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How's Steel made?

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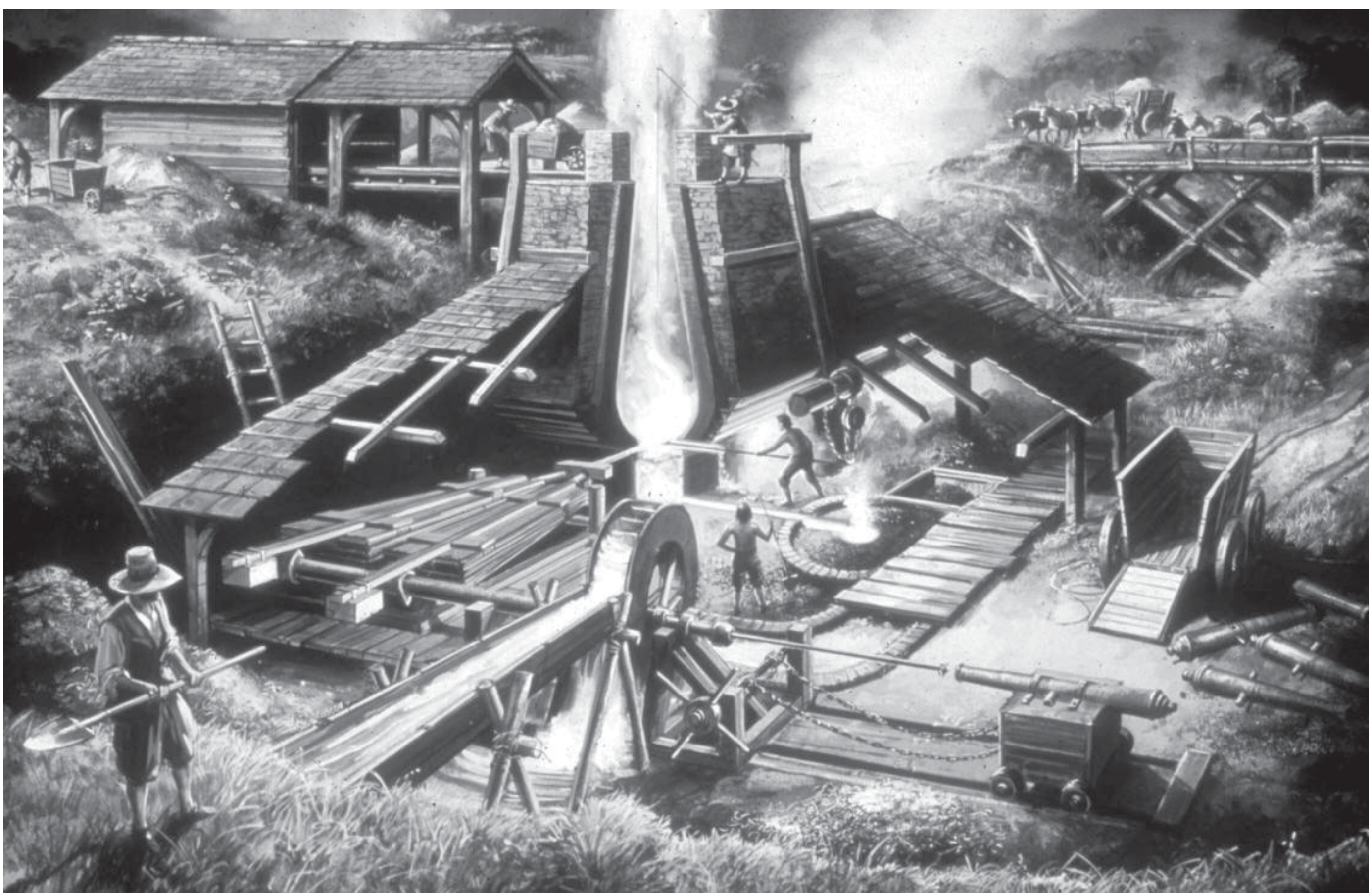
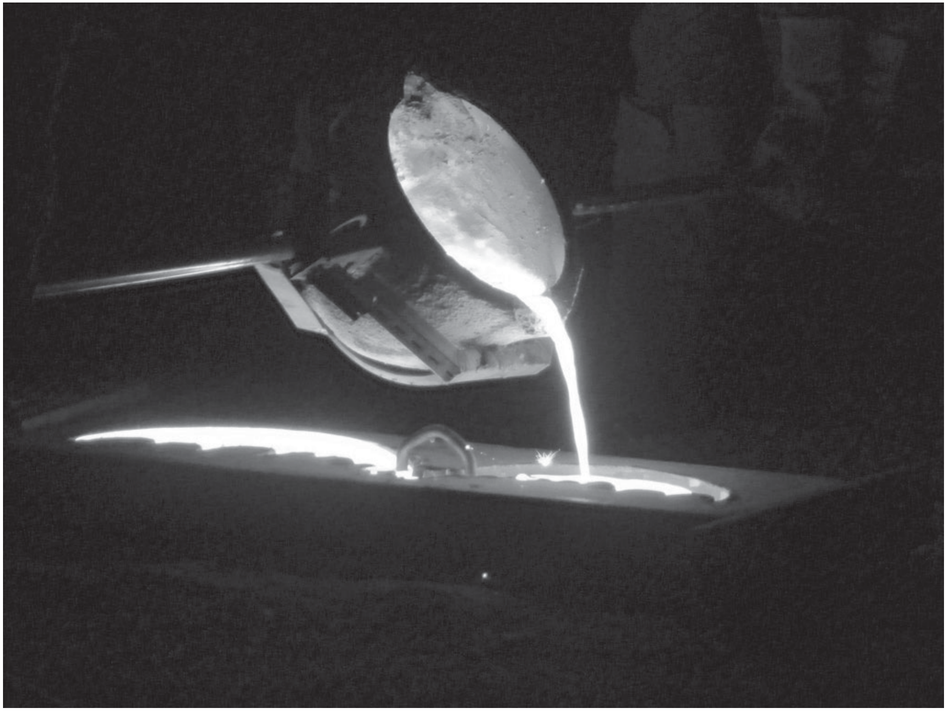
Iron is the most used of all the metals, comprising 95% of all the metal tonnage produced worldwide. Pure iron is not a good engineering material. It lacks sufficient strength as well as resistance to rusting. However, its properties can be significantly altered by alloying, thermal, and mechanical processing. Steel is the best known alloy (a mixture containing two or more metallic elements or metallic and nonmetallic elements usually fused together or dissolving into each other when molten) of iron. Its combination of low cost and high strength make it indispensable, especially in applications like automobiles, the hulls of large ships, structural components for buildings, and household appliances. Annual production and consumption of steel is often taken as a reliable indicator of economic performance of a country.

Raw materials for ironmaking

Iron, like most metals, is not found in the Earth's crust in a native stae but as an ore (a metal containing mineral valuable enough to be mined). There are many type of iron ores, but the most common ones are hematite (Fe_2O_3) and the magnetite (Fe_3O_4). Iron ore suitable for ironmaking (note that this is one word) contains about





65% iron, rest is impurities (known as gangue) such as alumina ($A1_2O_3$) and silica (SiO_2). In India we have both hematite and magnetite deposits. These days iron ore is mostly converted to sinter (a porous cake of powdered ore) for more efficient use in ironmaking.

In order to extract iron from the ore we must remove oxygen from it using a suitable reactant. Such reactions are known as reduction reactions. In ironmaking, carbon is such a reactant that can combine with oxygen of the ore. That way it acts as a reducing agent. An abundant source of carbon in the natural form is coal (a fossil fuel consisting of carbonised organic matter). Not all types of coal are suitable for ironmaking. The type of coal suitable for ironmaking is known as coking coal or metallurgical coal. Coking coal after washing is heated to about 1000^0C in absence of air in coke ovens. In the process, coal is converted to a porous substance rich in carbon (about 80%) known as coke. Compared to coal, it has high strength, high porosity, low ash, and low volatile matter. These qualities are very desirable for ironmaking.

In addition to iron ore and coke, we also need certain amount of flux for ironmaking. Function of flux is to aid slag formation by combining with gangue (molten impurities, mostly oxides and silicates) and ash. Limestone ($CaCO_3$) and dolomite ($MgCa(CO_3)_2$) are common fluxes for ironmaking.

Other materials required for ironmaking include large quantities of air (to burn the coke) and water (mainly for cooling).

Ironmaking

Ironmaking is known to man from prehistoric times. Modern ironmaking is about 200 years old. It is done by a smelting process (extracting metals by heating) in a huge furnace known as the Blast furnace. These furnaces can be as tall as 70 meters. Blast furnace has a circular cross section and its diameter varies such that it tapers up like a chimney. Its height and geometry is optimised to give best performance. Blast furnaces are never stopped except for major repairs. Usually they can continue to operate without interruptions up to 15 years. In big steel plants there can be more than one such furnaces.

