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coffee – disease

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coffee

▷ Coffee plants grow in most tropical parts of the world. The fruits, red berries about the size of cherries, are picked throughout the year. (Right) Each berry contains two beans. The husks of the berries are removed and the beans washed. Then they are laid out to dry in the open air and sun. The drying process may take two weeks. Here a Colombian man is turning the coffee so each bean will be thoroughly dried

Coffee is one of Britain's most popular beverages. It is made from the beans, or seeds, of the coffee plant. This is grown in most tropical areas of the world. Brazil is the leading producer of coffee.

There are several species of the coffee plant. The Arabian variety is the one which supplies the majority of the world's coffee. The Latin name for the Arabian coffee tree is *Coffea arabica*. It is an evergreen plant with waxy, pointed leaves. It will grow to a height of 10 metres (30 feet) or more, but it is usually cropped to a height of less than 3 metres, (10 feet) so that the fruit can be removed easily.

The trees are usually grown in rows in shady plantations. They produce small white fragrant flowers, which fall from the trees as the fruits develop. The trees produce flowers and fruits (which are called berries) for about eight months during the year. A coffee tree may live for 40 years or more. And each year, it may produced up to 3·5 kg (8 lb) of berries.

When ripe, the fruits or berries are bright red and about the size of cherries. Beneath the pulpy red skin of each berry, there are two seeds or beans. The beans are greyish-green and are surrounded by a thick, silvery skin and a parchment-like layer.

The berries are harvested usually once a year. The beans are removed from their shells. Then they are roasted and ground down. This brings out the characteristic flavour of coffee. How strong the coffee is depends on the roasting process. The longer the beans are roasted, the darker they will become and the stronger the flavour.

'Instant coffee' is made by drying liquid coffee so that it leaves a powder. In one method, the hot coffee is sprayed, and as each drop evaporates, a grain of coffee powder is left behind. In the 'freeze-drying' method, liquid coffee is frozen and put into a vacuum chamber. The frozen water turns straight into a gas on melting, and leaves solid coffee behind.

Coffee contains a compound called 'caffeine'. This compound is also found in tea, cocoa and cola drinks. Caffeine stimulates the central nervous system. In this way it makes people feel more alert by overcoming tiredness and muscle fatigue. Caffeine gives only a temporary relief from tiredness. It can also be helpful in treating some diseases.

But strictly speaking, coffee is 'addictive'. People who drink coffee regularly come to depend on it. And coffee has bad effects on the body if too much is drunk over the years. For example, some people may not be able to sleep, and feel restless and irritable. Too much caffeine in the body also causes high blood pressure and irritates stomach ulcers (see: *cocoa, drug*). It is possible to buy 'decaffeinated' coffee, with the caffeine removed, which avoids some of the ill effects, like sleeplessness.

Coffee was probably discovered and first used in Arabia at the beginning of the 13th century. From there, it was introduced to Europe and America in the 16th and the 17th centuries.

See: *food*.

cold

Every day we use the words 'hot' and 'cold' to describe things around us. We say that the Sun is hot and that ice cream is cold. We tend to think of hot and cold as being two separate and different qualities. But of course they are really not separate at all. They are just opposite ends of the same scale.

We say the Sun is hot because it contains a great deal of heat – and we can feel the heat being given out. It is tempting to think of cold in the same way. You might think that an ice cream contained a great deal of something called 'cold' – and that the 'cold' given out by it affected your lips and tongue as you ate the ice cream. But that is not true at all. Cold is simply the absence of heat. Ice cream contains less heat than your mouth. So as you eat it, the ice cream takes heat from your mouth and produces the sensation of coldness.

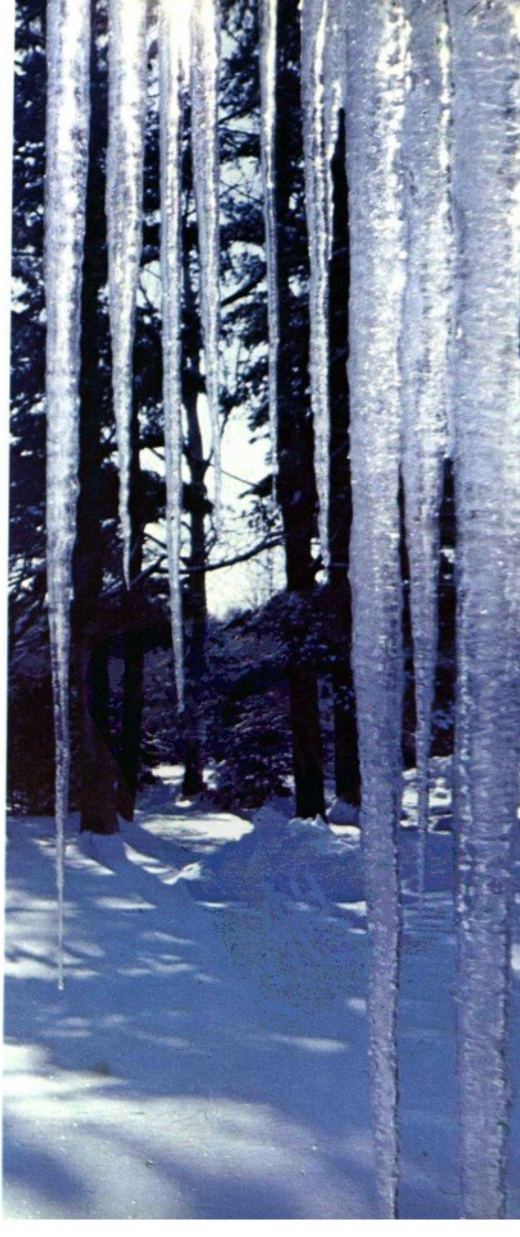
Hot and cold are not exact words. They are useful for comparing one thing with another, but it depends what things you are comparing. If you jump into a swimming pool, you might say that the water is cold. But compared with a glass of water taken from a refrigerator, the water in the swimming pool would be warm. To express how hot something is exactly, we have to use a temperature scale. Temperature is a measurement of hotness. The higher its temperature, the hotter a thing is, and the lower the temperature, the colder it is. Temperature is measured in degrees, by means of a thermometer.

