry non-nuclear missiles. The remaining 14 carry roughly 50 per cent of the United States' active thermonuclear warheads. One of the silos that held a nuclear missile before USS Ohio is now a hatch to allow Navy Seals to exit the submarine during their covert operations.

USS Ohio has been designed to be highly self-sufficient, producing its own power, drinking water and oxygen. It produces breatheable air via a clever process that uses electricity to separate oxygen from the hydrogen in seawater. This allows USS Ohio to remain submerged for up to 90 days; the only limitation being food supplies. USS Ohio's crew will typically include 15 officers and 140 other sailors. All of the crew are exceptional sailors, and volunteer to go aboard the submarine.

Awesome power

See inside the lead submarine of the Ohio class



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What are buoys used for?

How these simple floating devices keep sailors safe and provide valuable scientific information

Buoys serve a number of important purposes in our waters. They were first documented in 13th-century Spain, where they were used to help ships navigate into the port of Seville. The word 'buoy' is thought to have derived from the Middle Dutch word 'boeye', meaning 'float.' By definition, they are a float that is usually anchored, often made of plastic or fibreglass.

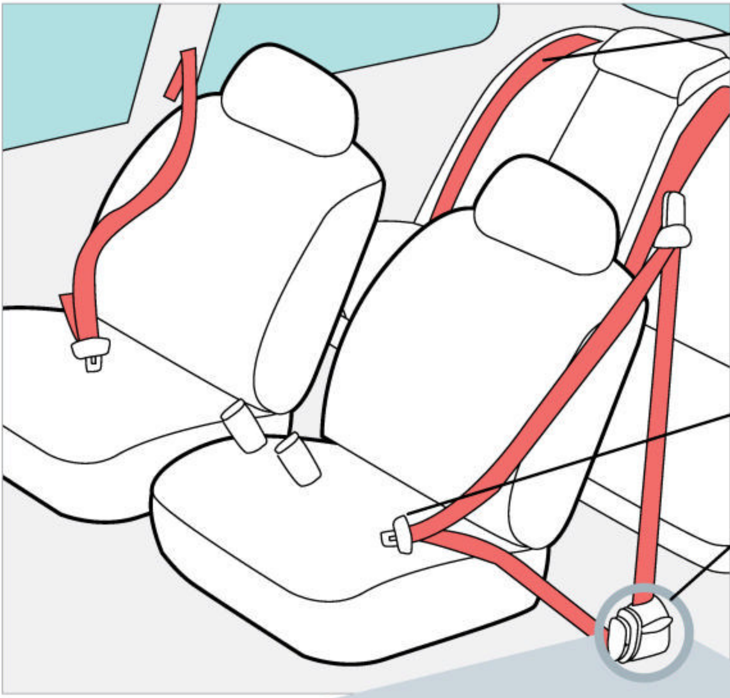
Part of their function is to alert people at sea to potential hazards, such as rocks or dangerously shallow water. In areas where many ships operate, buoys can be used to indicate the location of shipping lanes, reducing the risk of collisions between boats. Meanwhile, the majority of small buoys found in harbours will act as mooring devices, allowing boats to be anchored in place without needing to be attached to a dock.

Buoys are also hugely significant for science. They are used throughout the world to collect data on ocean currents, climate change and the weather. Many weather forecasts use buoys to predict weather patterns and learn more about the conditions in specific regions.

Above
Large marker buoys show the location of deep channels safe for large merchant vessels

What makes seat belts secure?

Safety belts work pretty hard to protect you in the event of a collision



The belt

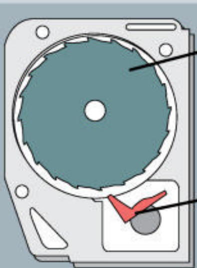
Made of polyester webbing, this is tough and durable, yet smooth to touch – crucial, as it is strapped over the torso.

Belt fastener

The clip at the end of the belt is secured into the fastener, which is attached at the bottom of the seat and holds the belt in place.

Retractor

Attached either to the seat, adjacent to the fastener, or holed in a car's B pillar, the belt runs through this mechanism that reacts in an accident.

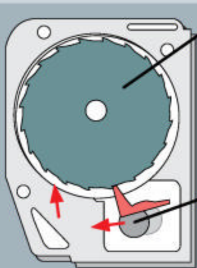


Locking gear

The locking gear spins freely inside the retractor as the belt runs over the locking teeth.

Claw

When the ball moves forward, it pushes the claw upward, which jams against a tooth in the locking gear.



Locking gear – on impact

With the claw jammed against one of the gear teeth, the locking gear holds firm, keeping the seat belt tightly in place.

Ball sensor

The ball sensor is housed in a small shaft, and is moved forward in the shaft under force, for example in an impact.

How do you fly a helicopter?

What it takes to be able to fly this unique type of aircraft

Piloting this incredible piece of engineering is no mean feat. Immense mental and physical co-ordination is required; the ability to use each hand and foot independently to operate the flight controls is a prerequisite for any prospective pilot. This means training to become a pilot takes a significant amount of time and money. Typically more than 1,000 registered flying hours and numerous written exams are needed if you want to fly commercially.

Below
Helicopter pilots have to be experts at multitasking!

© Dreamstime

At the helm

Navigate the cockpit's many buttons required to move a helicopter

Centre console
The radio and transponder tend to be located on the centre console. A variety of other instrumentation will also be present, including master switches for the engine, and multiple temperature gauges.

Instrument panel
Similar to an aeroplane, there are a number of instruments that need constant monitoring while airborne, including speed indicators, as well as the altitude (height) and attitude (forward speed) values.

Cyclic-pitch lever
Sitting between the pilot's legs, the cyclic-pitch lever works to tilt the aircraft forwards, backwards or side-to-side. It tilts the rotor disc in the desired direction of flight, changing the angle of the rotor blades to alter the helicopter's direction.

Anti-torque pedals
Located at the front of the cockpit are two pedals, which control the tail rotor. Operating the pedals causes a lateral change in direction, and is used to combat the torque created by the main rotors during takeoff, which causes the helicopter to turn.

Collective-pitch lever
This works to move the aircraft up and down, and is used during takeoff. When engaged, a collective change is imparted on the pitch of all the aircraft's rotor blades. The throttle is also located here, which controls the engine's power.

How are parachutes deployed?

How does a parachute safely return a person in free fall to the ground?

Below
The AAD sits snugly at the top of the pack and is easily accessible to the person wearing it

During free fall, our bodies accelerate at just under ten metres (33 feet) per second squared until we reach a terminal velocity of about 55 metres (180 feet) per second. Hurtling toward the ground at 200 kilometres (124 miles) per hour would be ill-advised without a parachute strapped to your back.

Although Leonardo da Vinci is credited with the first parachute design, found scribbled into the margin of his notebook, Louis-Sébastien Lenormand was the first to demonstrate the parachute in 1783. Early parachutes were made from silk, but these days they are made of synthetic, lightweight materials such as nylon or Kevlar.

Once you've jumped clear of the plane, you deploy the parachute by pulling the ripcord that releases the pilot chute. The pilot chute will quickly open and the air hits it with enough force that the main chute will be pulled from its container. It is vital that the main chute is packed precisely, so that it opens correctly behind you and the suspension lines connecting it to your harness do not become tangled. The main parachute is actually designed to open slowly. If the main chute were to open quickly to its full size, it would reduce your free fall speed very suddenly, jerking your body harshly and potentially damaging the parachute itself.

A parachute slows you down by increasing your air resistance. Parachutes decrease your terminal velocity by around 90 per cent, allowing you to land at a safe speed of around five metres (16.4 feet) per second. This should be slow enough for you to land gently on your feet when you reach the ground.