Iron ore, sinter, coke, and flux are

charged through the top of the furnace in a certain sequence. A hot air blast (900 - 1200^0C) at high pressure (3 to 4 atmospheres) is sent from the bottom of the furnace. Coke begins to burn when it comes in contact with the hot air. This generates enormous amount of carbon monoxide and heat. Temperature in the burning zone in the furnace can be as high as 2000^0C. Hot gases travels upwards through the furnace transferring heat and causing chemical reactions. As the gas ascends through the furnace it comes in contact with iron oxide causing reduction reactions. It progressively gets cooled as it moves up and the amount of carbon monoxide also gets diminished. Some of the most important chemical reactions taking place in the blast furnace are listed below:

$$C + C_2 = CO_2$$

$$CO_2 + C = 2CO$$

$$3Fe_2O_3 + CO = 2Fe_3O_4 + CO_2$$

$$Fe_3O_4 + CO = 3FeO + CO_2$$

$$FeO + CO = Fe + CO_2$$

$$FeO + C = Fe + CO$$

Iron that is formed by reduction reactions eventually melts and collects at the bottom of the furnace. Temperature of the molten metal (or hot metal as it popularly known as) can vary between 1200 and 1500^0C. Besides carbon, hot metal has small amounts of silicon, manganese, sulfur, and phosphorous dissolved in it. Along with ore reduction, slag formation also takes place. The slag floats over the hot metal as it is lighter than hot metal. Its temperature is usually about 50 to 100^{0}C higher than that of the hot metal.

Both hot metal and slag are taken out of the blast furnace through tap holes. Hot metal is send to the steelmaking shop, while slag is send to slag pits for granulation and later sold to cement industry.

Steelmaking

Steelmaking involves precise control of amount of dissolved elements in iron. Hot metal from blast furnace contains about 4% carbon. Although carbon makes iron stronger and harder, too much of it makes it brittle. Similarly, amount of sulfur and phosphorous must be as low as possible since they make most steels unusable. Other elements such as silicon and manganese must also be controlled and extra elements such as chromium, nickel, vanadium, etc. may be added depending up on the type of the steel being made. For example, stainless steel contains substantial amounts of chromium and nickel. There are about 3000 types of steel!

Main chemical process of steelmaking involves oxidation of carbon and other elements. This is quite a contrast to the ironmaking process where the main reactions are reducing. Hot metal from blast furnace is first poured into a bucket-shaped vessel known as converter. Usually some amount of steel scrap is placed in the converter prior to the pouring of hot metal. Like in ironmaking, here also we need a flux for slag formation. For this purpose powdered line (CaO) is added to the converter. Oxygen is then blown into the converter at supersonic velocity. Violent oxidation reactions take place in the converter during the oxygen blowing. Carbon is oxidized to form carbon monoxide which burns at the mouth of converter. Silicon and phosphorous are also oxidised to become a part of the slag. During the process, composition and temperature of the metal is monitored and blowing is stopped at an appropriate time.

The converter is tilted and the molten steel is run out via the taphole into a ladle. Once the steel has been drained, the furnace is turned upside down and the slag that is left inside runs into another ladle. The solidified slag may be sent back to the blast furnace for recycling as it contains lots of lime and iron oxides.

Sulfur control, removal of dissolved gases, addition of other alloying elements, etc. are done outside the converter in the ladle. Finally molten steel is solidified into various shapes in continuous casting machines. Some products may be shaped to sheets or rods by rolling in special mills.

A long journey back home

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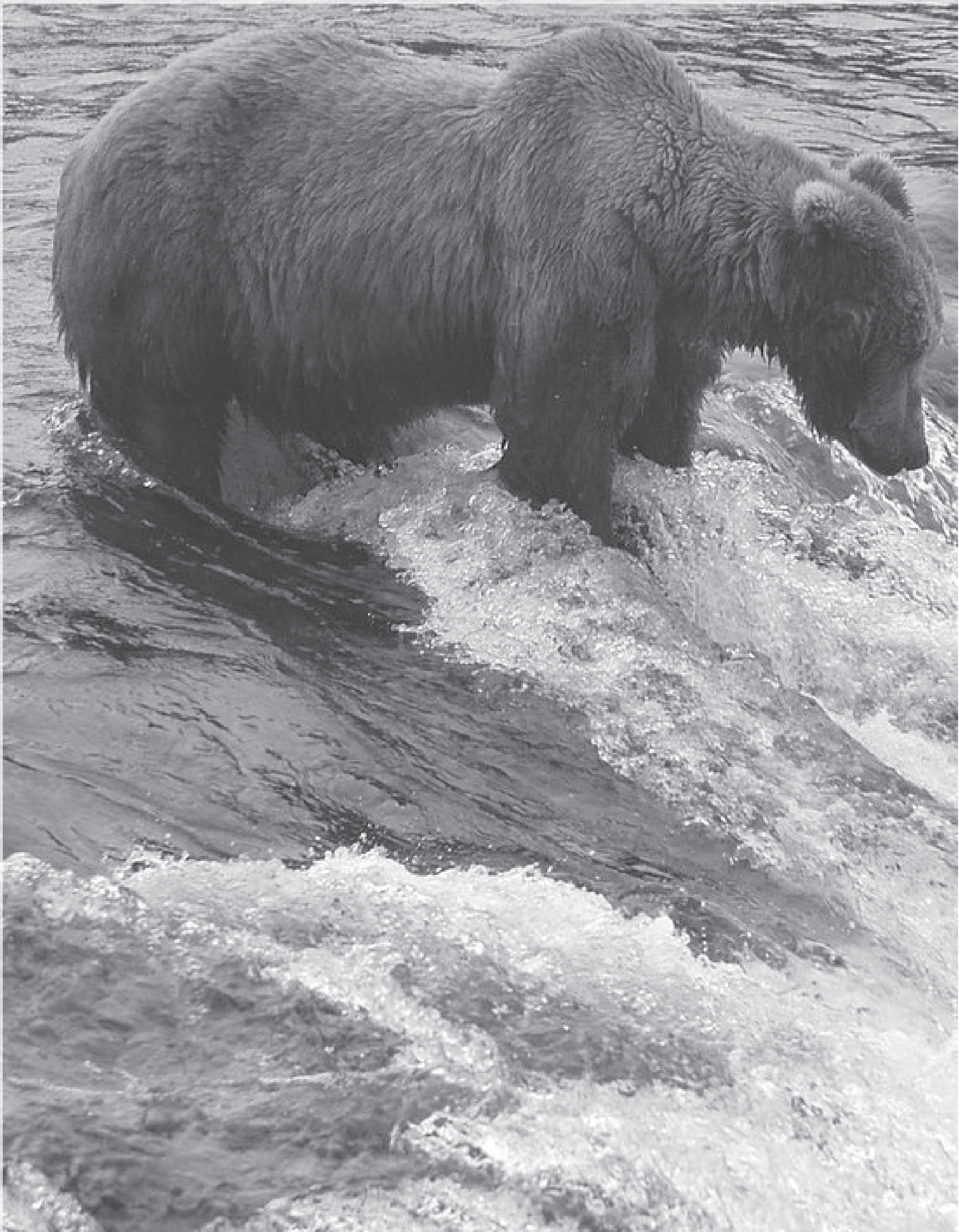
In the fish avatar of 'matsyavatar' in Hindu mythology, the story goes that a tiny fish began to grow bigger and bigger. As a child I wondered which species of fish could do such amazing things. Perhaps the fish in the ancient story was some species of salmon. The life cycle of the salmon is a wonderful tale in itself. No other fish can do what the salmon does; it returns precisely to the stream of its birth to lay its eggs!

The life of the salmon begins in a small 'nest', essentially a hollow swept out by the 'tail' of the female Salmon, into which she lays about 7,000 eggs.The 'nest' is called a 'redd'. The hatchlings from the eggs are called 'alevins'. A yolk sac is attached to the alevin, which contains protein, sugar, minerals, and vitamins. As the alevins grow into fry, a few centimetres long and



then into fingerlings (about the size of your finger), the yolk sacs disappear. In many species of Salmon, their long journey to the ocean begins at this stage.

The salmon fingerling is a freshwater fish. You might wonder how they survive the salt water in the ocean. The salmon fingerling waits in the estuary, the mouth of the river as it enters the sea, to slowly allow its body to acclimatize to the changing conditions. Many salmon wait for a year before they begin this long and tiring journey. By the time they reach the ocean, they are big. They feed on a diet of shrimp and other smaller fishes and accumulate fat reserves in their body.

When the salmon are ready to lay eggs, they begin their return journey. The salmon is an anadromous fish, meaning one which begins life in fresh water, migrates to the ocean and returns to fresh

water to reproduce. Migration to the ocean allows these fish to grow a lot larger than would be possible in fresh water because the ocean has so much more food. Large fish dominate reproductive areas and lay more eggs than smaller fish. These are advantages for the long seasonal migration of the salmon.

There are five species of salmon native to the North Pacific. All of them are anadromous. All the North Pacific salmon die after spawning - providing food for predators or docomposing to release their nutrients into the stream or surrounding land.