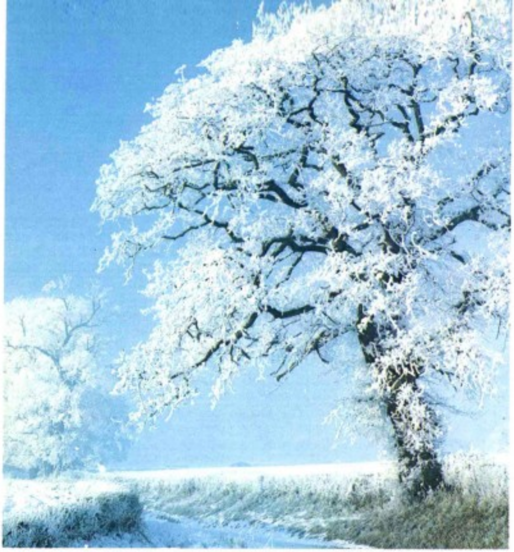
Temperature

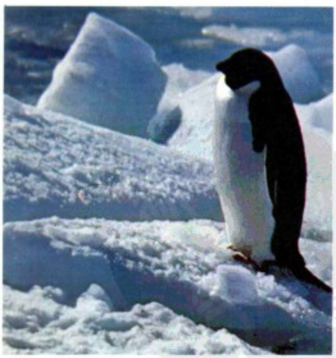
Temperature is not the same thing as heat, and it is important to understand the difference. Heat is one form of energy. The atoms that make up all substances are moving around all the time, although of course we cannot see them (see: *atom*). In gases the atoms are free to move around a great deal. In liquids they can also move a considerable amount, but in solids they cannot move so much. They can move only from side to side, or vibrate. The more heat energy a substance contains, the faster the atoms move around. If you put a pan of cold water on a hot stove, the energy from the electricity or gas passes into the water. The atoms in the water begin to move faster and faster the more heat energy they receive. The water becomes hotter and hotter, and its temperature rises.

The opposite happens if you put a pan of water in the freezing compartment of a refrigerator. Energy is taken from the atoms of water, and they move around less and less. Eventually they move around so little that the liquid turns into a solid – ice. While the atoms are slowing down like this, the temperature of the water is gradually falling.

Even in ice the atoms are moving to some extent. This means that although we think of ice as being cold, it still contains some heat energy. It is possible to imagine a state when all the atoms in a substance were perfectly still.







△ In midwinter the trees and grass are covered with snow. Plant life grinds almost to a halt, waiting for summer and warmth to make up for lost time.
◁ Water acquires special properties in extreme cold. It forms beautiful crystals and solidifies. It is one of the few substances that are less dense when solid (frozen), than liquid.
▷ Penguins are adapted to extreme cold and can cope with the Antarctic winter.
▽ Humans are not adapted to extreme cold and can suffer quite severely. Blood vessels shrink, reducing the blood flow. The vessels suffer from lack of blood and leak plasma to the surrounding tissue causing swelling. This is frostbite

constriction of blood vessels reduces blood flow

▽ blood flow poor and plasma leaks out of damaged vessels

▽ blood flow increased but still poor. Leaking plasma causes swelling

In this case they would have no heat energy at all, and they would have the lowest temperature possible. This temperature is called absolute zero. In fact it has been found that there is still some movement even at absolute zero.

Just as there are different scales by which we can measure distances, using inches and feet, or centimetres and metres, so there are different temperature scales. This can cause confusion, and it is very important to state what scale you are using when you write a temperature.

A scale commonly used is called the Celsius scale. On this system the temperature at which water freezes into ice is called zero, or 0°C (the sign ° means a degree, or unit of temperature). The temperature at which water boils into steam is 100°C. Anything colder than the freezing point of water is measured in minus degrees, for example -10°C or -50°C. This scale is now standard in Britain.