Parafoil cells
This is a typical parafoil parachute. It is split into cells that channel air and allow speed and direction to be controlled easily.
Pilot chute
This small, auxiliary parachute functions to deploy the main or the reserve parachute. These can be spring-loaded, pull-outs or throw-outs.
Suspension lines
Multiple suspension lines connect the parachute's canopy to the parachute pack. If the lines are too short the drag may be decreased, meaning the parachute will fall faster.
Steering toggle
A parachute is equipped with two steering toggles attached to the break lines at the back of the parachute. By pulling both, you can slow your descent.
Slider
The slider works to slow down the speed at which the parachute deploys, reducing the risk of damage to the canopy and of the suspension lines becoming entangled.
Body straps
These straps attach the parachute securely to the individual and must be tightly fastened to hold the parachute in place.

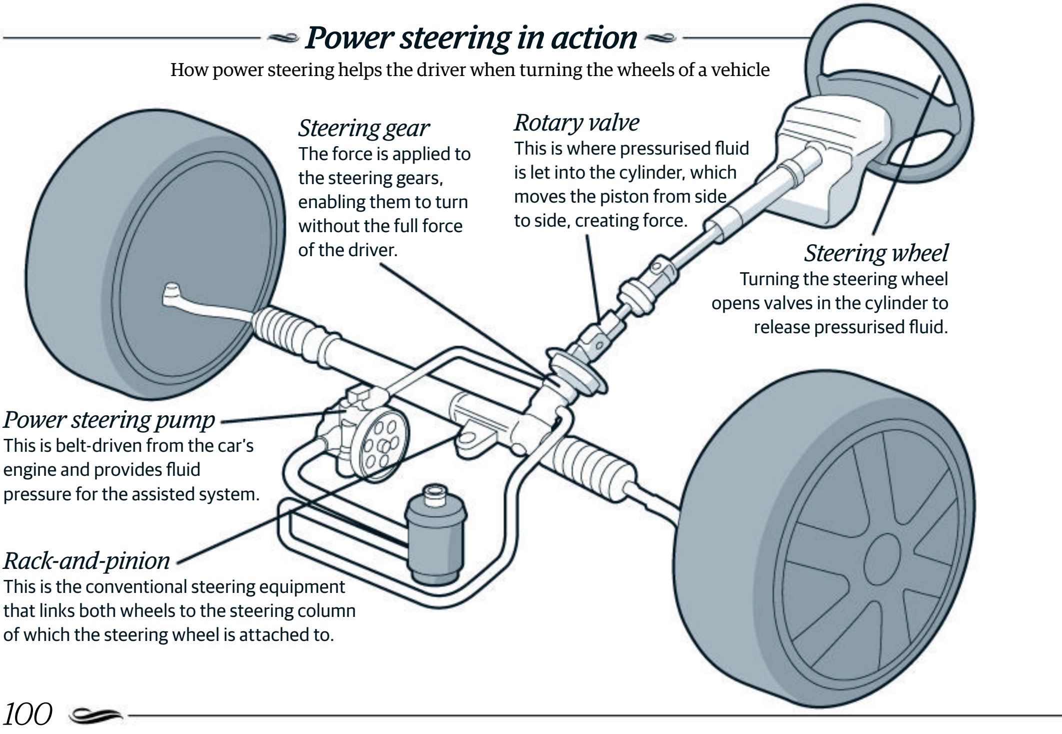
Why does power steering work?

This clever system provides actually reinvents the wheel

Power-assisted steering provides extra power when turning the wheel. It works through a hydraulic system, where a pump, running off a belt from the engine, creates hydraulic fluid pressure. This fluid pressure moves a piston inside a cylinder, which applies force to the gears on the rack-and-pinion steering system. When the driver turns the steering wheel, this opens valves in the cylinder, letting fluid pass into it, moving the piston and creating added force. However, hydraulic-assisted steering creates extra drag on the engine due to that pump, meaning engine efficiency (and therefore MPG) is reduced. To combat this, manufacturers have now developed electric power-assisted steering (EPAS). This works by an electric motor mounted on the steering rack forcing the steering round, working independently of the engine, thus improving fuel economy.

Power steering in action

How power steering helps the driver when turning the wheels of a vehicle



How does fuel injection work?

How does a gas pump know when your tank is full?

Below
A clever little mechanism lets the pump know when your tank is full


©Thinkstock

Have you ever wondered how the pump knows when your tank is full? The process is entirely mechanical and begins with a small hole near the tip of the pump's nozzle. This hole allows air to enter a small pipe inside the nozzle, which runs along to the handle of the pump. When the nozzle is inserted into your car's fuel line and the refuelling process begins, air is sucked into this pipe thanks to a vacuum – known as the Venturi effect. When the fuel level in the car rises up to the tip of the nozzle, the air in the small pipe is replaced with fuel, which needs a greater suction force to carry it along the pipe. The shutoff mechanism in the handle senses this change in suction pressure and duly closes a valve in the nozzle, blocking the fuel from leaving the pump.

What causes a sonic boom?

How the Super Hornet jet makes a really loud noise

Below
It takes just milliseconds for a jet fighter to create a sonic boom


© Rex Features

One of the planet's most advanced fighter jets, the US Navy's F/A-18F Super Hornet is capable of staggering speeds of up to 1,915 kilometres (1,190 miles) per hour – far beyond the speed of sound, which travels at a rate of 1,225 kilometres (761 miles) per hour. As the aircraft reaches that 1,225-kilometre-per-hour mark, waves of pressure are created in front of and behind it. These waves can only travel at the speed of sound, which means as the aircraft accelerates past that threshold, they collide, creating one large shock wave. This large shock wave creates a loud noise similar to that of an explosion, which is known as the sonic boom. Many factors determine the intensity of a sonic boom including the aircraft's altitude, size and shape, as well as the weather conditions.

How do hydrogen cars work?

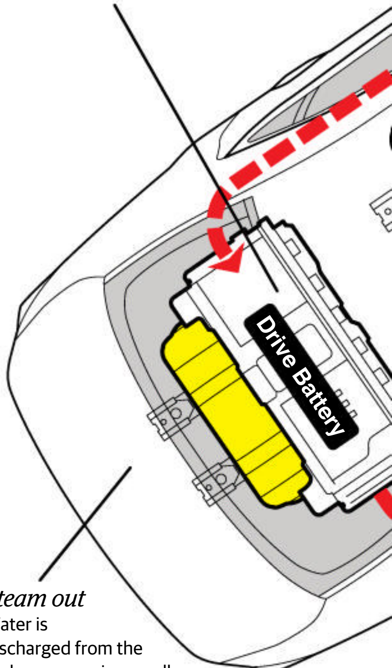
How this gas powers vehicles with zero emissions

Hydrogen-powered vehicles, otherwise known as fuel cell vehicles (FCVs), are seen as an eco-friendly alternative for future motoring. Hydrogen power works by chemically combining high-pressure hydrogen and oxygen to produce electric power. While oxygen for this chemical reaction is garnered from the atmosphere, the hydrogen is stored in large tanks mounted low down within the body of the car, keeping the vehicle's centre of gravity low, which is important for stability and handling.

Hydrogen is the most abundant element in the universe, is easy to store and transport, and hydrogen-powered cars only produce water as a waste product, meaning zero harmful emissions are released into the atmosphere. It is for these reasons that some of the biggest manufacturers have taken to this technology.

Hydrogen-powered cars have had to overcome some basic problems though, including making suitable space within a compact modern vehicle in which to store hydrogen tanks and additional electric motors. Weight is also an issue, as carrying heavy hydrogen tanks can be detrimental to a vehicle's performance.

Drive battery
This provides power to other elements of the car, such as headlights, radio and air conditioning.