There is one species of Atlantic salmon found in the rivers of Ireland, the United Kingdom, Canada, the Faroe Islands, Iceland, Norway, Sweden, Finland, Russia, France, Spain, Canada and the Pacific Salmon, the Atlantic salmon too return to their homes, making an extraordinary journey of more than 4000 kms. They leap up 3 m. high obstructions to reach their spawning sites! The Atlantic salmon can spawn up to three times in its life, returning to the ocean in between. None of the Pacific salmon can do this. Some Atlantic salmon never reach the sea, because they are found in land - locked lakes. These fish migrate between deep-lake feeding areas and spawning grounds along shorelines or in tributaries.

The Asian salmon is called the cherry (or masu) salmon and is classified in the same genus as the five North Pacific salmon. The Masu salmon is a Pacific salmon that is found only in East Aisa. Masu die after their first spawning. Male masu salmon generally reach maturity a year ofter hatching. The North Atlantic salmon belong to the genus Salmo.

How do the scientists know the age of the salmon? Scales cover the body of the salmon. The scales of the salmon have concentric rings. Just as in trees, these rings can be counted for age.

How do salmon make this incredible journey back home? Scientists don’t completely understood how the salmon accomplishes this feat. Some scientists think that they use their sense of smell. Others feel it is accomplished by their excellent sense of vision. They can see both in front of their bodies and to the sides. Salmon can see colors and are good at judging distances both in and out of the water. They have been known to jump out of the water to pluck a flying dragonfly out of the air. Salmon are also known to be able to see land-based predators from under the water and swim for cover. They have the ability to focus both at close range and far away and can see and interpret movement.

Wild Pacific salmon are still abundant but wild Atlantic salmon are rare, mainly due to overfishing. Farming Atlantic salmon is a large industry, while Pacific salmon farming occurs at a much smaller scale.

The salmon is an incredibly beautiful wild creature with several billions of history behind it. The native Americans built their lives around the salmon lifecycle, referring to themselves as the salmon people. They believe that God became a salmon to save them from starvation. While they eat salmon as their main food, they take care to use every part of the salmon, from skin to bones.

Nature is full of creatures and their delightful stories. Do think about them!

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Do Not sleep under the Banyan Tree

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Asha for Education

Often the older people tell us that we should not sleep under trees. Why? Plants are remarkable organisms. In the presence of the sunlight, carbon dioxide and water, they make their own food. This process is called as photosynthesis. The reaction can be written down as:

$$CO_2 + H_2O + \text{light} \dashrightarrow (CH_2O) + O_2$$

where CO_2 = carbon dioxide from air, H_2O = water from roots, Light = energy source, CH_2O = food made by the plants; it is also known as starch and O_2 = oxygen released into air.

Chlorophyll is green in color, and it is present maximum in the leaves. That is why leaves are green in color. Now one of the things all the organisms have to do is to breathe. We survive because of the oxygen in the air. The process by which oxygen is taken in to our cells and carbon dioxide is released is known as respiration. Respiration is absolutely essential. If we do not respire, or if we do not get oxygen, we will die. The process of respiration is written down as:

$$(CH_2O) + O_2 \dashrightarrow CO_2 + H_2O + \text{energy}$$

See! What an exactly opposite process in respiration! It takes the carbohydrates and other food sources and in presence of oxygen, it breaks them down to form carbon dioxide and water. This process releases energy which allows us to walk and talk and move our hands, and think. Animals only respire. Plants respire as well as do photosynthesis. If we look at the two equations it is absolutely clear that for photosynthesis, plants need light. Thus, photosynthesis occurs only during day time. But respiration does not need a light source. It happens during night and day. And now if you see the superstition in the sense of respiration, you can see why the elders warn us about sleeping under a tree in the night. It will be releasing carbon dioxide which is not very good for us.

By the way, respiration occurs with all the trees. So, carbon dioxide will be generated under all trees. In fact, this is the reason it is said that you should not have too many plants in a bedroom.

Science Activity

Latrenda Knighten

Did you know that inks and markers are often combinations of several colored dyes? We can separate these combinations of colors or pigments through a process called chromatography. Here's how to get started:

What You Need:

Coffee filters (any tissue paper)

Clear plastic cup

Water

Tablespoon

Water soluble colored markers

Paper towels

Clothespins

What You Do:

Use a pencil to make a mark on a coffee filter about two inches from the bottom.

Give your child the coffee filter and ask him to fold it in half.

Use water soluble markers to decorate the bottom of the coffee filter above the 2-inch mark.

Add 2 tablespoons of water to the cup.

Fold the coffee filter in half and then in half again and place it in the cup.

Watch the colors move up the filter. Talk about the different colors that appear on the filter as the filter absorbs the water.

Unfold the filter and place it on paper towels to dry.Once the filter is completely dry, your child can use his science project to make a pretty craft project! Allow your child to showcase the results of the chromatography experiment by making a butterfly magnet or a flower.

What's Happening?

When the liquid creeps up the coffee filter, it dissolves the coloring molecules and splits it into different colored chemicals. Different colors get carried along faster and farther than others because some color molecules are bigger and heavier than others.

Turn Science Into Art!

To make a butterfly magnet: gather the filter into a clothespin to resemble a butterfly; place a piece of a magnet strip on the back of the clothespin and display on your refrigerator.

To make a flower: fold the filter into fourths and twist a wire around the bottom, then fluff the filter so that it looks like a flower.

http://www.education.com/activity/article/Color_Science_kindergarten/

The Mushroom

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Mushroom is a fruit (like an apple) of the mushroom ‘plant’ and contains mushroom ‘seeds’ called spores. The body of the mushroom in called mycelium and its individual parts are microscopic. Since the body of the mushroom is usually dispersed over a relatively large area it is rarely noticed. In nature, there are some species of mushrooms that can have a body which spreads over hundreds of square miles!

Mushrooms are fungi, and are usually placed in a Kingdom of there own apart from plants and animals. Mushrooms contain no chlorophyll and most are considered saprophytes. That is, they obtain their nutrition from metabolizing non living organic matter. This means they break down and ‘eat’ dead plants.

The body of the mushroom stores nutrients and other essential compounds, and when enough material is stored and the conditions are right they start to fruit -

produce mushrooms.

Why do Mushrooms grow overnight? Some days, we see many mushrooms in our garden. If the body is spread out and microscopic, how do mushrooms grow so quickly? There are two basic reasons : 1) Since they store up compounds between fruiting and most fruit once a year, they have a lot of reserve available to support the mushroom. 2) Mushrooms develop differently than plants or animals do.

Plants and animals grow through cell division. They have to produce more cells, to get bigger in size. Cell division is relatively slow process and requires a lot of energy. The mushroom body also grows by cell division. However, the mushroom fruit does not grow by cell division. Just about as soon as it starts to develop, a mushroom has almost the same number of cells that the mature mushroom will have. The mushroom increases in size through cell Enlargement! This means that the cells can balloon up very rapidly. Very little energy is required, basically the cells just enlarge with water. So a mushroom can increase in size as fast as water can be pumped into its cells. Almost overnight a mushroom can go from a pin head to a large mushroom.

Mushrooms need water for their fruit to 'grow'. They can lose water to the atmosphere very easily due to lack of the skin. That is why they grow in high humidity (lots of water vapor in the air) conditions. If the humidity is toolow the cells lose water faster than it can be 'pumped' in and the immature mushroom dries up and dies.

Mushrooms need to breathe just like humans do, except they do not have lungs. Mushroom cells exchange gases directly with the atmosphere. If the body of the mushroom is submerged in water it is comparable to drowning. No oxygen can be exchanged, anaerobic bacteria (bacteria which do not need oxygen to thrive) build up, and the mushroom is choked to death.

It is almost the same with the mushroom fruit. If it is too dry they lose too much water and desiccate. However, if it is too wet - the humidity is too high - the excess water prevents any gas exchange and the developing mushroom chokes off.

Of Clouds and Winds

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If a fluid (liquid or gas) moves northwards in the Earth's northern hemisphere, it will curve towards the right.

This strange happening is called the Coriolis effect. For example, the monsoon winds coming north from the Equator up the Indian Ocean turn right and become the South West Monsoon in India. (The monsoon winds are named by the direction they come from).

If you have a fluid moving southwards inthe northern hemisphere, it also curves to the right. This is also the Coriolis effect. The monsoon winds coming south down the Bay of Bengal turn right and become the North East Monsoon, giving rain to Sri Lanka and Tamil Nadu.

Your school textbook might talk of a Coriolis force and say that it is caused by the Earth's rotation. What is this mysterious force? How does it come about?

It is actually quite easy to work out why the Coriolis effect takes place because of the spinning of the Earth. All you have to do is to imagine you are a cloud.

Suppose you are a cloud over the Seychelles islands in the Indian Ocean and you are heading north across the Equator. In 24 hours, as the Earth spins, the Seychelles has to travel around a distance equal to the circumference of the Earth (around 40,000 kilometres) and come back to the same spot. That works out to about 1600 km per hour. That is the speed the Seychelles is travelling at, and so is every one on it, and the clouds above it. Of course, nobody feels anything special because everything around you is travelling at the same speed.