Another scale is called the Fahrenheit scale. On this scale water freezes at 32°F, and boils at 212°F.

We have already mentioned that absolute zero is the coldest temperature possible. This is zero on another special scale, called the Kelvin scale. Absolute zero can be written 0°K. On the Celsius scale this is about -273°C, and on the Fahrenheit scale -460°F.

Scientists have not yet managed to lower anything to a temperature of absolute zero, although they have come pretty close. It is hard to imagine what would happen if absolute zero were reached, because strange things happen to substances that are cooled, even a long way above that point.

Cooling a substance makes the atoms move less and less, and come closer together. So a gas turns into a liquid, and then into a solid. The gas carbon dioxide, for example, which we breathe out, becomes solid at a temperature of -78°C (-108°F) This is what we call dry ice.

Although temperatures in the Arctic and Antarctic do not drop so low that the gases in the air become solid, or even liquid, they do affect other things. Mercury, which is liquid at normal temperatures, becomes solid metal at -39°C (-38°F). So it is useless to use a thermometer containing mercury in these regions, where the temperature may fall to -40°C (-40°F) or even -45°C (-49°F) Alcohol must be used instead. This has a lower freezing point and still stays liquid inside the glass of the thermometer.

At very low temperatures, the resistance of metals to electric currents is reduced. The metals are said to become 'superconductive'. When mercury is cooled to near absolute zero an electric current will flow in it for weeks with no outside source of energy. Another strange thing happens to helium near absolute zero. It appears to defy gravity. At this temperature it is a liquid, not a gas. If the liquid is put in a glass, it flows up the sides and out over the rim by itself.

The study of the strange things that happen near absolute zero has become a branch of science in itself. It is called 'cryogenics', from the Greek words for 'ice-making.' Scientists working in cryogenics are hoping to develop a theory to explain the odd behaviour of substances at these low temperatures.

Cryogenics is of interest to physicists. But what of the more ordinary sort of cold – the low temperature that anyone might encounter? How does it affect our bodies?

Cold slows down the processes of life. It makes all the chemical reactions in our bodies go slower, so that, at a low enough temperature, they stop completely. Human beings are warm-blooded animals. This means that we are able to regulate the temperature of our bodies to keep ourselves not just comfortable, but working efficiently. The temperature at which the human body works most efficiently is about 37°C. Above this temperature the important chemicals in our body cells called enzymes (see: *enzyme*), that control the reactions going on inside, are destroyed. And below this temperature the enzymes are unable to work. So the body has means of reducing the loss of heat when the outside temperature drops, as well as means of increasing the loss of heat when the outside temperature rises.

One reaction to the cold is that the blood vessels in our skin tighten up. This means there is less blood flowing in an area where its heat could be lost into the air. One effect of the lessened blood supply is that the hairs on our skin stand on end, causing 'gooseflesh'.

Also, the way that we shiver in the cold is simply a defence mechanism. The very rapid quivering of the muscles makes them warm, and so the whole body is kept warm. Babies are unable to shiver until about the age of two, and this is one reason why they are very susceptible to the cold.

All these means of defence against cold, including the natural ones, such as shivering, and the artificial ones, such as clothing, are to prevent possible illness or death. The body cannot survive cold because all the chemical reactions inside it have to happen at a certain temperature. The blood is always a constant temperature, except in illness. So is the flesh of our bodies. In the cold, so much heat can be lost from the surface of the body that the temperature is no longer constant. Then, when our bodies cool down, all the chemical reactions are slowed down or changed. This is so unnatural that the body cannot survive it.

Mountaineers are accustomed to the problem of cold and they wear the right protective clothing. Most people in our cities and towns do so too, and they have their homes to go back to. The people in greatest danger from the cold are often the young and the old. Babies, as we have said, cannot easily survive even a slightly cold environment. They have very delicate and fragile bodies. Old people are also very delicate, and when they have no proper heating or clothing, their temperature can fall very low. Many old people die every year because of this, in Great Britain and in many other countries.

▷ When the human body is cooled below its normal functioning temperature its processes slow down. In this operation the patient is being treated for cancer with drugs that are harmful to normal tissue. At the reduced temperature the drugs do not get to the healthy tissue because the circulation is slowed. The drugs attack only the cancer cells.

▽ Freshly-harvested peas are quick-frozen in a refrigeration tunnel

Adaptation

People who live in very cold countries can adapt to the cold. Their bodies become accustomed to the low temperature, and are not so likely to be damaged by it. This is called adaptation to cold. It may be that people from warm countries can also adapt to the cold if they go to the Arctic for a long enough time. But the changes in their bodies are of far lesser importance than the artificial means of protection: fire, clothing and shelter. Indeed, the same is true even of people like the Eskimoes. Their bodies are more used to the cold, but it is really their skill with fur clothing and safe shelters that ensures their health and survival.