Steam out
Water is discharged from the hydrogen car via a small exit channel.

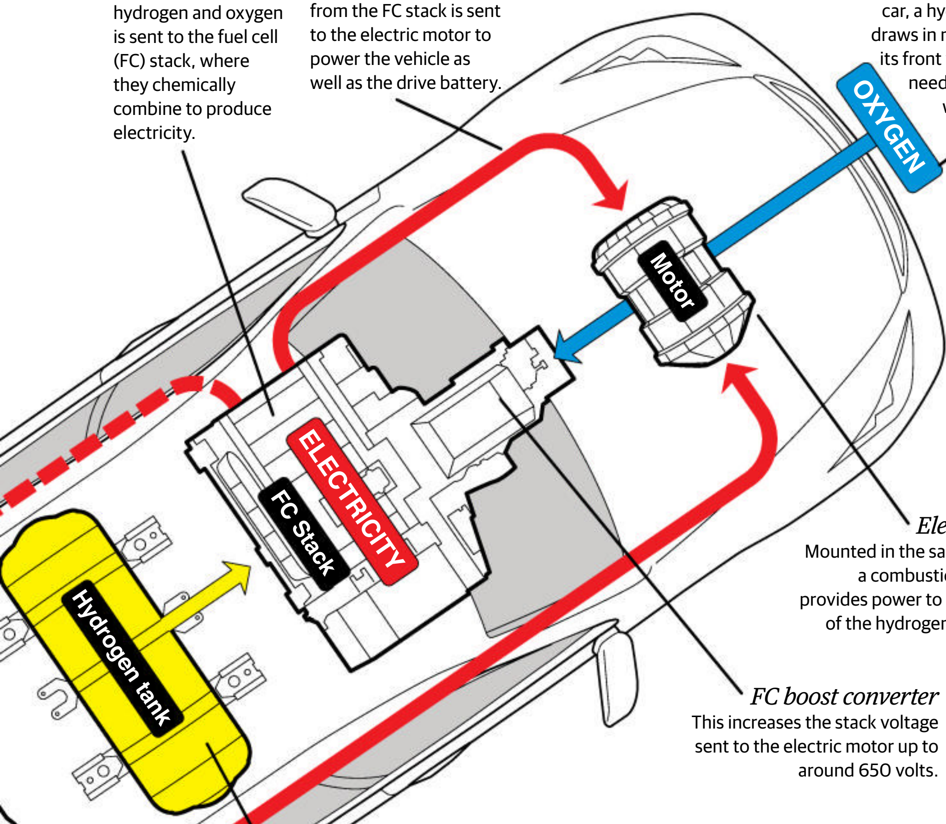
Hydrogen power in action

How the first element of the periodic table is used to provide motion

FC stack
A mixture of hydrogen and oxygen is sent to the fuel cell (FC) stack, where they chemically combine to produce electricity.

Electricity supply
The electricity harvested from the FC stack is sent to the electric motor to power the vehicle as well as the drive battery.

Air in
Much like a petrol-powered car, a hydrogen vehicle draws in natural air from its front vents, which is needed to combine with hydrogen.



Electric motor
Mounted in the same position as a combustion engine, this provides power to all four wheels of the hydrogen-powered car.

FC boost converter
This increases the stack voltage sent to the electric motor up to around 650 volts.

High-pressure hydrogen tanks
Much like a conventional fuel tank, these store hydrogen reserves to power the vehicle.

The hydrogen-powered Toyota FCV will goes on general sale in late-2015

What's inside an ambulance?

How well equipped are these hospitals on wheels?

Paramedics need assess to all the equipment to treat injuries and illnesses on the scene. Current ambulances come fully loaded with defibrillators and can administrate oxygen and monitor the heart. The wheels and suspension have also been improved for off-road routes if there is congestion on the journey to the hospital.

The LifeBot 5 is one device that has taken mobile healthcare that step further. Developed by the US Army, its motto is 'saving lives in real-time' and the telemedicine system comes equipped with a live link to a doctor in the nearest hospital. This allows the hospital to make more accurate assessments of the patient's condition and to prepare the ward for any surgery that may be required.

Despite all the modern upgrades, reaching the hospital in the quickest time is still the key objective. Today's vehicles come complete with a device that can change red traffic lights to green at certain intersections and use the best GPS and mapping systems available. These aids can prevent the motorist from driving recklessly and reduces shake and vibration from the road. This will enable more intricate and efficient treatments to be undertaken during the journey to the hospital.

Medical supplies
All modern ambulances must contain everything a patient could need on a journey, from medicine to defibrillators to breathing apparatus.

Interior
The surfaces inside an ambulance are easy to clean for greater control of infection and spillage.

Stretcher
Stretchers are designed to comfortably transport the patient from the scene to hospital and can be wheeled or carried.

Chassis
Modern chassis are constructed to be both light and manoeuvrable by using a lining of felt to dampen vibrations.

The modern ambulance

The medicines and equipment that paramedics have at their disposal

Communication
Ambulance staff communicate within the vehicle via hands-free audio links and panic buttons are fitted in case of emergency.

Lights
The bright flashing lights and piercing siren of an ambulance alert other drivers and pedestrians to its presence so they can quickly get out of the way.

Seating and safety belts
Paramedics now have specially designed seatbelts that allow them to treat the patient while safely restrained.

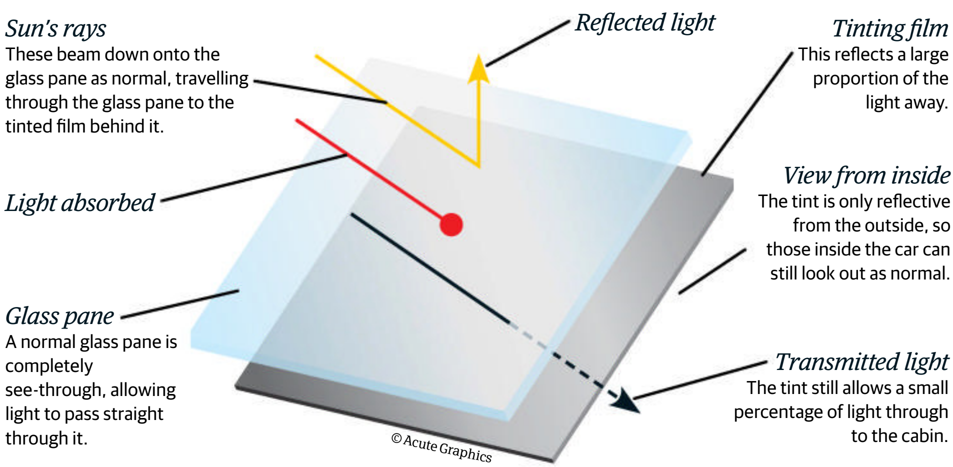
Wireless medical equipment
Treatment carried out in the ambulance is recorded to help medics operate accurately while on the road to the hospital.

Computer system
A 'black box' is installed on modern ambulances to record the driver's speed, handling, signalling and overall driving safety.

How do tinted windows work?

How a basic film protects occupants of a car from the Sun's powerful rays

You may see them being used as 'privacy glass', but the original purpose of a tinted car window is to block the Sun's rays from entering the vehicle, keeping the occupants inside cool while still enabling them to see outside. Tinted glass works by applying a thin film tint to a pane of glass. The tint is sticky, so careful application is essential to avoid creating air bubbles. The tint simply reflects the sunlight, meaning only a small percentage of the Sun's rays are transmitted into the vehicle. The heavier tint you have, the less the Sun's rays are transmitted into the vehicle – but be careful, as this is to the detriment of vision through the window.



What causes a tarmac mirage?

Why does the mirage effect appear on roads?