Now you, the cloud, start moving north, crossing the Equator and heading towards Arabia and Iran.

Teheran, the capital of Iran, also makes a full circle in 24 hours as the Earth spins. But it is at 30 degrees latitude, and the distance it has to traverse is less. (If you know some trigonometry, you can figure out that the distances for the Equator and this latitude will be in the ratio cos 0 : cos 30.) A simple estimate is that Teheran travels eastwards at about 1300 km per hour as the Earth goes round. And of course, a resident of Teheran or a cloud above it does not feel anything special about this.

But you, the cloud moving northwards, start in an atmosphere moving at 1600 km per hour and land up in one moving at 1300 km per hour. So you will be moving 300 km per hour faster than Teheran when you land up there. To the Iranians, you will seem to zoom eastwards!

Of course, this doesn't actually happen, because you don't travel from the Seychelles to Teheran in a flash, but you move slowly, and the speed of the atmosphere you are travelling through also decreases slowly. The friction of the slower air also slows you until you are travelling at the same speed as it.

Seen on a map of the Earth, you will seem to be bending towards the right, moving more and more eastwards into the Arabian Sea until you hit the Indian peninsula from a south westerly direction.

This is the Coriolis effect, found by a French engineering professor, Gustave Gaspard de Coriolis, in 1835.

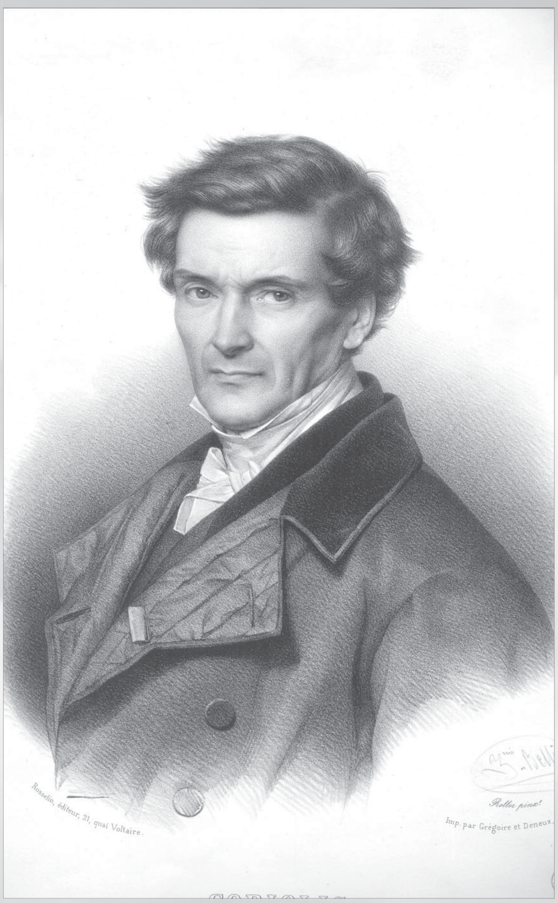
You can work out a few things for yourself now.

1) Why does a cloud from Kolkata, moving southwards down the Bay of Bengal, also curve to the right?

2) Why does Arabia get so little rain that it is a desert?

3) Why does Australia get a North West Monsoon?

4) What is the speed of the rotating Earth at the poles?

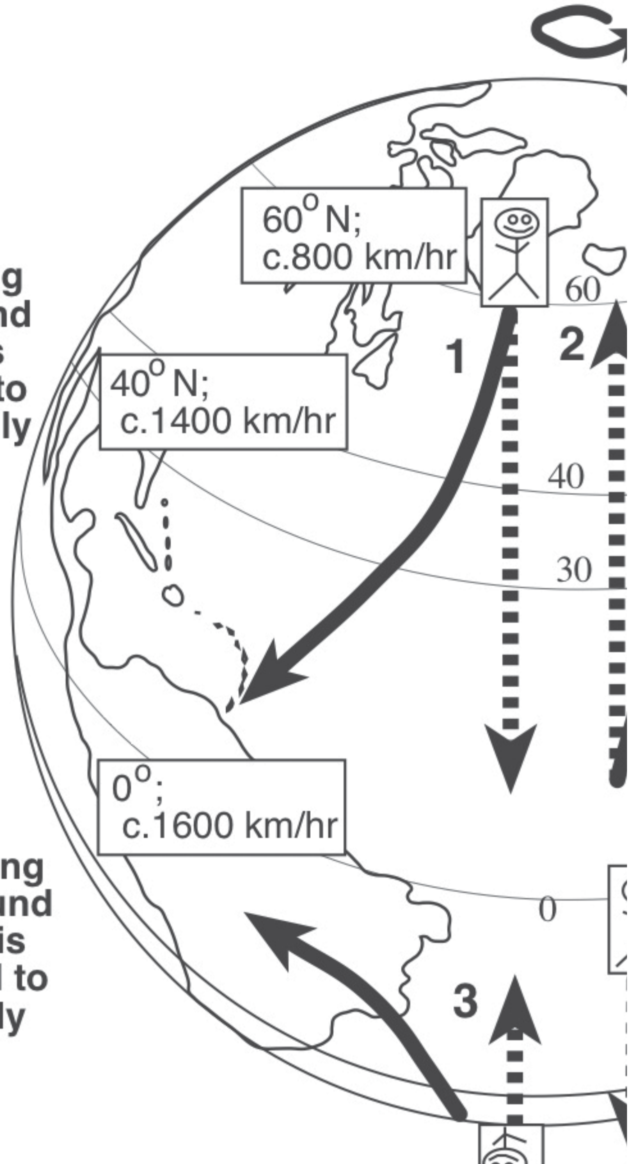


Coriolis effect

Objects moving in air and/or wateron the Earth's surface
independently. Coriolis deflection is an apparent movem
speed of rotation is slower at the poles than at the equat
and governs atmospheric and ocean-surface circulation

Earth's rot

1). Object moving south in northern hemisphere is moving *slower* than the ground underneath, and so is apparently deflected to the *right*; but it actually travels in a straight line.



3). Object moving north in southern hemisphere is moving *slower* than the ground underneath, and so is apparently deflected to the *left*; but it actually travels in a straight line.

e are decoupled from the solid earth, and move
nent (to an observer), due to the fact that the Earth's
tor. Coriolis deflection also affects air and water masses
patterns.

ation

2). Object moving north in northern hemisphere is moving *faster* than the ground underneath, and so is apparently deflected to the *right*; but it actually travels in a straight line.

4). Object moving south in southern hemisphere is moving *faster* than the ground underneath, and so is apparently deflected to the *left*; but it actually travels in a straight line.

Stars

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Bangalore

Twinkle, Twinkle, Little Star,
How I Wonder what You Are!

The curiosity about the heavenly objects has existed as long as human thought. Evidence of this has been found whenever and wherever we uncover the evidence of civilization. Astronomy as a subject mush have begun when people started to notice the regularities in the movement of celestial objects. Intelligent as man was, he learnt to use this information to his advantage. By looking at the stars he learnt to keep track of time. Later when he took to sailing and travelling for trade, the stars served as his compass.

In the lands where civilization flourshed very early, namey, Arabia, Mesopotamia,the Mediterranean regions, China and India, the night sky is a clear marvellous sight. Hence the interest in Astronomy in these regions was quite natural. They made certain important observations and laid the foundation on which, the mighty Astronomy of today, stands.

Do you know what cuneiform is? It is the first system of writing in human history, developed in ancient Mesopotamia. In this system, a reed was used to impress wedge shaped marks onto the surface of clay tablets. Early cuneiform clay tablets dating from about 2800 BC record the Mesopotamian's observations of the Sun, Moon and the bright stars at regular intervals. Hipparchus, a Greek Astronomer who lived around 120 BC made a catalogue of 850 stars and divided them into six classes of brightness. This system is in practice even today!

The prime source of the study of Indian Astronomy are the Vedas. The Vedangas or parts, relevant to Astronomy are the Kalpa and Jyothisha. In Jyothisha, 28 constellations are enumerated. These names Aswini, Bharani etc. have continued to this day and are loosely referred to as the 28 stars.

The Chinese were the first to map the heavens and prepare stellar atlases around the 11th century AD. They showed the stars as dots and connected them by lines to mark the constellations. This convention is followed the world over, even today! It is amazing that even though in terms of knowledge, what the ancients knew was a mere fraction of what constitutes Astronomy toda, this ancient phase in the history of Astronomy, where the observations were made with just the naked eye, lasted from distant past to the 17th century!

If any of the great minds from the ancient world were to come and read a modern day, school lesson on Universe, he would be baffled to know that the Sun is only one of the countless stars in space. And that the powerful Sun is but an average member of the star family in terms of size and brightness! Indeed it is hard to believe, because the Sun appears so much brighter and so very different from the other stars. But that is because the Sun is so much nearer to us than all other stars. The nearest of the other stars, Proxima Centauri is about 27,000 times as far away from us as the Sun!