Animals, too, must live in the cold. The ones that survive best in cold climates do so because of their protective 'clothing'. The fur of a polar bear, and the feathers of birds, give good insulation against loss of heat from the body. Animals that live in warmer countries need fur too, although not so much.

Other animals cope with the problem in different ways. Those that hibernate, for example, are protected by their fur, but they keep their bodies only just 'ticking over', so that the food they have in the autumn lasts them until the spring.

Some more primitive species do not keep their temperature constant. It varies according to the weather. These, the cold-blooded animals, are able to survive the cold because their body's chemical reactions are not disastrously affected, as ours are. It may sound like a very useful thing to be cold-blooded, but in fact the complicated organization of the human body could never exist that way. A constant body temperature is

△ Oxygen cooled to -183°C (-297°F) becomes liquid. By cooling it further to -219°C (-362°F) with liquid hydrogen, bluish-white solid oxygen can be obtained. The liquid and solid states show quite different properties. For example, liquid oxygen is magnetic.

▷ At this army centre in Natick, Massachusetts, men test their ability to function while wearing cold weather clothing. They are running on treadmills against an artificial gale, in a temperature of -23°C (-9°F). Temperatures as low as -56°C (-69°F) have been endured in these experiments

Survival in extremely cold conditions for any warm-blooded animal is a continual battle to maintain body temperature. Animals which live in cold climates are specially adapted, with very thick fur and extra layers of fat beneath the skin. Fur traps air close to the skin which, once warm, stays warm, as air is a bad conductor of heat. Man has no special physical adaptations and survives by adapting his clothes and shelter. Clothes like fur-lined parkas that take advantage of the natural heat-conserving properties of fur are light and unrestricting. Mirror sunglasses protect against the glare of the sun reflected off snow.

one of the factors that makes advanced life possible.

Some of the very lowest and most primitive forms of animal life, including germs and the tiny one-celled protozoa that live in ponds, can survive cold spells by changing almost completely. Bacteria, plants, and fungi – all these have ways of altering themselves to a very hardy form which will stay just barely alive through the crisis. Some form spores, tiny specks that are wafted on the wind until they land somewhere warmer. Plants 'die', or appear to die, leaving all the life in their underground bulbs or seeds, ready to grow again later.

As we have seen, nature has come to terms with the cold. It is not so cold anywhere on this planet that nothing can survive.

Refrigeration

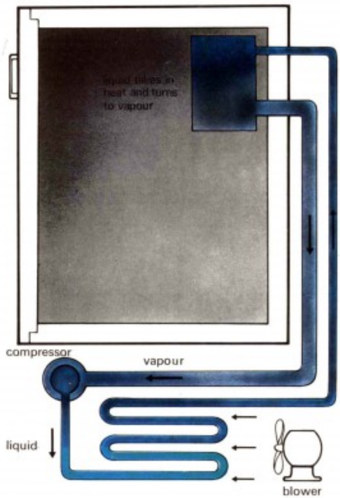
Man has been very ingenious with cold. Besides protecting himself from it, he has harnessed it for his own purposes. An obvious example is the refrigerator. At low temperatures, as we have mentioned, the processes of life slow down. This means that the tiny organisms responsible for making food decay are slowed down. So food keeps better, and stays fresh, when frozen. The bacteria cannot get to work to spoil the food. Refrigeration has made possible the storage of food for long periods and its transportation over long distances. (See: *refrigerator*.)

Cold has uses in surgery, too. When the body is cooled, its chemical reactions are slowed down. Less oxygen is needed by the cells, so that it is possible to interrupt the circulation of the blood without dangerously affecting the body. Deliberately cooling a patient's body – 'hypothermia' – has made possible many surgical operations, particularly on the heart, that would otherwise have been too dangerous to undertake.

The surgical instrument called a 'cryoprobe' uses extreme cold to destroy diseased tissue. It is a fine tube of metal, with a bulb at the end that can be cooled with a refrigerating gas expanding from an even finer tube within. The cryoprobe is sometimes used in eye surgery, to remove a diseased lens of the eye. The lens comes away cleanly, frozen to the tip of the cryoprobe, without breaking, as might otherwise happen. The instrument can also be used to freeze and destroy tiny areas of diseased tissue deep in the brain, without harming the surrounding healthy tissue.

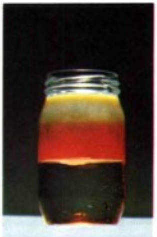
It is perhaps rather strange that although cold is not a 'thing', but an absence of something – heat – we can talk about it. We can talk about protecting ourselves from it, and we can talk about using it in various ways to our advantage. The old saying goes: 'Fire makes a good servant but a bad master.' This means that as long as we are in charge of it, it can be very useful. If it gets out of control, it can be one of our worst enemies. Exactly the same thing could be said about cold.

See: *energy*, *heat*.