Although they're often associated with deserts and summer temperatures, it doesn't have to be a particularly hot day for you to see a mirage on dark tarmac – just a sunny, dry one. Mirages are caused by waves of light passing through layers of air that have different densities, then refracting – or bending – towards the densest layer of air. In an inferior mirage, the layer of air on the surface is warmer than the air above it, creating an image below that of the actual object. This is why you can often see mirages on road surfaces because tarmac heats up quickly on a sunny day.

Right
Apeldoorn, the Netherlands, in May, when the average high temperature is 13°C (55.4°F)

How does salt melt road ice?

How ice gritters protect drivers against black ice

We spread granulated salt on icy roads because it lowers the freezing and melting temperature of water. When water cools to zero degrees Celsius (32 degrees Fahrenheit) or below, it freezes into ice. But if you added, for example, a 20 per cent salt solution, it would freeze at -16 degrees Celsius (three degrees Fahrenheit) instead. If you sprinkle salt on ice that's formed on the road, it will dissolve into the liquid water film on the surface of the ice and ultimately melt it. There is a limit, however; if the road temperature is lower than minus-nine degrees Celsius (15 degrees Fahrenheit), the salt cannot penetrate the surface of the ice to begin the process of melting it. Sometimes calcium fluoride is added to the road-salt mixture, allowing for melting at slightly lower temperatures.

Below
Granulated salt lowers the freezing and melting temperature of water

What was life like in Ancient Egypt?

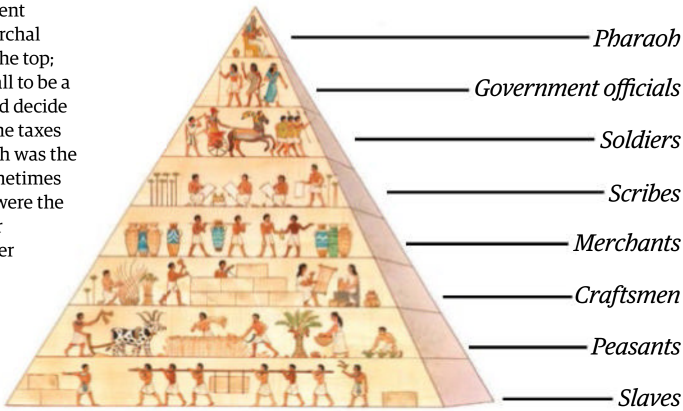
Explore the everyday rites and rituals of a mystical, long-ago society

Most of what we read about the Ancient Egyptians revolves around death, from their gruesome funeral rituals to their elaborate tales of the afterlife. In fact, this civilisation led very rich lives indeed. The River Nile provided fertile soil for crops and thick grasses for grazing animals, so the majority of the population were farmers. Other common professions included craftsmen like carpenters, weavers and jewellers, while people from wealthier families could go on to become scribes or priests.

In the time of the Old Kingdom, Egypt did not have a standing army; the pharaoh would simply call upon peasants when an army was needed to defend the country. But when Egypt was invaded by

Egyptian society

Like many kingdoms of the ancient world, Egyptians lived in a hierarchal society with a supreme ruler at the top; the pharaoh was considered by all to be a god on Earth. The pharaoh would decide on the laws of the land, collect the taxes and wage war. Below the pharaoh was the vizier – his chief advisor and sometimes also the high priest. Below him were the nobles, who were responsible for individual regions as well as other priests. Scribes were also well respected, as they were the only people who could read or write, and therefore the only people who could keep records of the Egyptian dynasty.



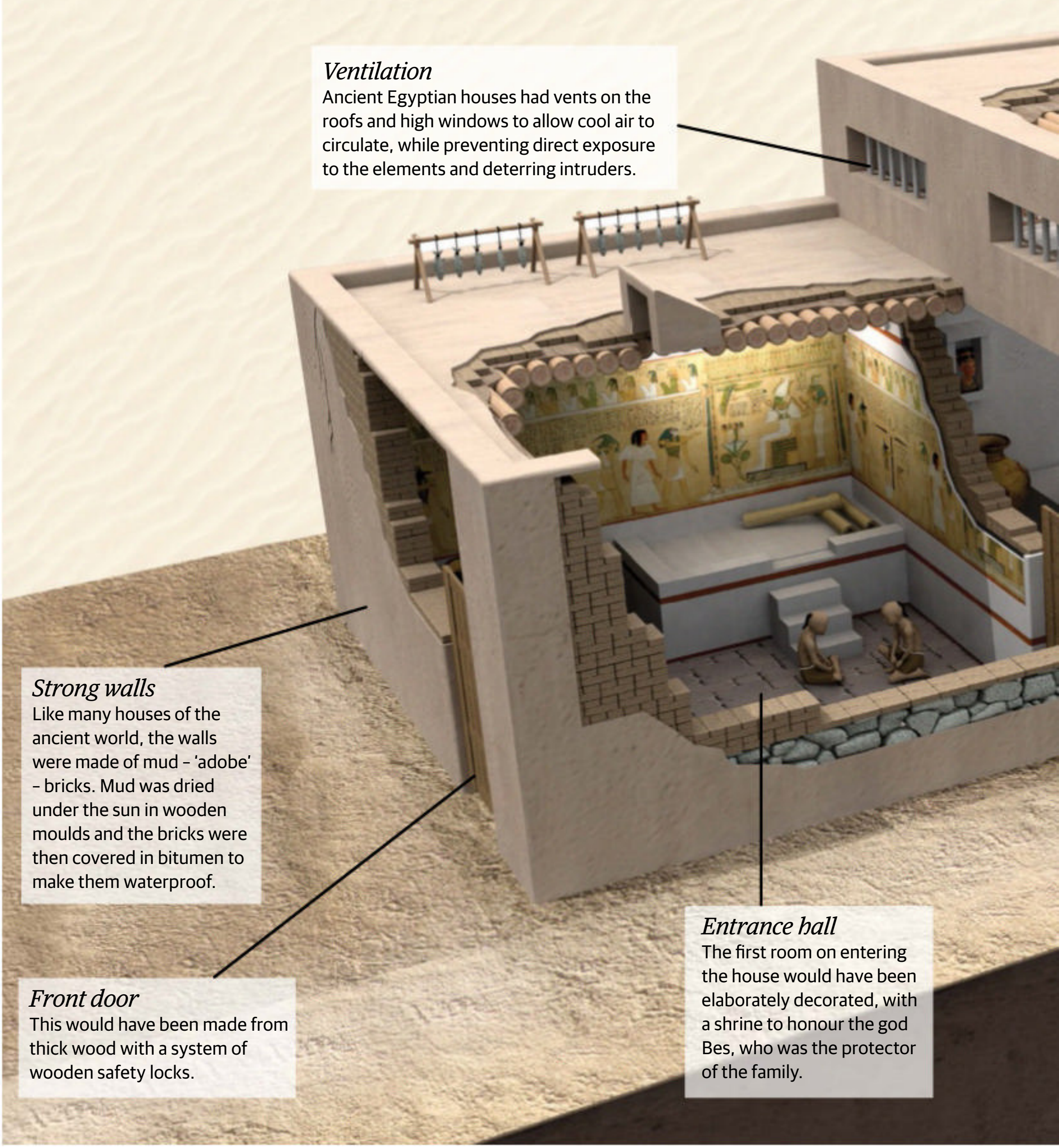
the Hyksos (a Canaanite tribe), it was decided that a permanent army of trained soldiers was needed. This was seen as a way for men to rise up through the rigid social hierarchy of the ancient kingdom. The river allowed transport and communication from one end of the kingdom to the other, helping to create a strong, unified nation and – most importantly – a strong, unified army.