The fact that the Sun is a star has helped astronomers learn about the incredibly distant stars. For instance we

know that stars like the sun, are hot gaseous mass of mostly hydrogen and helium and not rocks that are like a diamond in the sky! They appear to twinkle because their apparent size is less than the size of the atmospheric disturbances. If viewed from space, stars just shine. They don't twinkle.

To shock the elder from the past further, we could next take him to an observatory! Have you ever looked up into the night sky and wondered just how many stars there are in space? On a clear night, out of the glare of streetlights, you will see a few thousand individual stars with your naked eyes. The ancients too must have seen just that many with their naked eye. But, put your eye on the eyepiece of a telescope and millions more will come into view!

All these stars are however not scattered randomly through space. They are gathered together into vast groups known as galaxies. The Sun as you know belongs to a galaxy called the Milky Way. Astronomers estimate there are about 100 thousand million stars in the Milky Way alone. Outside that, there are millions upon millions of other galaxies also!

The early man would, on seeing so may stars, possibly ask the question, 'So how many stars are there in the Universe?' For once the modern day astronomers cannot impress the elder with an answer. For it is difficult even for scientists, to give even a rough estimate of the number!

But scientists do have fairly accurate explanation to many other important questions. For instance we now know that stars differ in their apparent brightness for two reasons. One is that they are at different distances. And secondly, they vary in their size and surface temperature and therefore in their intrinsic brightness. Stars differ in colour because of their different temperatures. The cooler stars are red and the hottest are blue. Scientists are also unanimous in their theories on how stars are born, how they change and what happens to them eventually.

Stars begin as very, very diffuse clouds of gas present in the galaxy into which they are formed. The density of gas in such a cloud is very low and the gas is in the form of molecules because it is very cold. Gravity causes every atom and every bit of dust to pull on every other one and all move to the centre. This causes the star matter to collapse into clumps. The large ones, which become stars in future, are called protostars. Having begun with a dismeter of perhaps 1.5 trillion km, the protostar now shrinks at a very fast rate (that is in about 1,000 years!) to a diameter of about 80 million km. Because the atoms move faster and faster as they fall to ward the center, friction is created as they rub together and the temperature rises. The cloud settles as a spherical mass with hydrogen as its core.

The contraction and heating up continues and the temperature rises to millions of degrees. When the temperature is high enough, fusion of hydrogen begins. Enormous energy is released and the star shines brightly. The star is said to be now in its yough stage. Our Sun, incidentally has been in this youth stage for about 5 billion years and will continue to be in the stage for another 5 billion years.

As the hydrogen continues to fuse forming hellium, the core of the star becomes entirely helium and the hydrogen forms an outer shell. The hydrogen

continues to fuse, radiating energy. The colour of the star changes to red and the star is now called a red giant. When our Sun gets to the red giant stage it will swallow the Mercury, and Venus and burn up the Earth!

At the core contraction continues. Temperature rises, and Helium is converted to Carbon. At this stage, the core and the outer shell get detached. The core is now called the white dwarf. In moderately sized stars (like our Sun) further nuclear reactions stop and the star cools gradually. It gets dimmer and dimmer until it emits no light and becomes a black dwarf.

In the case of massive stars, after the white dwarf stage, the carbon gets ignited resulting on the formation of heavier elements like oxygen, magnesium and silicon. In the innermost regions, iron is formed. At this stage the star explodes and this event is known as ‘Supernova’. During a supernova, most of the materials are thrown out at great speed and only a sphere of neutrons remains at the centre. The star is now called a neutron star. The materials thrown out during supernova, mix with the gaseous clouds in the galaxy. Fresh star formation could take place here.

In case of stars 30 times as heavy as the Sun, the remnant at the end of the supernova has a huge amount of matter compressed into a very small region. This is a region of intense gravitational field and is called a ‘Black Hole’. A black hole obviously cannot be seen. For any light or radio waves we send in gets sucked in and does not return to us! Then how do scientists know they exist? The presence of a black hole is inferred from the gravitational force it exerts on bodies close to it.

So the next time you gaze at the night sky you would perhaps not ‘wonder’ what the twinkling stars are! But I am sure the wonder at the vastness of the cosmos can only increase with increasing knowledge!

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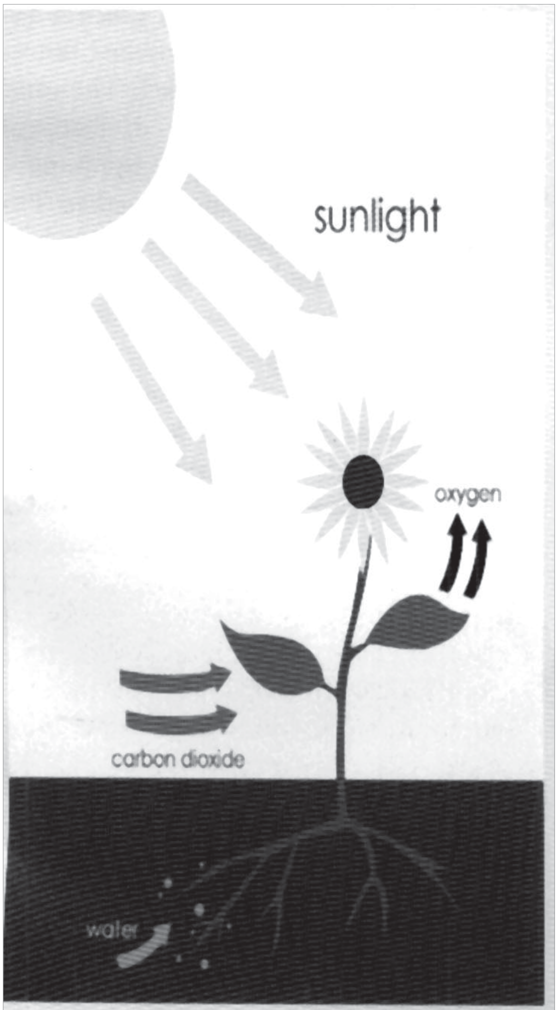
Chemistry in Human Evolution, Sustenance and Survival

Dr. C.P.Reghunadhan Nair

Among the diverse fields of science, chemistry plays the key role in determining the nature of the modern world. Though by definition, chemistry is the science of matter which undergoes changes, in reality, chemistry goes beyond its traditional definitions. From the evolution of mankind itself, chemistry has had a close connection with the daily acts of human beings. Every matter is related to chemistry; even we, the human beings are made of chemicals.



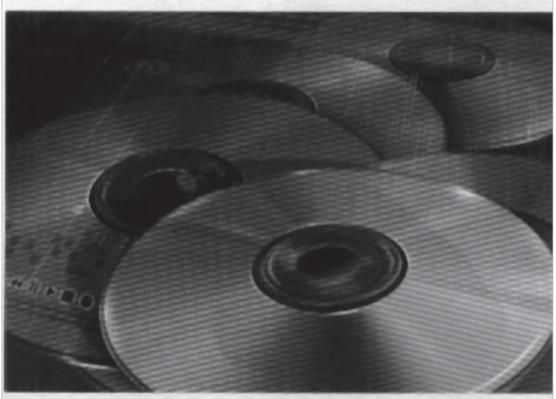
Photosynthesis (Credit: Wikipedia)

Chemistry - Lifeline of the universe

Chemistry is responsible for creating and sustaining ife on Earth, and is a key science of the future. All the substances that we see around us - rocks, plants, water, air and everything else is a product of chemistry. The chemistry of photosynthesis in plants creates food out of carbon dioxide and water. Plants fix the carbon dioxide from air to produce food and oxygen for us. The Amazon forest alone produces 15% of oxygen on Earth. Biosynthesis in plants and animals creates many complex molecules that sustain the life. Oxygen generation and the fixation of nitrogen and carbon dioxide are done by chemical processes in plants. Water is our lifeline. The chemical reactions in all plants and animals that support life take place in a water medium.

Chemical processes occurring in the atmosphere render it conducive for life. Plants synthesis organic pigments (anthocyanins, flavones, etc.) to make

Colour of flowers is due to organic chemical molecules



Polymer-based CD/DVD (Credit: Wikipedia)

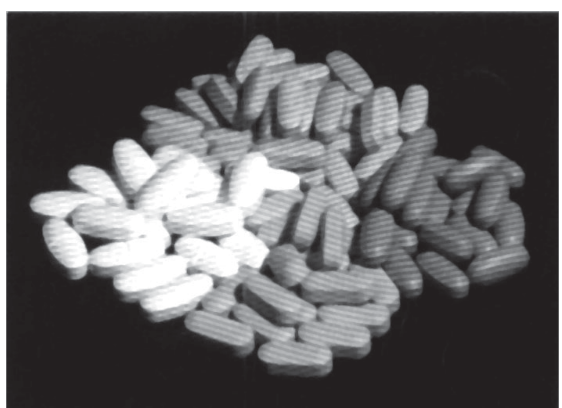
flowers colourful. Perfumes are organic molecules synthesised by plants.