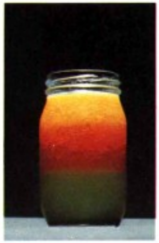


◁ It is useful to be able to keep food cool if not frozen. Liquids that vaporize at low temperatures are used in domestic refrigerators to do this. When the liquid vaporizes it takes heat from the surroundings. It is then recompressed, liquefied and recirculated.
▽ Rangers on patrol in Alaska. They have special training and equipment for survival in conditions of extreme cold. They also have a heated tent to come home to

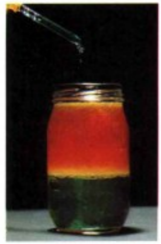
colloid



Oil and water do not mix well. In fact they tend to separate, the oil floating on the water



Even if the jar is shaken the result is not a colloid: droplets of oil will rise and water sink



Drops of detergent are added. Each detergent molecule attracts a water molecule and one of oil

Eventually all the water and oil molecules are equally distributed in colloidal suspension

Colloids are familiar to all of us. We walk through the fog, eat jellied foods and drink homogenized milk. These are all colloids.

A colloid is a system in which particles of a certain size are dispersed in a gas, liquid or solid. To be colloidal, a particle must be so small that it stays suspended. It does not fall to the bottom, as mud does in standing water, nor rise to the top as cream does in milk. Yet it must not be so small that it dissolves.

Atoms and most molecules dissolve in liquids to form a solution. Colloidal particles disperse to form a 'colloidal system'. Most colloidal particles are groups of molecules. They are too small to see with an ordinary microscope, but can be seen with the electron microscope. Their size is between about 0.001 and 0.1 microns. (One micron is one thousandth of a millimetre.)

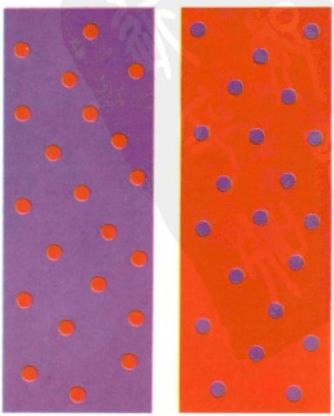
There are several types of colloids. Tiny droplets of water dispersed in air form mist, fog or clouds. Aerosol sprays are also droplets of liquid in a gas. Solid particles dispersed in gas produce a smoke. Foam rubber is gas dispersed in a solid. Gas in a liquid is familiar to us in shaving foam or whipped cream.

Emulsions are a common form of colloid. They may be droplets of oil dispersed in water, or of water dispersed in oil. Milk, margarine, mayonnaise and cosmetic creams and lotions are emulsions.

Particles of gelatin suspended in water form an interesting colloidal system. It becomes liquid when it is heated and solidifies when it cools. The liquid state is called a sol, and the solid state is called a gel or jelly. As gelatin cools, the particles form a framework. Water molecules become trapped in the spaces within the structure. This makes the resulting jelly solid, yet 'wobbly'.

One interesting property of sols is Brownian motion. The particles are constantly bombarded by the molecules of the medium they are suspended in. They bounce off to collide with another molecule. This gives them a constant random motion visible through a microscope.

The most important aspect of colloidal particles is their huge surface area in relation to their volume. If an object is cut into small pieces its volume does not change. But at each cut it acquires a new surface area. So the tiny colloidal particles have an immense surface area compared to their volume. Chemical reactions take place on these surfaces. The great number of chemical reactions that occur in the cells of living things are possible only because of the small size and large surface area of the colloidal particles within them.



Gelatin (orange) and water (purple) form a colloid. This has two forms: a sol when heated and a gel when cool. Hot, the colloidal particles of gelatin attract water molecules and stay in suspension. As the liquid cools these particles form a lattice-work that traps the water molecules. The gel is solid, yet wobbly. It may be as much as 90 per cent water

Find out by doing

To understand how the surface area of an object increases as its size decreases, place eight sugar lumps together to make a cube. Count how many of their surfaces are exposed. There are 24. Now separate them and count the exposed surfaces. There are 48. Yet the volume, the amount of sugar in the cubes, is the same. If a sugar cube one centimetre on a side were divided into colloidal-sized particles, their combined surface area would cover about 6,000 square metres.

colour vision

▷ Our eyes see different wavelengths of light as different colours. All visible wavelengths together look white. A glass prism splits up white light into all the colours of the rainbow

We say an animal has colour vision if it can distinguish between different colours. But some animals and a very few people can see only shades of darkness and brightness. They see the world like a black and white movie. They are completely colourblind. We also call a person colourblind if he or she does not see all the colours that a normal person can.