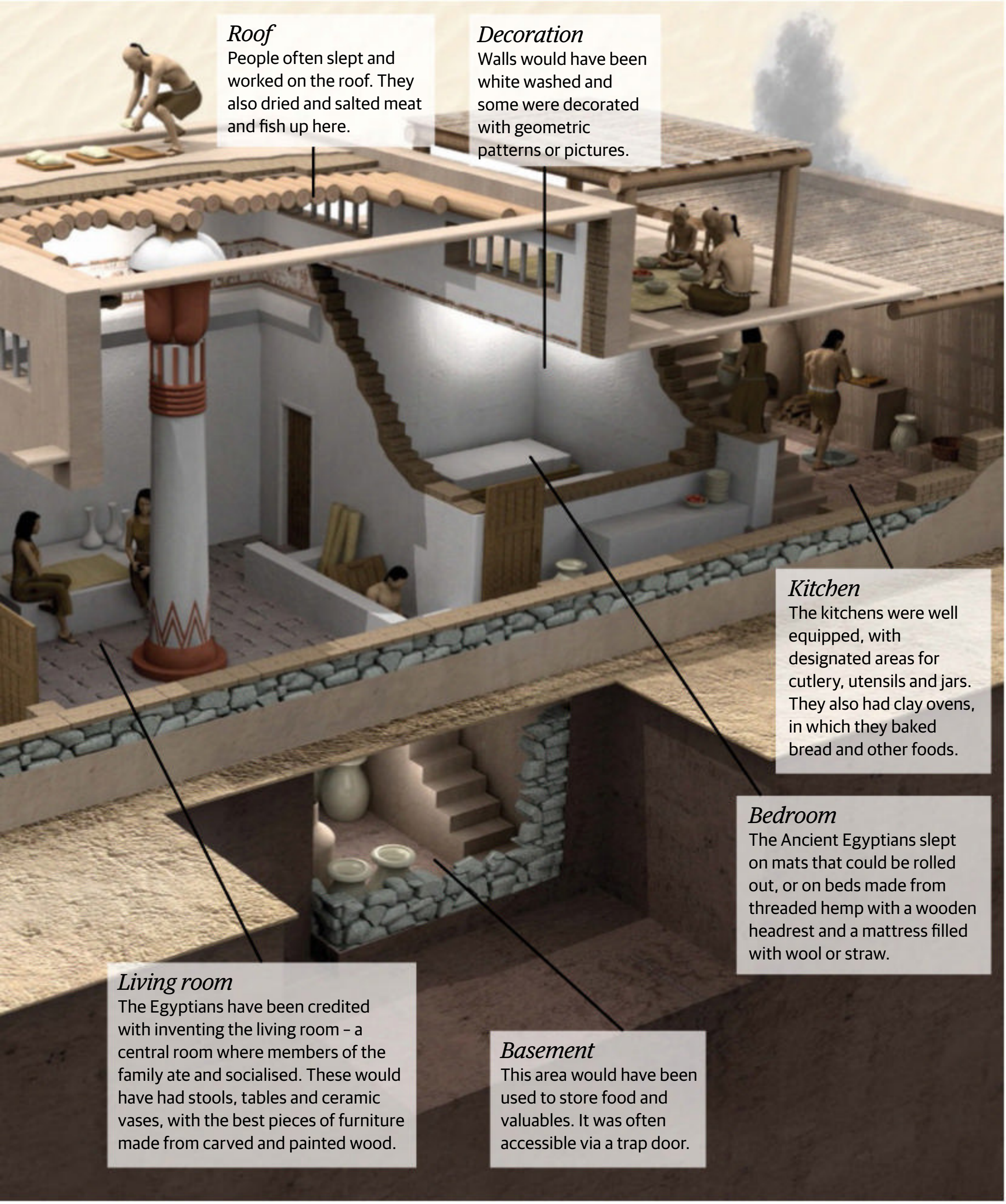
Egyptian boys from wealthy families attended school, where they studied religion, reading, writing and arithmetic, while poorer boys learnt their father's trade. Girls were educated at home or went to work before getting married at around the age of 12 – often to a man chosen by their parents. Though women were expected to obey their husbands, they could participate in business deals, own land and represent themselves in court. As well as looking after their children and the household, they were able to work on farms or be employed by the courts and temples as acrobats, dancers and musicians. Noblewomen could even become priestesses and government officials. The Egyptians valued family life, and uncles, aunts and grandparents would all live together under the same roof – often in the same room.

Below
Painting of various Egyptian workers from a tomb in Thebes, Egypt

Inside an Egyptian home

Extended families lived together in these mud-brick houses, often spending as much time on the roof as indoors




Roof
People often slept and worked on the roof. They also dried and salted meat and fish up here.
Decoration
Walls would have been white washed and some were decorated with geometric patterns or pictures.
Kitchen
The kitchens were well equipped, with designated areas for cutlery, utensils and jars. They also had clay ovens, in which they baked bread and other foods.
Bedroom
The Ancient Egyptians slept on mats that could be rolled out, or on beds made from threaded hemp with a wooden headrest and a mattress filled with wool or straw.
Living room
The Egyptians have been credited with inventing the living room – a central room where members of the family ate and socialised. These would have had stools, tables and ceramic vases, with the best pieces of furniture made from carved and painted wood.
Basement
This area would have been used to store food and valuables. It was often accessible via a trap door.

What is the history of the beard?

Beards have protected from the elements and prompted duels

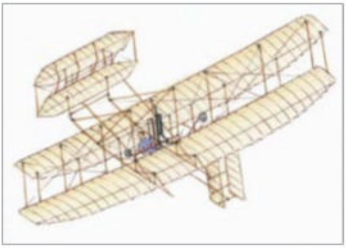
Beards are currently trendy, but their popularity has cycled. Prehistoric men are believed to have had thick beards for protection from both the elements and other men during fights. They also may have been an intimidation factor, as they made the jaw look bigger and more menacing. Beards have often been said to project a strong sense of masculinity, and a big beard was a sign of honour in ancient times. Cutting off one's beard was used as a punishment. Then things changed around the time of Alexander the Great, in the mid-300s BCE. He banned beards on his soldiers because he feared that enemies could use them to pull them in for attack. In the Middle Ages, it was considered highly offensive to touch another man's beard and could lead to a duel. In the 18th Century, beards fell out of favour, then returned during Victorian times. Beard wearing has had - and will continue to have - many different influences, including politicians, celebrities, religion and societal changes.

Right
Hans Langseth, pictured here in 1912, grew his beard to a record-setting 5.33 metres (17.5 feet) long

How powerful was the Flyer?

How many horsepower did the Wright Brothers' invention pack?

Below
The Flyer was the first successful aeroplane and produced 12 horsepower



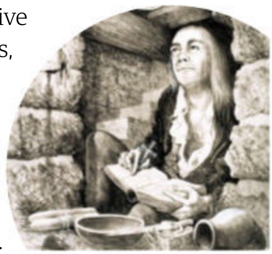
© DK Images

In December 1903, after years of studying, designing and inventing, American brothers Orville and Wilbur Wright finally invented and built the first successful aeroplane. Known as the Flyer, it had a simple motor without a fuel pump, carburettor, throttle or spark plugs. Yet astonishingly, it was capable of producing 12 horsepower. This was pretty impressive, considering their minimum requirement was only 8 horsepower. The first flight lasted 12 seconds and covered a distance of 37 metres (120 feet). The Flyer's water-cooled gasoline engine had four cylinders that were enclosed in a cast aluminium crankcase. It weighed less than 91kg (200lb) and powered two propellers.

What is a priest hole?

