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Exploration of Antarctica

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Antarctica is the name of a great continent covered with snow and ice that surrounds the South Pole. It is the 5th largest continent and covers about 14 million square kilometres, an area about the size of the United States and Mexico combined and has a coastline of 29,600 kms. Over countless years, snow and ice have built up on the land burying all but 4.5 per cent of it. The ice sheet counts for about 90 per cent of the world's ice. If this were to melt, sea level would rise at least 75 metres.

Antarctica is the place where a full year consists of only one day and one night, each of six months duration. Daylight at the South Pole begins on 21 September and ends on 21 March.

It is the coldest and windest continent in the world. Lowest temperature ever recorded on our planet is – 88.3°C which is found in the last continent — Antarctica.

The Antartica mainland nurtures no trees and shelters no mammals other than some seaguls. It supports only a few species of birds such as penguins (flightless birds), snow petrels, and polar skuas.

An Emperor Penguin in Antarctica. The emperor penguins are larger birds; an average bird stands about three feet tall and weighs about twenty-seven kg. In the autumn a single egg is laid. The young chicks are hatched and raised during the cold and dark antarctic winter in temperatures as low as –79°C.

Man has done magnificent work in wresting secrets from this cold continent but Antarctica still remains a land of mystery.

The author, who was the first Indian to visit the South Pole, tells us a fascinating story of the exploration of Antarctica.

Antarctica is the last *terra incognita* on the Earth, covered with snow and ice that surrounds the South Pole. Men's

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minds were haunted by the idea of a great southern continent for many centuries before Antarctica was discovered. Earlier, the ancient Greeks believed that a great southern continent must exist in order to balance the land masses of the Northern Hemisphere. The name of the region has come from the Greek "Antarktikos" which means 'Opposite the Bear', the northern constellation i.e. the 'Opposite of the Arctic'.

Many famous voyages were made to discover the fabled continent because men imagined it to be populated and to contain great riches. It was on 17 January 1773, that Captain James Cook of the British Navy became the first man to cross the Antarctic Circle, and brought to an end the dream of an inhabited southern continent. In 1820 Captain Nathaniel Palmer of Stonington, Connecticut, and commander Thaddeus Bellingshausen, and an officer of the Russian Navy, sighted the continent near the tip of the Antarctic Peninsula. The real proof that Antarctica was a continent came from the adventurous voyages of Lieutenant Charles Wilkes of the United States Navy, Captain Dumont d'Urville of the French Navy, and James Clark Ross of the British Navy in 1838-41. After Wilkes, d'Urville and Ross returned to their homelands, men lost interest in Antarctic exploration. For nearly 50 years only sporadic endeavours were made to learn more about the mysterious white continent, although sealers and whalers continued their operations to the far south for hunting whales and seals.

Shortly after 1890, interest in the Antarctic revived, to continue forever, because the scientists were then convinced that more must be learnt about the south polar region if we are to understand the world and the universe better. Moreover, new methods of whaling made it possible to catch and use Antarctic whales and seals for the prospect of riches from fur and blubber oil.

In 1901, German, Swedish, and British expeditions took to the field. All had their thrilling times. Their experiences proved that men could live in the Antarctic from what they could find there, although a diet of seal and penguin is somewhat monotonous. In 1901 Captain Falcon Scott of the Royal Navy led the British National Antarctic Expedition (1901-1904). It could be said to be the first expedition to Antarctica which had very strong scientific interest. Enough scientific information was then collected to put Antarctic studies and research on a sound basis. From 1901-1912, Scottish, French, Japanese, German and Norwegian expeditions were actrive in the area.

The climax of the heroic period came in 1911 and 1912 when the South Pole was reached. First to arrive there was the great Norwegian explorer, Roald Amundsen with his four companions, on 14 December 1911. On 17 January 1912, about a month after Amundsen, Captain Scott and four other Englishmen stood on the same spot. On their return from the Pole, misfortune followed their footsteps. Captain Scott had collected about 13 kg of rocks for scientific interests. This was really a triumph of science. A distinguished Australian Scientist, Mawson, was one of the truly great Antarctic explorers, who, in 1911-1914, set up a camp there, at what is perhaps the windiest place in the world. Winds of over 170-320 km an hour are very frequent there. A young British Naval officer, Lieutenant Ernest Shackleton, took his first expedition to the Antarctic in 1907. The Antarctic entered his heart never to be absent until his death. In one of the greatest adventures, Shackleton and his men spent over six months in tents on drifting ice. He lies buried in South Georgia, the gateway to Antarctica and his grave is a shrine to all who pass that way.