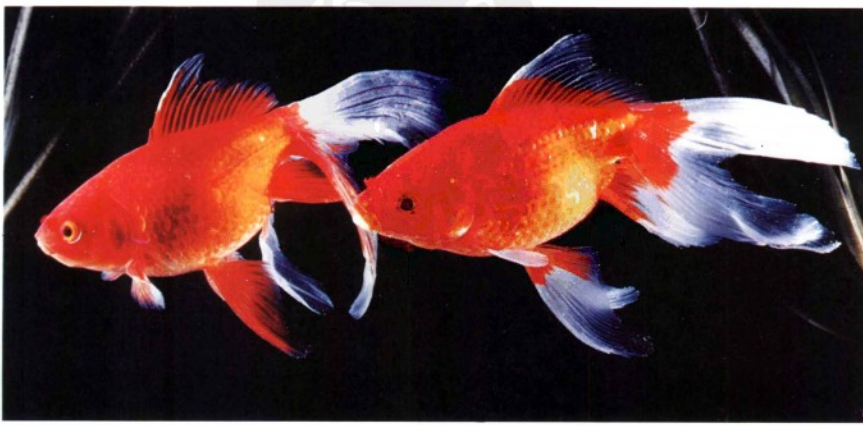
We can compare the eye with a camera. Light enters the camera via a lens which focuses a picture on the film behind the lens. Films that are coated with chemicals that respond to different colours can be processed to give a colour photo. In the eye, the light passes through the lens to make a picture on the back of the eyeball. The back of the eyeball is covered with a layer of nerve cells called the retina. They respond to light and send messages to the brain. From these messages the brain builds up a picture of the scene that the eye is looking at.

The nerve cells which make a colour picture are called 'cones', from their shape. The cones work only in bright light. Other nerve cells in the retina are specially sensitive to dim light. They are called 'rods'. But they cannot detect colours, so we cannot see colours in very dim light. Unless the moon is very bright at night, you cannot even tell that grass is green. It just looks grey.

If we go suddenly into a darkened room we cannot see anything for a minute or so. But soon, when our eyes become used to the darkness, we can recognize things around us. We see better in a bad light if we look sideways than if we peer ahead. This is because the sensitive rods are arranged at the edge of the retina. Light falls on them from the edges of the scene that the eye is seeing.

Different animals have different arrangements of cones. Some have only rods. Nocturnal

▽ Not all animals have colour vision and some only see certain colours. Goldfish have a highly developed sense of gold colour which helps them find other goldfish

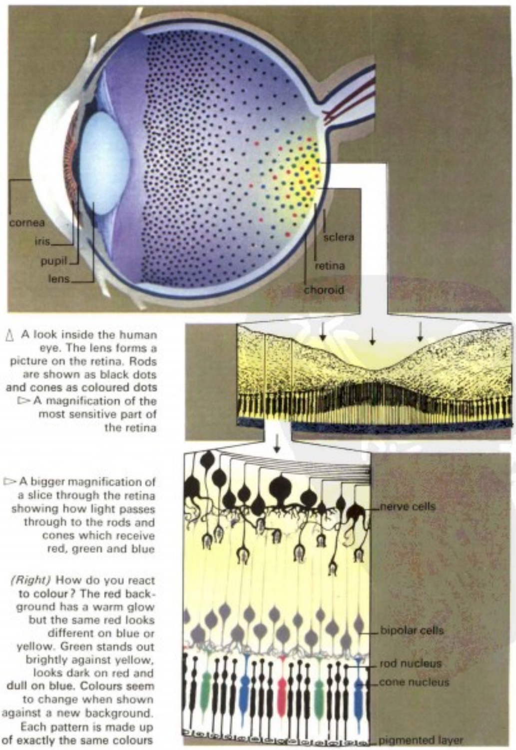


Colours as seen by three people: *1*) normal vision *2*) colourblind to red *3*) colourblind to green and unable to tell red from yellow

animals, like bats and owls, usually have very good night vision but poor colour vision. This is because they have very few cones. Bats have no cones at all.

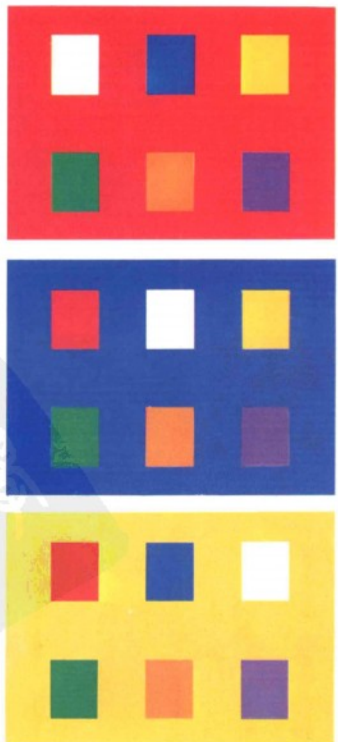
Light has different 'wavelengths'. Your radio receives different radio stations on different wavelengths. We see different wavelengths of light as different colours. No-one yet knows exactly how the human eye sees different colours but we believe that we have three different kinds of cone. Each kind of cone is switched on by different wave bands. A wave band is a group of wavelengths. You know about the wave bands of a radio. Some radios receive many different wave-bands: long wave, medium wave and several short wave. The human eye receives on three different wave bands. But it receives light waves, not radio waves. One kind of cone is switched on by the long wave band. We see this as red light. The second kind of cone is switched on by the medium wave band of light, which we see as green. The other kind of cone is switched on by the short wave band of light, which we see as blue. But, unlike the radio, the eye can receive all the wave bands at once.