What would the world be without chemistry!

Chemistry gives colour and fragrance to life not only through plants, but through many other ways. Here are some of the things that would not have been possible without chemistry. No plastic means no plastic bags, no DCs or DVDs no iPods, no plastic ware and furniture, no scotch tape, and no synthetic fabrics. No parts of your car would be made of plastic to make it lightweight. There would also be no gasoline, no aircraft, no modern pharmaceuticals, no pain killers! No water purification and no sewage treatment using chemistry. No glues, no synthetic fertilisers and insecticides, no green revolution. Farming and food production wouldn't be nearly as productive and starvation would have been a massive problem

There would also be no microcircuits through photo lithography and hence no compact televisions, radios or computers. No batteries, no cell phone! The list is almost endless.

You probably wouldn't be alive were it not for chemistry. Trillions of chemical reactions that happen every second in your body keep you alive (and sane!) Chemistry doesn't make our lives easier, it makes them possible. Application of chemistry has widely helped the growth of medicinal and pharmaceutical chemistry and paved the way for the development of drugs and

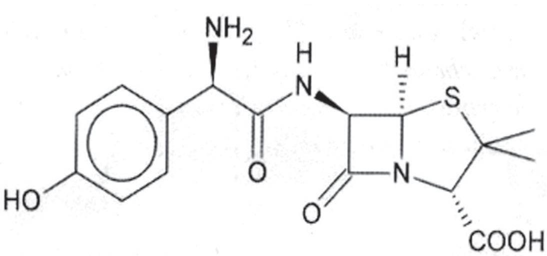


Medicine tablets (Credit: Wikipedia)

artificial body implants. But for chemists, medicines for diseases right from common cold to deadly cancer would not have emerged. The antibiotics that save our lives are complex organic molecules - products of chemistry.

Role of polymer chemistry

Polymer chemistry is an integral part of chemistry and hence of our life. Polymers have benefited our society in a number of ways. Polymers have helped aerospace technology take giant steps forward over the past 50 years, including advancements in



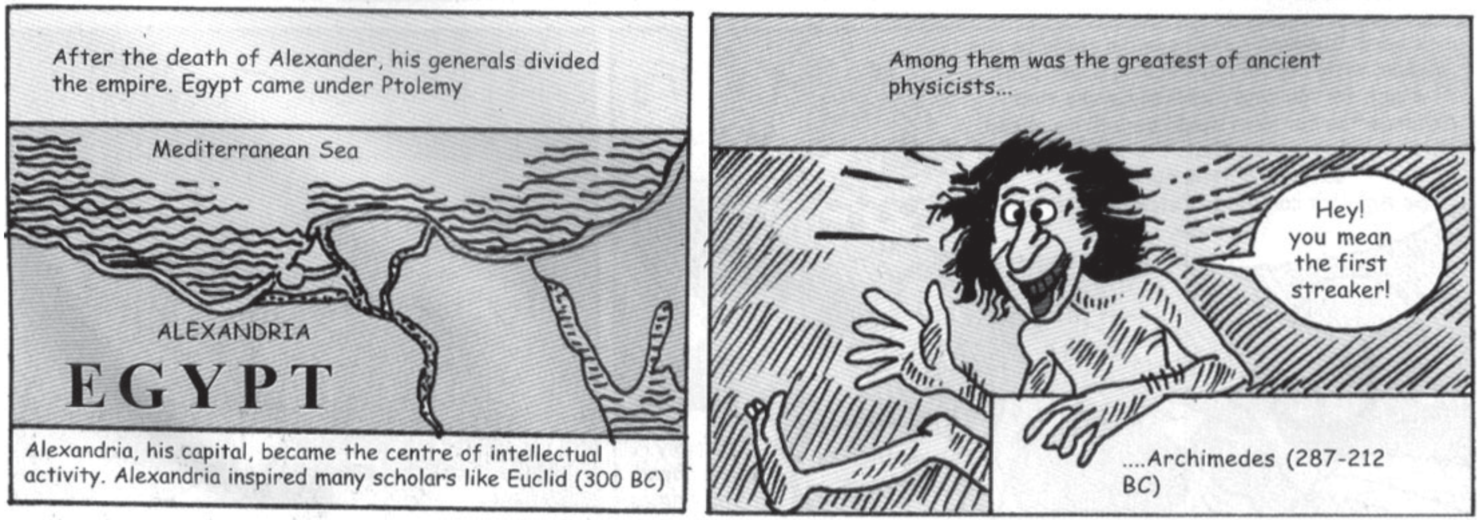
satellites, shuttles, aircraft, and missles. As a result, civilian air travel has improved, along with military air power and space exploration. In addition, the building and construction, electronics, packaging, and transportation industries have all benefited greatly from polymers. In fact, nearly all modern homes use polymer as electrical insulators, connectors, switches, and receptacles. Polymers are indispensable for making small appliances, food processors, microwave ovens, mixers, coffee makers, shavers, irons, and hair dryers, and what not! Computers as we know them today would probably not exist without polymers. Components such as circuit boards and computer chips are possible to be miniaturised thanks to the use of polymers. Without polymers such as rubber and nylon, vehicles would have to be fitted with wooden tyres like bullock carts!

Can you find the sum in the second column?

@	&	&	$	23
@	#	#	£	18
@	&	£	$	24
#	#	£	&	15
24	?	17	25	

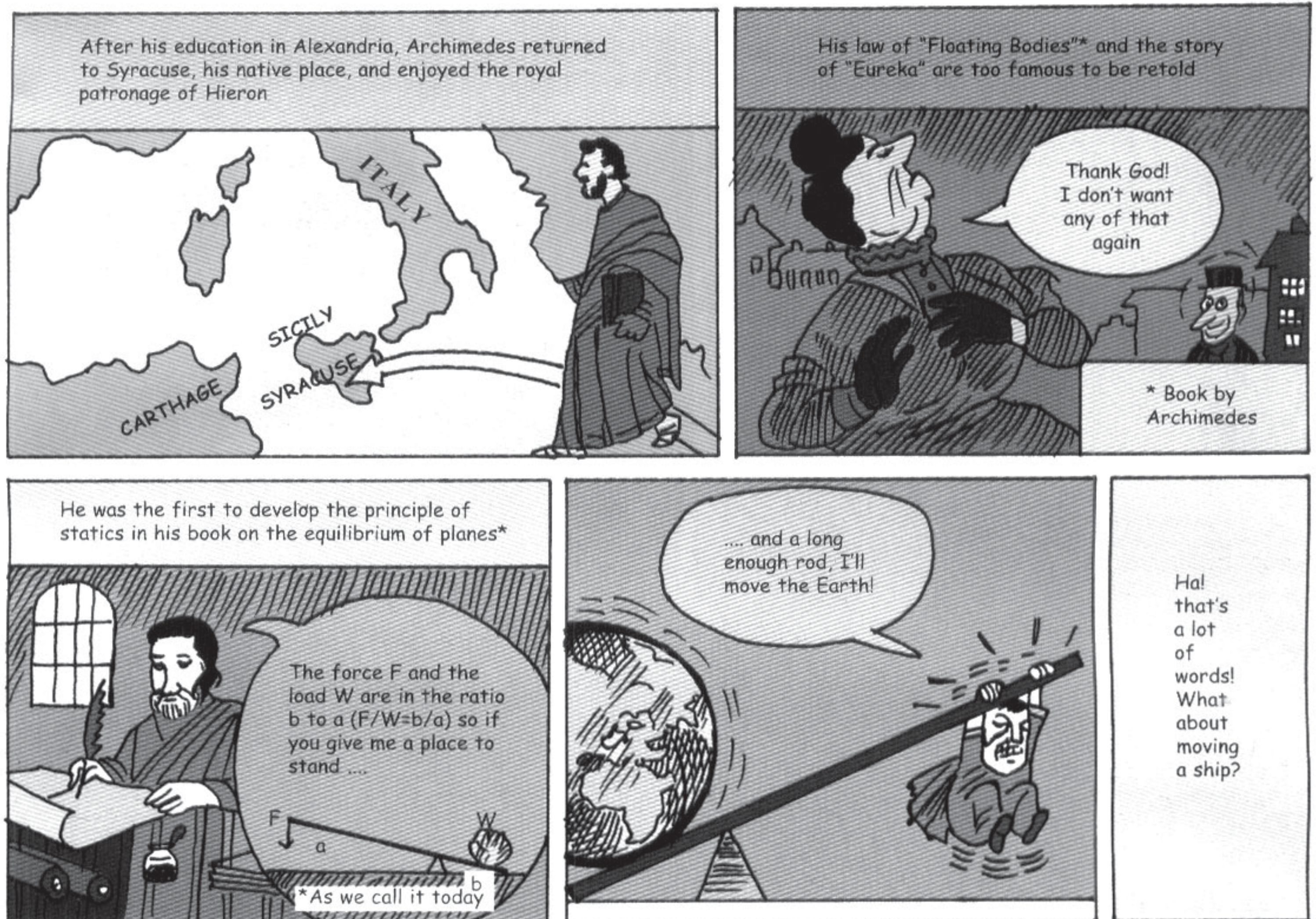
Answer: 14. You don't have to find the value of every symbol. The rows add up to 80, and this will be the sum of every symbol in the grid.
23+18+24+15=80.
Therefore the columns must also add up to 80, making the missing column 14: 24+14+17+25=80.
(From www.brainbashers.com)