The story behind 16th-century hiding places

Priest holes were built into many Catholic houses during the 16th Century for hiding priests. Following the English reformation, Mary I reverted back to Catholicism, but Elizabeth I changed it back and began a ruthless programme of retribution against Catholics. Many people who didn't want to give up their faith built priest holes in their homes, in which Catholic priests could hide during raids by priest-hunters. Often cramped and uncomfortable, these priest-holes allowed Catholics to meet and pray in secret, as well as providing sanctuary to those bravely retained their faith against great persecution.



© Look and Learn

Right
If captured, priests during this period faced arrest, torture and even execution

How was plate armour made?

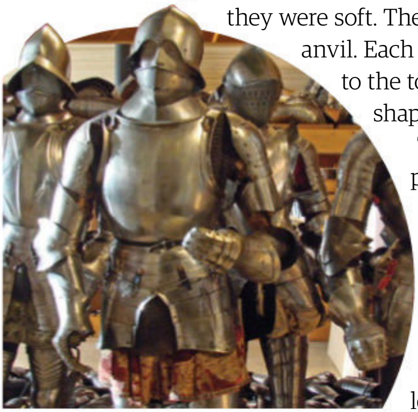
Plate armour changed the nature of Medieval warfare, but how was it created?

Although armour made from strips of metal had been worn as far back as Ancient Greece, the use of fully enclosed suits of plate armour began in the early-15th Century. Associated with European knights charging into battle on horseback, plate armour was worn by whoever could afford it - regardless of their status - as it could easily deflect sword and spear blows. Plate armour fell out of use in battle in the mid-17th Century as firearms became more powerful, but it continued to be worn for jousting.

Specialist armourers - not blacksmiths - made plate armour in workshops and many of the best could be found in southern Germany and northern Italy, close to where iron was mined. First, a hammer man - often an apprentice - would heat up iron bars in the forge until they were soft. Then the iron would be hammered into shape over an anvil. Each segment of the armour, from the tip of the helmet to the toe of the boot, had a different anvil in a different shape that worked as a cast.

The completed piece would then be given to a polisher, who would smooth it down to the correct thickness with a grinding stone powered by a water mill. The finisher was often the master armourer as this was the most complex job; he would then assemble all of the individual pieces. It would also be his job to add the padding that let it sit comfortably on the body, as well as the leather buckles that held it together.

Below *Medieval armour would have been carefully crafted by expert armourers*



Armour explained

The anatomy of a suit of 16th-century plate armour

Pauldron
In jousting suits, the plate protecting the shoulder and upper arm was cut away on one side for the lance to rest.

Doublet
A padded leather or cloth doublet was worn under the armour for extra protection and comfort.

Couter
A heavily armoured elbow joint, this one has 'wings' to protect the inner arm when it's braced while jousting.

Tasset
Protecting the upper leg was important on horseback, where the knight was exposed to upward blows from warriors on foot.

Poleyn
The armoured knee also has 'wings' that protect the back of the joint when the legs are braced in a riding position.

Cuirass
The cuirass rested on the hips, not on the shoulders, as the weight was too great to press down on the body for long.

Gauntlet
Effectively a metal glove, special jousting gauntlets were also available. These were more heavily armoured but fixed in position to hold a lance.

Broadsword
The traditional weapon of the Medieval knight in both battle and tournaments, the broadsword was used for slashing.

Sabaton
While sabatons of the 14th and 15th Centuries typically ended in a point, from the 16th Century they would start to be rounded in shape.

What is the mystery of Easter Island?

Who built the giant heads of Rapa Nui and why?

The most easterly island in Polynesia, approximately 3,700 kilometres (2,300 miles) west of South America in the Pacific Ocean, Easter Island could hardly be more remote. Yet it's home to some of the most incredible man-made wonders on Earth – over 887 carved stone heads, called moai, that has seen the entire 166.3-square-kilometre (64.2-square-mile) island, known as Rapa Nui by its population, designated as a UNESCO World Heritage Site.

The origin of these stern-faced monoliths – which average four metres (13 feet) tall and weigh an average of 14 tons – and the society that built them is largely a mystery. What is known is that settlers travelling on wooden outrigger canoes arrived on the island between the 4th and 13th Centuries and carved the moai sometime between the 10th and 16th Centuries from tuff – a light, porous volcanic rock – and placed them upon platforms called ahu. Some even wear 'hats' of red scoria, representing the topknot hair styles of the Rapa Nui people.

How were they moved?

With no evidence of wheels or cranes – and no large animals to do all the heavy pulling – archaeologists originally believed the moai may have been moved on sledges or wooden rollers as far as 18 kilometres (11 miles) from the quarry. A more recent theory is that the curved bases were designed for them to be 'rocked' and pulled forward by teams of workers with ropes. Damage to the base during experiments moving replica statues is consistent with flakes of rock found along roadsides on the island. The debate is still ongoing, but this theory may be the source of Rapa Nui folklore that recalls the statues being commanded to walk by the gods.

The eye sockets are believed to have held coral eyes with either black obsidian or red scoria pupils, while the bodies may have been carved with patterns that mimic the traditional tattoos of the Rapa Nui.

As for why they were carved, it may have been to honour important chieftains or warriors as some of them contained tombs in their ahu, or it may be to offer protection as with only a few exceptions they gaze over nearby villages. Ultimately it's impossible to know for certain. When Dutch explorers arrived on the island on Easter Day in 1722, the islanders who had created these breathtaking monuments had long since been divided by civil wars and many of its moai toppled, leaving only stories preserved in the oral histories of the Rapa Nui people and a forest of impassive stone heads breaking forth from the earth to stare out across the grass.

Below
There is much debate about how the moai were transported and erected

What were the first rugby balls like?

The grisly roots of the game, not suitable for vegetarians

Produced close to the school from which its name derives, the rugby ball was originally made from pigs' bladders, which is why they possess such an unconventional shape. In the 19th Century, shoemakers Richard Lindon and William Gilbert began making balls for the pupils at Rugby School by blowing up the bladders and encasing them in stitched leather. The bladders were even inflated manually, which would clearly have been a particularly unpleasant task.

In practical terms, because each pig came with a different-sized bladder, this meant the original rugby balls came in a variety of sizes. It was even later that the characteristic oval shape emerged.

It wasn't until 1845 that rugby rules, written by the pupils of the school, were established. By 1892, specifications for the ball were written into the game, stating that, among other things, it had to be hand-sewn with eight stitches per inch and have a weight of 368.5 grams (13 ounces).

Rules governing the weight and dimensions of modern balls remain strict and highly regulated.

Right
Originally, rugby balls were less oval and more rounded in their shape

Why is gold so valuable?

Not just staggeringly beautiful, gold is worth a mint

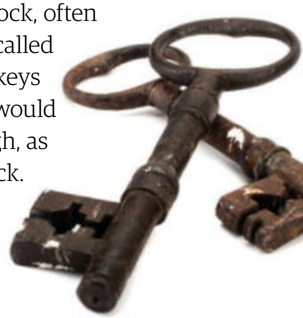
Below
Gold has been used as a currency by cultures across the globe

Gold has been prized throughout human history due to its scarcity, combined with a unique selection of properties that led to its use as a currency. Gold is rare, making up just five parts per billion of the Earth's crust, so only very limited quantities are mined every year, making it a stable currency. Gold is also remarkably unreactive and does not oxidise like silver or iron, so gold coins do not lose or gain weight over time. While other metals such as aluminium, platinum or silver look quite similar, gold is the only yellow metal, rendering it instantly recognisable. Gold's attractive appearance has also made it a popular material for jewellery and other adornments. Gold's malleability allows it to be moulded into different shapes and divided easily. Hence the cost!

Who invented the first keys?