When all the cones are 'switched on', we see the colour white. Daylight consists of all the



△ A look inside the human eye. The lens forms a picture on the retina. Rods are shown as black dots and cones as coloured dots ▷ A magnification of the most sensitive part of the retina

▷ A bigger magnification of a slice through the retina showing how light passes through to the rods and cones which receive red, green and blue



(Right) How do you react to colour? The red background has a warm glow but the same red looks different on blue or yellow. Green stands out brightly against yellow, looks dark on red and dull on blue. Colours seem to change when shown against a new background. Each pattern is made up of exactly the same colours

wavelengths of visible light. When we look at clean snow our eyes receive all the wavelengths of visible light and so the snow looks white. Soot looks black because it absorbs light as a sponge absorbs water. Complete darkness – the complete absence of light – looks black to the eye. Neither rods nor cones are absorbing light. Soot absorbs all the visible wavelengths of light.

By mixing light of any three colours we can make any other colour we choose. Usually red, blue and green light are taken as the starting colours, or 'primary' colours. But many other sets of three colours could be used.

Colour TV pictures rely on this effect. They are built up of red, green and blue dots. The brightness of each dot is varied so that, viewed from a distance, the right colours are seen at each part of the screen.

It is possible to have only two kinds of cone switched on at once. Yellow light switches on both the 'red' cones and the 'green' cones. But of course they can also be switched on separately by red light and green light. So, if we shine a beam of green light and a beam of red light on a piece of white paper it will look yellow where the beams overlap. If we shine a red and a blue light together the result is purple.

You cannot ask an animal what colours it can see, but it is possible to find out. Bees have very good colour vision. In some countries the beehives have different coloured entrances so that the bees know where to go home with their honey. If bees did not have colour vision they would not be able to tell the difference between entrances.

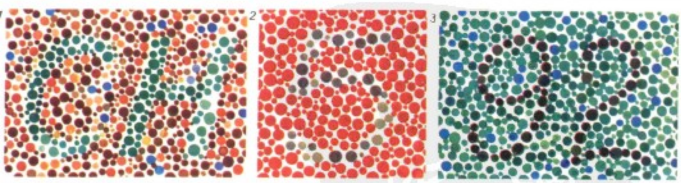
The Ishihara colour cards are tests for colour-blindness. Each card is covered in dots in different colours and different shades. A person with normal colour vision sees the figures picked out in colour. A colourblind person does not see these figures. Instead he will pick out another pattern.

Colourblindness can be caused by illness or it can be present from birth. (See: *heredity*.) Inability to tell red from green is the usual trouble. People with no colour vision at all are very rare.

See: *absorption of light, eye, light, paints and pigments*.

Find out by doing

Cut some small squares of different coloured shiny papers. Mix them up and pick one out with your eyes closed. Hold up the paper with your arm stretched out at your side. Open your eyes and keep looking straight ahead. Now swing your arm around slowly. You can see the paper from the corner of your eye. At first it looks grey but as you move it in front there comes a point when you see its colour. You will find this position is different for different colours. Which colour do you see first, red or blue? In what order do the colours become visible, starting from the side?



◁ Ishihara colour cards. *1*) A person with poor colour vision might see 31 instead of CH because he sees the dots as gray. *2*) A test for red-green colour blindness. *3*) 92 is invisible to someone with blue-yellow colourblindness

▽ Colour matching tests for colourblindness

comet

Every few years a comet makes a spectacular appearance in the night sky. It is first visible as a faint point of light, looking like a star. But over several nights it moves slowly against the background of true stars. At this point it is in the depths of space, far from the sun. It approaches the sun, growing brighter and larger as a fuzzy ball of gas appears round it. Then it grows a tail. The tail may be huge, longer than the distance from the Earth to the Sun. To the naked eye it looks like a milky-white streamer, possibly stretching across a large part of the sky.

Then the comet swings past the Sun and slowly disappears back into space, perhaps vanishing far beyond the orbit of the furthest planet, Pluto. In the past, comets were feared for they were thought to be signs of plagues, famines or wars to come.

Though comets are the largest objects in the solar system when their tails are fully developed, they are among the smallest in weight. A comet cannot be seen when it passes between the Earth and the Sun. The tail is too thin, and the solid head, or nucleus, is too small.

The nucleus consists of a few pieces of loosely-packed stony material, each perhaps a kilometre across. Dust and frozen gases from space are mixed in with these. When the comet approaches the Sun, the frozen particles are turned back into gas by the warmth of sunlight. The halo that is formed is called the coma, meaning hair. It might be several times the size of the Earth.

As the comet travels further into the solar system the intense light of the Sun knocks electrons out of the atoms of gases in the coma. The atoms are then electrically charged, and are called ions (see: *ion*). They are then acted on by the 'solar wind'. The solar wind is a stream of ions constantly flowing away from the Sun. They drag the ions of a comet's coma away from the nucleus to form a tail.

The direction of the tail is always approximately away from the Sun. So when it first appears, it trails behind the nucleus. As the comet passes the Sun at its closest approach, it seems to be going sideways. And as the comet moves away from the Sun, the tail seems to lead.