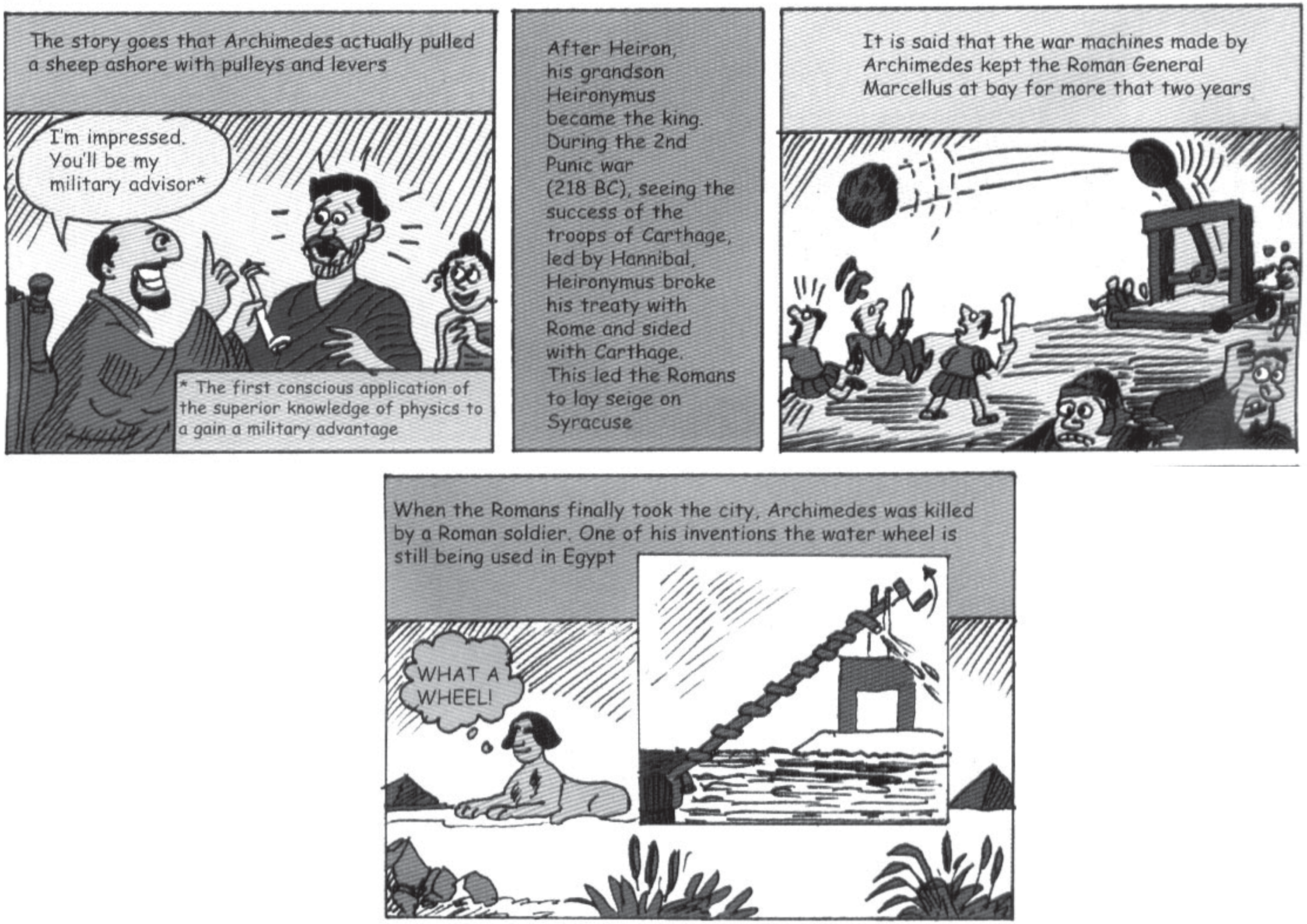
Archimedes



From the book: Story of Physics

T Padmanabhan - Illustrations:Avinash Deshpande


After his education in Alexandria, Archimedes returned to Syracuse, his native place, and enjoyed the royal patronage of Hieron
ITALY
SICILY
SYRACUSE
CARTHAGE
His law of "Floating Bodies"* and the story of "Eureka" are too famous to be retold
Thank God! I don't want any of that again
* Book by Archimedes
He was the first to develop the principle of statics in his book on the equilibrium of planes*
The force F and the load W are in the ratio b to a (F/W=b/a) so if you give me a place to stand ....
F
a
W
b
*As we call it today
.... and a long enough rod, I'll move the Earth!
Ha! that's a lot of words! What about moving a ship?


The story goes that Archimedes actually pulled a sheep ashore with pulleys and levers
I'm impressed. You'll be my military advisor*
* The first conscious application of the superior knowledge of physics to a gain a military advantage
After Heiron, his grandson Heironymus became the king. During the 2nd Punic war (218 BC), seeing the success of the troops of Carthage, led by Hannibal, Heironymus broke his treaty with Rome and sided with Carthage. This led the Romans to lay seige on Syracuse
It is said that the war machines made by Archimedes kept the Roman General Marcellus at bay for more that two years
When the Romans finally took the city, Archimedes was killed by a Roman soldier. One of his inventions the water wheel is still being used in Egypt
WHAT A WHEEL!

Cosmic Messengers

M.V.N. Murthy,
The Institute of Mathematical Sciences, Chennai

Introduction

Do you know that we are all exposed to natural ionising radiation at all times? It is natural because of its origins and it is ionising because there is enough energy in this radiation to knock out electrons in atoms. They come from various sources like—

. Cosmic rays from outer space which bombard the Earth continuously from all directions,

. Radioactive elements found naturally in the Earth's crust and in gases emanating from Earth,

. Some trace amounts of radioactive elements found in our own body.

Immediately after the discovery of radioactivity, the presence of ionising radiation on the surface of the Earth became known. The presence of this radiation was detected by an electrometer (or electroscope) developed by **Theodor Wulf** in 1909. In the beginning it was thought to have originated from the Earth itself. However, Wulf noticed that there was higher level of radiation at the top of the Eiffel Tower in Paris than at the bottom indicating the presence of other sources of natural radiation in the atmosphere.

Almost exactly a century ago, **Victor Hess** started investigating this question. He took the Wulf electrometer to higher altitudes on a free balloon flight. It was a daring thing to do since he did it without any protection and oxygen mask even at altitudes of 5 kilometres or more.

With increasing precision he made radiation measurements at various altitudes, during day and even during night. He showed that the levels of radiation decreased up to an altitude of about 1 kilometre and increased above that level by many times compared to the surface. He found energetic radiation coming from all directions. He even carried out the experiment during a solar eclipse ruling out the sun as the source of this radiation. He was awarded the Nobel Prize in physics in 1936 for his experiments.

The photo shows Victor Hess about to take flight in his Balloon. The graph shows his measurements carried out in 1913-14 at various altitudes. (Source: Wikipedia article on Cosmic Rays).

Robert Millikan later called them Cosmic Rays. He thought these cosmic rays are a form of electromagnetic radiation originating in outer space. Though this identification was not accurate, he correctly identified their extra-terrestrial origins. It was **Arthur Compton** who identified the cosmic rays with charged particles from outer space.

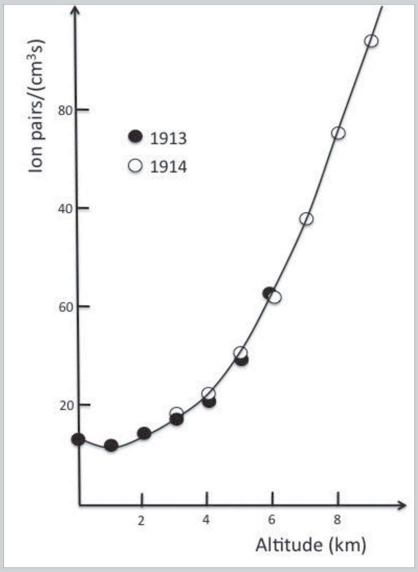
What are Cosmic Rays

After a century of observations, starting with the experiments of Victor Hess, we now know a lot about these so called cosmic rays. In fact these are not rays at all, in the sense of X-rays or gamma-rays, but high energy particles originating mainly outside our solar system though a small percentage could be coming from the Sun. We divide them into two types, Primary Cosmic Rays and Secondary Cosmic Rays.