Unlocking the secrets of keys throughout history

One of the earliest known examples of a lock system was used in Egypt 4,000 years ago, but the simple mechanism was essentially flawed as any key could open any lock. To solve this problem, the Romans developed the warded lock, often made of iron or bronze. Notches and grooves called wards were cut into the keyhole, so that only keys cut with corresponding notches and grooves would fit. They still weren't particularly secure though, as instruments could be fashioned to pick the lock. It wasn't until the 1800s that American Linus Yale and his son developed the spring-driven pin-tumbler lock commonly used today.



Right
The bronze and iron warded lock system was used throughout the Middle Ages

What were safety coffins?

How steps have been taken over time to avoid many people's worst nightmare

During the 19th Century, the inaccuracies of medical practices meant there was a real risk of a person being considered dead when they were not, leading to a premature burial. With techniques such as applying hot bread to the soles of feet and checking for a reaction used to determine death, it's not hard to imagine why.

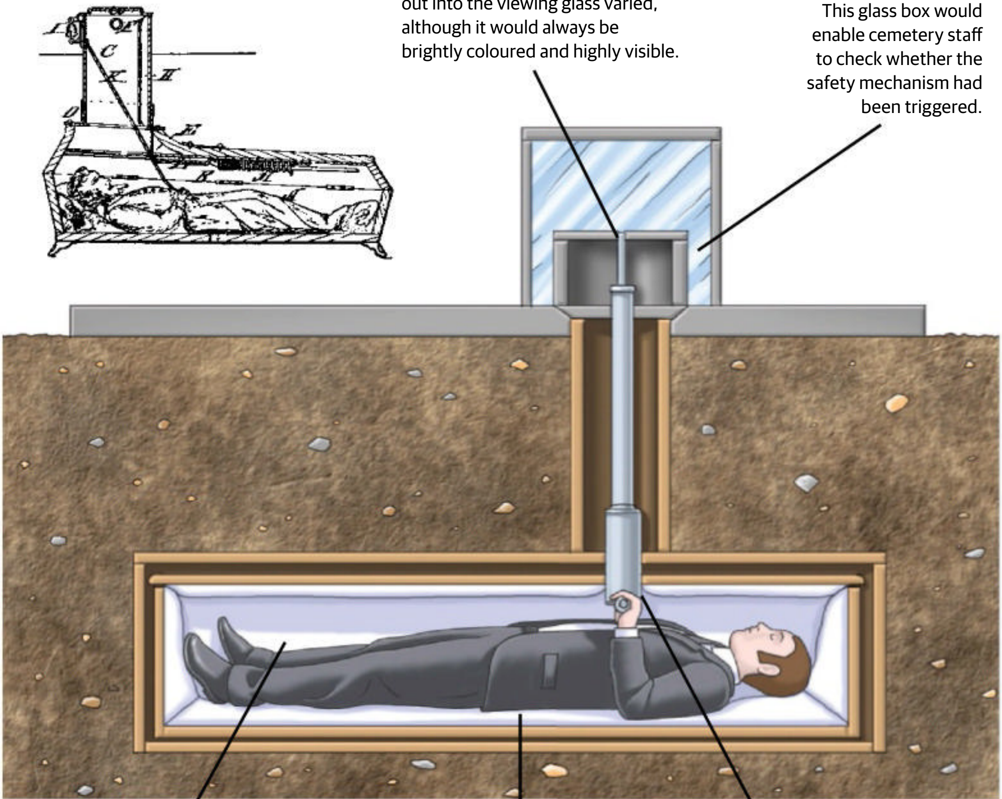
A number of systems were proposed to act as safety coffins. One German system worked using bells, which were attached to the buried person at the head, feet and hands by rope. Bizarrely, a spring-loaded ejector coffin was also proposed, though it was considered too shocking to suddenly see a buried body thrown from the ground into a cemetery.

Although modern medicine can now accurately say whether or not a person is dead, not everyone is convinced. As recently as 1995, Italian watchmaker Fabrizio Caselli built a casket fitted with a torch, an oxygen tank, a two-way microphone-speaker and a system to alert people above ground. Clearly the fear of premature burial is still alive and well.

Right
There are no recorded examples of a person being saved by a safety coffin

Opening the casket

Here's one design that aimed to let a prematurely buried person alert those above ground



Sign of life

The object that would be pushed out into the viewing glass varied, although it would always be brightly coloured and highly visible.

Viewing glass

This glass box would enable cemetery staff to check whether the safety mechanism had been triggered.

Fatal flaw

One major flaw of safety coffins was their lack of an oxygen supply; victims would have suffocated quickly after burial.

Effect of decomposition

Soon after death, the body bloats, which could trigger the safety coffin mechanism, falsely alerting people above ground.

Mechanism activation

To operate the device, the person in the coffin simply had to push the handle upward toward the surface.

Why was Magna Carta so important?

How this 800-year-old document shaped Britain into the nation it is today

It's a myth that Britain has never endured revolution. 800 years ago, on 15 June 1215, King John of England signed a document that was not only a revolution in paper, but the foundation for every uprising against the Crown that followed and the cornerstone of democracy in the English-speaking world. This document is Magna Carta.

Meaning 'the great charter' in Latin, Magna Carta was the first time the king's power – which many believed came straight from God – had been limited. Angered by the taxes levied by an unpopular king to fund an expensive and disastrous war against France, Magna Carta was mainly concerned with protecting the wealth and power of England's nobility. However, the 3,600-word contract contained three important clauses that would profoundly alter English society: it guaranteed a fair trial for everyone, removed the king's ability to issue

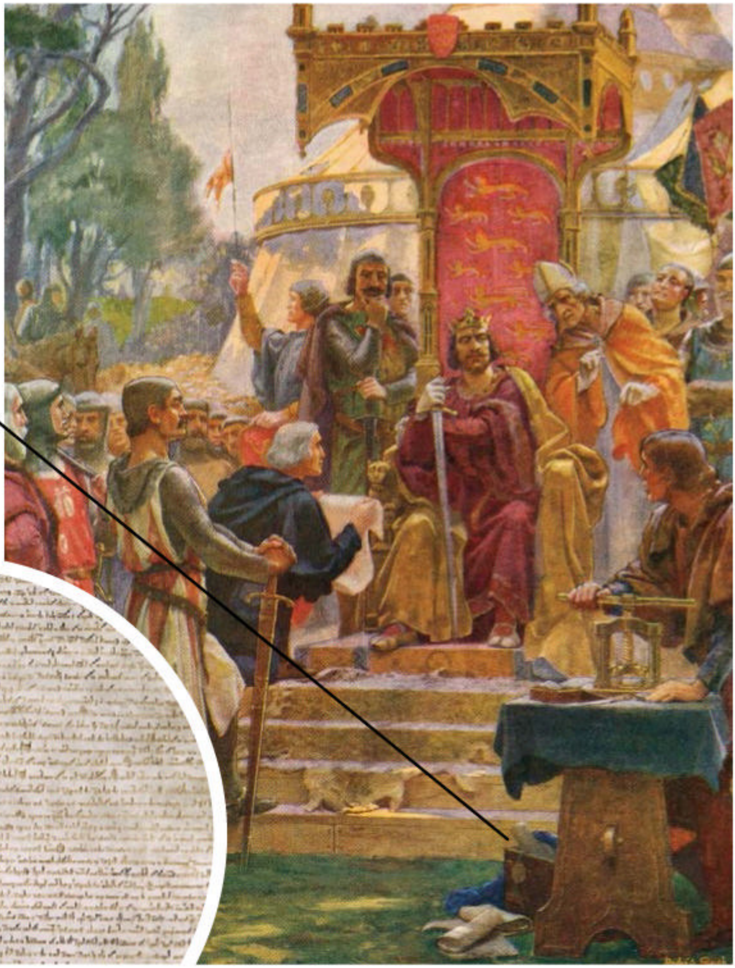
Below
US founding father Thomas Jefferson was directly influenced by Magna Carta

Magna Carta in North America

The rights of the free man against the tyranny of kings contained in Magna Carta didn't just give the American colonists cause to turn against George III and his unwanted taxation in the American Revolution; it inspired them to write their own. The 1776 Declaration of Independence and the 1789 Bill of Rights are influenced by Magna Carta and nine of the provisions of the latter are taken directly from Magna Carta. Thomas Jefferson, one of the Founding Fathers and the principal author of the Declaration, even owned a copy of English barrister Edward Coke's legal interpretation of Magna Carta, Institutes of the Lawes of England. Magna Carta was revised by later monarchs and a copy from 1297 is permanently held by the US National Archives, displayed alongside the two documents it inspired as the birth certificates of the United States of America.