Through a telescope, the direction of the tail can be seen to change slightly from hour to hour. This is because the direction of the solar wind changes slightly.

Other tails can be formed. There is some dust in the coma, and sunlight can push it out to form a tail. (Everything receives a push when light falls on it, but the push is very small. Only particles the size of dust can be made to move under the pressure of sunlight.) The dust drifts away from the comet's nucleus slowly, and is pulled into a curved shape by the motion of the comet. The ions of gas travel faster and form a straighter tail. The gas tail shines mainly by its own light, which is bluish. The dust tail shines by reflecting the white light of the Sun.

Every time a comet passes the Sun it loses some of its matter. The gases that make up the tail and coma are lost, and the solids in the nucleus break down slightly forming dust.

Two comets photographed in the night sky. *(Above left)* Humason's Comet. The stars appear as streaks because the camera has tracked, or moved to follow the comet. *(Above)* Comet Ikeya-Sek[i] photographed in 1965 from California. It shone very brightly for a few nights

After many returns, there is nothing left of the comet but a swarm of dust which spreads out along its orbit.

If the Earth's path passes through the dust cloud some of the dust will be swept into our atmosphere regularly every year, forming a shower of shooting stars or meteors (see: *meteor*). It is possible that all meteor swarms are the remains of comets that 'wore out'.

Though thousands of comets have been observed, less than 200 are known to make regular returns to the Sun. These all have short periods (the period of the comet is the time between returns). The shortest period known is just over three years. This belongs to Encke's comet, which comes within the orbit of Mercury. Most of the short-period comets have periods of less than ten years. At their furthest from the Sun, they are usually as far away as Jupiter, the largest planet. It is very likely that all the short period comets once had larger orbits. They were disturbed by Jupiter's strong gravity and moved into the orbits we see now.

The most famous of all comets is Halley's. It was the first comet whose orbit was worked out. Halley made the calculations in 1704. He found that the path of a comet seen in 1682 was the same as the paths of comets seen in 1607 and 1531. He realized that one comet was returning every 75 years or so. The time was never quite the same because its motion was disturbed by the planets.

Halley predicted that the comet would return in about 1758. He did not live to see it, but it came back in 1759. It has been seen regularly ever since, and will next appear about 1986.

The comets which have periods of more than 200 years travel far beyond the solar system. Astronomers cannot even be sure that such a comet will return. Comets of this type sometimes 'graze' the Sun – that is, they pass within 65,000 kilometres of its surface. They can be extremely bright, but a lot of gas and dust will be driven into space from the comet. If any short period sun-grazers ever existed, they would soon have been worn out.

Comets are named after their discoverers, and are given a code number. Comet Mrkos 1957*d* was discovered by Mrkos in 1957. The letter *d* indicates that it was the fourth comet to be discovered that year. Later, when the orbit has been fully worked out, a different number is given to the comet. This one tells the astronomer when the comet passed closest to the Sun. Comet Morehouse 1908 III was the third comet to reach its nearest point to the Sun in 1908.

Many amateur astronomers search for comets. They use telescopes or binoculars with low magnification so that the area of sky they can study is not too small. When a new point of light appears among the countless stars they can see, they must notice it. This means that they must have a good memory for patterns of stars much fainter and more numerous than the ones we can see with the naked eye.

See: *astronomy*, *planet*.

△ An 18th century drawing of a shower of meteors seen off Cape Florida. These 'shooting stars' are dust particles from a comet being burned up as they enter our atmosphere

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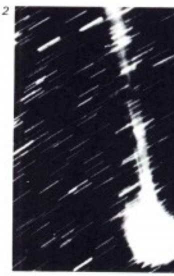

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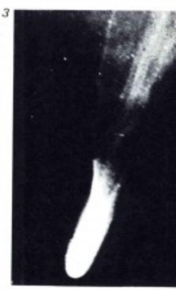
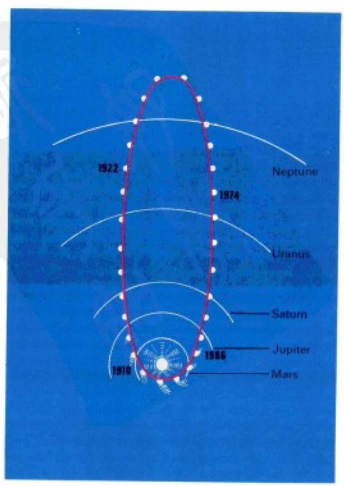


1) Bennett's Comet, seen in 1970, will not be seen again for centuries.
2) Burnham 1960.II. Its tail wagged like a dog's.
3) Halley's Comet, next expected about 1986



◁ The orbit of Halley's Comet carries it way past Neptune where we cannot see it. When it is near the Sun the solar wind blows a tail of ions away from the comet. Last seen in 1910 it appears about every 75 years. This time is called the period of the comet. Some material is lost each time it approaches the Sun