Primary cosmic rays are those which come from outer space and reach the top of the atmosphere. Most of them are even of extra-galactic origins. Nearly 99 percent of cosmic rays are nuclei (that is atoms stripped of their electrons) and the rest is made up of electrons and traces of some stable anti-matter like anti-electrons and anti-protons. Of the 99 percent of nuclei, nearly 90 percent is made up of protons or the nuclei of the hydrogen atom and about 9 percent consists of the nucleus of the Helium atom or alpha particle. Less than one percent is made up of the nucleus of heavy elements. All these particles are of course charged.

The primary cosmic rays come in a huge energy range. A large number of them have energies lower than the energy of a single proton at rest (approximately 10^9 electron volts or eV for short). An eV is the smallest unit of energy equal to $1.6x10^{-19}$ Joules. However, the maximum energy can be as large as 10^{11} times the rest energy of the proton. The most powerful accelerator on Earth, the Large Hadron Collider (LHC), at present can only accelerate particles to about 4000 times the rest energy of the proton. At its highest energy a single cosmic ray proton packs the energy of a tennis ball moving at a speed of around 200 km/hour or about 10^{20} eV (but a tennis ball is made up of more individual particles than that!).

When these primary cosmic rays collide with air molecules, mainly nitrogen and oxygen, in our atmosphere they produce secondary particles in a cascade. Depending on the energy of the primary cosmic ray particle, the cascade may have even hundreds of secondary particles. These collisions produce particles called mesons which subsequently to muons, electrons and neutrinos. These are called secondary cosmic rays some times also called air showers. See back inside cover for a schematic.



The famous Indian scientist **Homi Bhabha**, along with **Walter Heitler**, was one of the first to work out the mechanism of these Cascade Processes. Bhabha not only provided the theory but also later set up experiments to study these air showers on the surface, using balloons to study them in upper atmosphere and also deep underground by placing detectors in the *Kolar Gold Field* mine. The bulk of cosmic rays that reach the surface of the Earth are these secondary particles like muons (which are like electrons, but heavier) while only a few of the primary cosmic rays reach the Earth's surface. For more than half a century the study of these air showers provided information about the primaries. In the last two decades it has become possible to study the primary cosmic rays directly through space-based observatories. But there remain many questions that are still in the open about their origins.

We will discuss this in the next issue of JM.

Cactus

Cactus is the singular word for the plant, cacti or cactuses are the plural forms.

Cacti are native to the Americas, ranging from Patagonia in South America through to areas of western Canada. One species, Rhipsalis baccifera, is the exception, it is also found in tropical Africa, Madagascar and Sri Lanka. It is thought that droppings from migratory birds dispersed the Rhipsalis seed in these other lands.

The cactus generally lives in dry places prone to drought, such as deserts.

There are 1,500 to 1,800 species of cacti. Each species for the most part fall into one of two core cacti categories, these being opuntias or cactoids.

Cacti come in all shapes and sizes from round and short through to thin and tall. The smallest grow just a few centimeters high and about 1 cm (0.4 in) across. The tallest cactus can reach heights close to 20m (66ft) and up to 1 meter thick.

The ancient Aztec's of South America often depicted cacti in many of their sculptures and drawings. While Mexico's national coat of arms shows an eagle, a snake, and a cactus.

Cacti show many 'adaptations' to conserve water during long dry periods. An adaptation is a trait in a living organism that helps it to survive, populate and evolve.

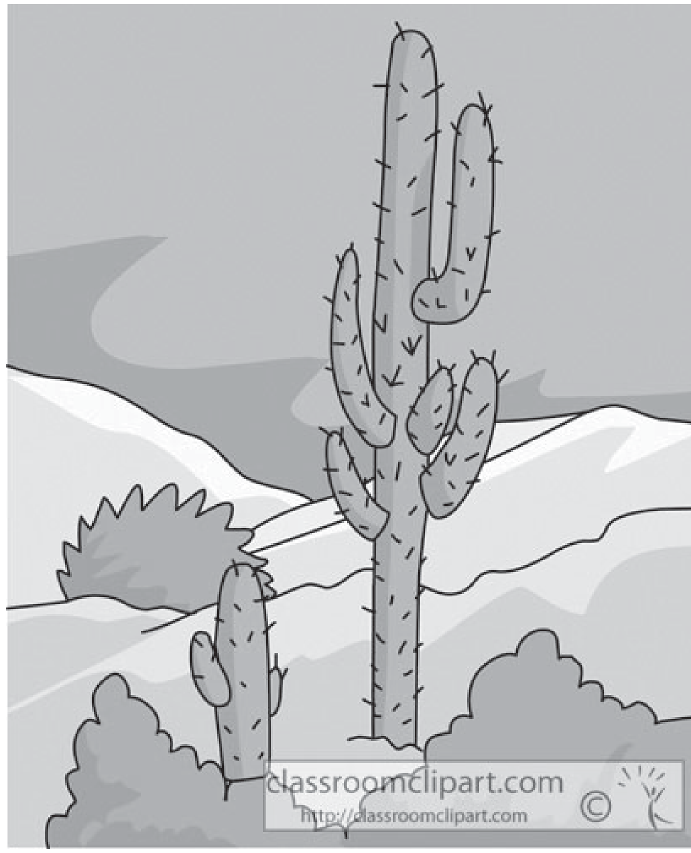
The spines (thorns, stickers) of a cactus are highly modified versions of plant leaves, there are very few cacti species with true plant leaves. These sharp spines and the thick tough skin of the stem help to protect the cactus from animals who would otherwise have easy access to the liquid inside.

The cactus manages to collect its water using its quite large root system. Small thin roots grow near the surface of the soil and collect as much rainwater as quickly as possible during the few times it rains. Cacti can also have a single long thick root called a taproot which grows much deeper to reach underground water supplies when the top soil is dry.

Cacti can gather and hold a lot of water in their stems. The water is not pure, clear water but is quite a thick viscous liquid. It is drinkable though and has been known to save many peoples lives in the desert.

In the early 1800s when cacti were first taken back to Europe they were cultivated as ornamental plants. Rare species were often sold to collectors for very high prices. Today cacti continue to be grown as houseplants as they are pretty easy to grow and maintain.

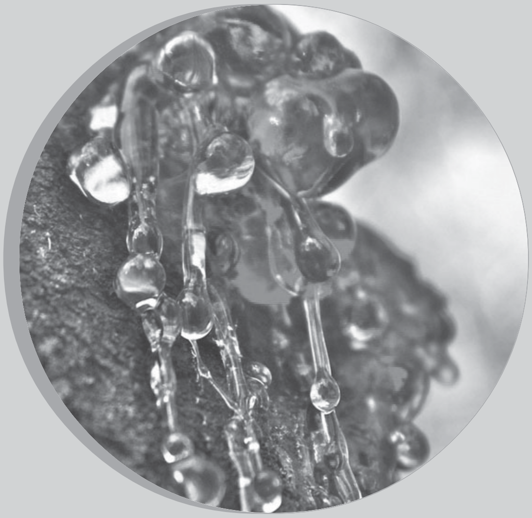
Certain kinds of cactus have fruit that are a popular source of food. The dragon fruit (pitahaya) is now widely grown in Asia. The prickly pear or Indian fig are varieties of cacti whereby both the fruit (called tuna in Spanish) and the pads (called nopal in Spanish) can be eaten.



The nopal industry in Mexico was worth around US$150 million in 2007 and the fruit (nopal) is an important commercial crop in Mediterranean and North African countries.

Wild cactuses are under threat from building developments, animal grazing and collectors digging them up. All cacti are now included in the 'Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES)'. Unless permits are issued, international exports of most species is illegal. Some cacti species are on the more restrictive endangered species list and can only be exported for scientific purposes.

Science facts



♦ Tree resin which has been fossilized is known as amber, it sometimes contains plant material or small animals that were trapped inside.

♦ Some plants are carnivores, gaining nutrients by eating various small insects and spiders. A well known example of a carnivorous plant is the Venus Flytrap.

♦ Bamboo can be a fast growing plant, some types can grow almost a metre in just one day!

♦ While using energy from sunlight, plants turn carbon dioxide into food in a process called photosynthesis.

♦ Around 2000 different types of plants are used by humans to make food.

♦ Onions might taste good but they can be painful to chop. A gas is released when you cut onions that irritates you eyes, the tears you produce while this happens are your body's way of washing it from your eyes.

♦ In the agricultural industry, to ensure crops of food grow well water is often added to soil in the form of irrigation.

♦ Plant matter found at the bottom of areas with water such as swamps can eventually turn into coal due to a process called metamorphosis (changing form).

♦ There are over 200,000 identified plant species and the list is growing all the time.

♦ Poison ivy produces a skin irritant called urushiol. Touching poison ivy will cause an allergic reaction, usually in the form of an itchy rash on the skin.

♦ Fertilizers are chemicals added to plants to help them grow. Important elements in fertilizers include nitrogen, phosphorus and potassium. Manure (animal waste) is also used as a fertilizer.

http://www.sciencekids.co.nz/sciencefacts/plants.html