The period from 1895 to 1915 has sometimes been referred to as the Heroic Age of Antarctic Exploration. The period following World War I can be thought of as the beginning of the Mechanical Age. The urgent demands of the war speeded the development of the airplane, the aerial camera, radio and motorised transport and all of these devices were introduced into Antarctic Exploration before 1930. Sir Hubert Wilkin, Australian leader of the American financed Wilkins-Hearst Antarctic Expedition, made the first airplane flight in Antarctic History on 26 November, 1928. In fact, it was Rear Admiral Richard E. Byrd who proved the usefulness of the airplane in Antarctica and brought modern machines and methods of communiction to the area. Some expeditions dug trenches in which buildings were placed with the hope that snow would blow across the covered trench with minimum accumulation. Pre-fabricated buildings were commonly used in Antarctica and for small stations, vans called Wanigans, have often been used. Looking like house trailers on skis they were pulled into place by tracked vehicles. Because the Wanigans can be moved it is possible to relocate them on the surface as snow piles up. It was not until the advent of the new technical advances, such as aircraft, radios and aerial photography, that the bulk of the Antarctic coastlines and interior were first crudely mapped in the late pre-World War II period. Afterward, much-improved technical developments further stimulated interest in exploring the continent.

The first big step toward a long-range scientific effort was taken in 1956-57. To continue the international scientific cooperation that was so important, a feature of the International Geophysical year (IGY), the International Council of Scientific Unions established Scientific Committee on Antarctic Research (SCAR). The Committee develops broad programmes in which it identifies subjects for investigation, establishes goals to be achieved and describes uniform methods for collection and presenting information. Permanent occupation also made it desirable to regulate political relationships in the Antarctic because prior to the IGY, seven governments had laid claim to portions of Antarctica while three of the claims overlapped one another. In 1959 an Antarctic Treaty extending for 30 years was signed by 12 nations then actively exploring Antarctica. They were Argentina, Australia, Belgium, Chile, France, Japan, New Zealand, Norway, South Africa, the Union of Soviet Socialist Republics, the United Kingdom and the United States of America. The Antarctic

Treaty was signed on 1 December, 1959 and became effective on 23 June, 1961 when the last ratification was received. Since 1959, Czechoslovakia, Poland, Denmark and the Netherlands have also joined. Provisions of the Treaty opened Antarctica to unrestricted scientific exploration in a spirit of international cooperation. With the advent of the Treaty of Antarctic continent developed into a scientific laboratory of the first order, where extensive research is being continued since the IGY.

India became involved in scientific research in Antarctica as a result of an agreement with the USSR for joint meteorological exploration of the upper atmosphere. Under this agreement the author was the Project Scientist with the Soviet Antarctica Expedition during 1971-1973 and became the first Indian ever to winter over the South Pole and circumnavigate the Antarctic continent. (A brief account of the participation in the Expedition was published in Autumn 78 issue of 'Indian Mountaineer').

The great bulk of knowledge about Antarctica has been accumulated since the mid 1950s. Before that information was acquired slowly because Antarctica is not only remote but its access is too limited and difficult. In only a few places does this continent extend north of the Antarctic Circle, an imaginary line around the Earth at about 66° 33' South Latitude. Including its permanently attached ice shelves, Antarctica covers about 14 million square kilometres, an area about the size of the United States of America and Mexico combined. Over countless years, snow and ice have built up on the land burying all but 4.5 per cent of it. It is the fifth largest continent and has the highest average elevation, about 2.5 km and is overlain by a continental ice sheet containing about 90 per cent of the world's ice. If this ice were to melt, sea level would rise at least 75 m. Antarctica has about 29,600 km of coastline and off the shore there are many islands which are also ice-covered. They, too, are considered to be part of the South Polar region usually called the Antarctic.

Surrounding the Antarctic are the confluent portions of the Pacific, Atlantic and Indian Oceans. These waters are notoriously the stormiest in the world because there is nothing to break the force of the persistent winds. Warmer tropical waters meet with cold Antarctic waters in a remarkably discernible climatic and oceanic boundary ranging to the 50th Parallel known as the Antarctic Convergence. This circumpolar line which varies considerably with longitude but generally within and not more than a degree or two of latitude per year establishes a boundary between subtemperate and sub-antarctic zones. South of the convergence the waters are characteristically ice-laden and abound with subpolar acquatic life. It is a feeding region for myriads of pelagic sea birds, the world's largest population of seals and of whales. Sealing and whaling have provided Antarctica with its only economic activity, the former was conducted principally in the subantarctic islands and the latter on the high seas.