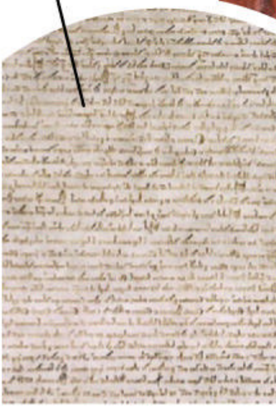
taxes at will and made it clear that if the monarch were to break the conditions of Magna Carta, he could be overthrown.

True to their word, when King John sneakily petitioned the Pope to overrule Magna Carta mere months after it had been signed, saying it conflicted with an earlier decree from the head of the church, the Barons went to war to protect their rights. This example would be followed time and time again to justify men standing up for their rights against the crown, most famously in the English Civil War and the American Revolution.



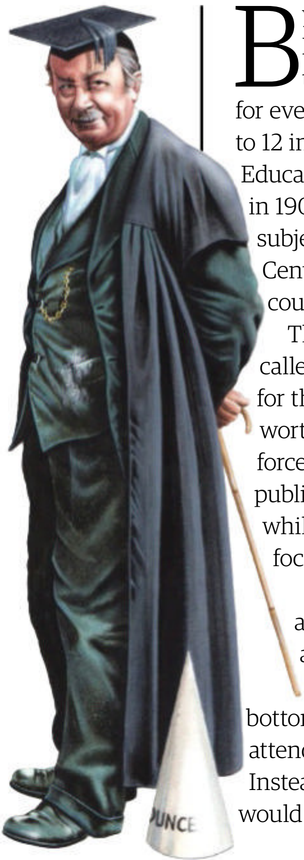
The king's seal
King John didn't 'sign' Magna Carta with his name, but with his royal seal, which was pressed into wax. Later versions of Magna Carta went on to be signed by different monarchs.

1215 edition
This is the one of the four surviving copies of the original Magna Carta issued in 1215. The charter was issued again in 1216, 1217, 1225 and 1297.



What was school like 100 years ago?

In Edwardian England all children went to school but that didn't mean things were fair



By the first decade of the 20th Century the lives of children in England and Wales had undergone serious change. In 1880 the Elementary Education Act had made school compulsory for every child aged between five and ten, with the leaving age rising to 12 in 1899. In 1902 – the year after Queen Victoria's death – the Education Act gave local councils control of schools and another act in 1904 decided that secondary schools should teach the same core subjects. However, things were far from equal; in the early-20th Century, the job your parents did and how much money they made could determine the type of education you received.

The upper classes sent their children to private schools (also called public schools) and succeeded in charged high fees in return for the guarantee that their children would receive an education worthy of high society. Some schools even had their own cadet force to prepare the boys for careers as army officers. Meanwhile, public schools for girls trained them to become well-to-do wives; while the boys would be playing rugby, their sisters would be focusing on how to become the perfect hostess.

Schools for the middle classes – the children of professionals and small businessmen – were similar, but the fees were lower and the school's reputation were rarely good enough to allow the pupils the luxury of attending the best universities. At the bottom of the pack, the children of the average working-class family attended free schools where going to university wasn't an option. Instead their education would impart them with practical skills that would prepare the boys for manual work and the girls for housework.

What is the secret of the Paris Catacombs?

Why were over 6 million people buried deep beneath the city?

During the late-18th Century, the people of Paris were running out of space in which to bury their dead. The Holy Innocents' Cemetery – the largest and oldest in the city – was bursting with corpses. In a bid to prevent further overcrowding, a radical solution was needed. Starting in 1786, corpses were gradually transferred into the labyrinthine tombs and antechambers some 20 metres (66 feet) under the capital. During the Reign of Terror, many 'enemies of the revolution' executed by guillotine were buried directly in the Catacombs.

The site was originally an underground quarry and the stone mined there was used to construct iconic Parisian buildings such as Notre Dame and the Louvre. The location's transformation into the macabre subterranean ossuary we see today even brought with it grim notices etched above doorframes: 'Arrête, c'est ici l'empire de la mort' ('Halt, this is the realm of death'). Mourners and intrigued tourists have visited the site since the early-19th Century, and human remains were regularly transferred there until 1859.

Below
The 'population' of the Paris Catacombs is more than of the living city above

What was it like on the Pullman train?

What made the Pullman railway carriage fit for a queen?

The first half of the 19th Century saw a rapid expansion in the rail network and train travel, with new companies and tracks springing up across the nation. This development occurred in the wake of Britain's first steam railway, which linked the growing industrial cities of Liverpool and Manchester, opening on 15 September 1830.

The Pullman Palace Car Company was established in 1862 in the United States. Although specialising in sleeper cars that turned out to be more popular in the US due to the greater distances travelled, they began exporting passenger coaches to Britain 1874. Far from being late to the party, Pullman quickly cornered the luxury market by providing excellent standards of comfort.

Appealing to the growing middle classes who had money to treat themselves, Pullman coaches offered leather seats, table lamps, dining cars, attentive stewards serving food and drink, and even heating and air conditioning. With the agreement of its American counterpart, a British company – the Pullman Car Company – formed in 1882 to produce similar carriages from a workshop in Brighton. The coaches and the service George Pullman's fleet offered endured into the 1960s and 1970s, when classic Pullman coaches began to be replaced by designs fit for the age of diesel power and regular commuter travel.

An instantly recognisable symbol of a lost era of elegance, Pullman coaches have been used by members of the royal family and are event known to have survived bomb damage suffered during the second world war.

Inside the coach

Discover how the Pullman carriage got its exemplary reputation

Engine

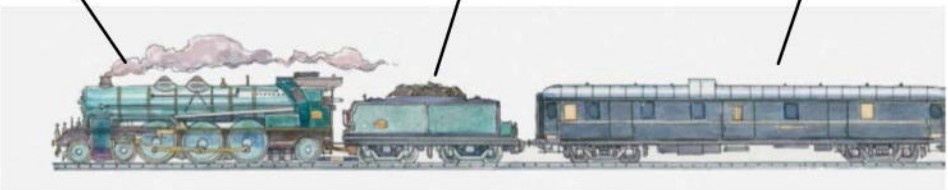
The steam train itself was essentially a large boiler that produced steam with enough force to power its wheels.

Coal car

The tender, or coal car, often contained not just coal for the steam engine, but water and wood too.

Luggage van

Luggage vans could carry either the passengers' belongings, or parcels and post for Royal Mail.



Livery

From 1906 the colour scheme of the Pullman Car Company was umber and cream, with "Pullman" written in gold.

Lavatory

Toilet windows on Pullman trains had been circular since 1906, but the design was phased out in 1951.

Coat of arms

The Pullman shield was always visible on the side of the company's iconic coaches.

Comfort

The fashionable art deco interior had electric table lamps, table clothes and upholstered seats.

Fine dining

The dining car was open to both Standard and First Class passengers, but First Class got first dibs.


101 Amazing FACTS
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What makes laughter contagious?
Why was Magna Carta important?
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