Along the coast piedmont glaciers, ice tongues and ice shelves discharge flat-topped icebergs into the sea. Tabular icebergs are unique to Antarctica and in some cases may be hundreds of square kilometres in area. Where glaciers have receded along the periphery of the continent, there, occasionally occur cold, arid deserts, described as 'dry valleys' or 'Oases', their total area constitutes 5,600 square kilometres. Farther inland, the gentle rolling surfaces of the ice-covered and crevassed regions, in places, reflect the hidden topography, and the nature of the sub-ice relied is also plainly apparent from the rugged mountains and nunataks which dominate the interior landscape. Seismic and gravity exploration also indicates vast low lands, some depressed below sea level beneath the existing ice sheet. The Antarctic continent has a diameter of about 4,500 km and is asymmetrically divided by the Transantarctic Mountains into two sub-continents, East and West Antarctica. Extensive low-quality bituminous coal outcrops to within 320-480 km of the South Pole, yield plant fossils which portray an earlier age when the land was forested. About 640 km from the South Pole were found some fossil remains of primitive fresh water amphibia and reptiles known as labyrinthodents and thecodents. A reptilian skull identified as Lystrosaurus establishes the former existence of the great southern continent Gondwanaland.

About three-quarters of Antarctica lie in East Antarctica which appears to be more contiguosly a continental mass. The sub-surface beneath the ice is extremely rugged except west of Victoria land where it appears to be an extensive plain close to sea level; the maximum elevation (more than 4,000 m) occurs slightly east of the pole of inaccessibility. Almost all and certainly the most extensive 'eases' occur in East Antarctica, Mount Melbourne and Mount Erebus, both active volcanoes in the Mc-Murdo Sound region are in the East and West Antarctica respectively. West Antarctica which includes Marie Byrd Land, Ellsworth Land and the Antarctica Peninsula is the smaller sub-division and generally lower in elevation. Ice soundings have shown this region to be largely an ice-covered archipelago; much of the central area is occupied by the Byrd subglacial Basin with a depth as much as 2,500 m below sea level. Ice thickness between the 'islands' ranges to 4,270 m with elevations 1,200-1,800 m above seal level. Volcanic activity in historic times is identified with Deception Island. In sharp contrast to the lushness of sea life, the continent is virtually lifeless and devoid of the familiar vegetational features seen on other land masses. It is without forests, brush or grass lands and lacks rivers, estuaries and marshes. Antarctica has no native land vertebrates and its fresh water fauna consists of microscopic forms. The major vegetation of lichens, bryophytes and algae rarely rises over 5 cm above the ground. The dominant land organisms are arthropods, mites, springtails and wingless midge. However, during the short austral summer millions of sea birds, penguins and seals migrate to Antarctica, competing for space on ancestral breeding grounds and bringing to the silent continent the noise and activity of life.

Even with the tremendous effort since 1955 to unlock its secrets, Antarctica remains the least known of the continents. This fact alone should ensure that explorer-scientists will be going south for a long time. Even now, scientists are developing techniques which will broaden their horizons and suggest to their imaginations new subjects for Antarctic research. There are, for example, data recording machines powered by radioactive isotopes. Thus they have been used primarily as automatic weather stations and some difficulties have been encountered in getting them to operate properly in the Antarctic environment. These problems, however, can be solved allowing expanded use of such devices. A network of automatic stations would offer the meteorologist a manifold increase in the number of observations available for both forecasting and the study of climate. Similar data-recording machines can be used in other studies. Satellites in polar orbit offer other possibilities. By radios, satellites could receive information from automatic observatories in Antarctica and retransmit it to laboratories and weather centres around the world. Satellites may also help to solve one of the greatest problems in Antarctic operations – loss of communications. Satellites already have their place in Antarctic meteorology, and geophysical satellites passing over the area have obtained information unavailable to observers on the ground. Satellites carrying different sensing equipment appear to have numberless uses in the Antarctic. Very little is known about the ice pack, the floating belt of sea ice that surrounds the continent. Although satellites orbitting a hundred or more miles up can play a part here, a closer look will also be necessary. Small submersibles carried by an icebreaker will be undoubtedly useful in the Antarctic waters.

The future of the Antarctica as a scientific laboratory seems assured but its natural resources are not much. The most easily reached are those of the sea. Since the 1890s the whales of the southern oceans have been hunted for their oil and meat. International agreement, however, has failed to adequately protect the stocks, and whaling is a declining industry — perhaps a dying one. There are, though, the vast quantities of plankton on which most Antarctic life is based, and the Japanese and the Soviet have been investigating whether plankton can be used for human nourishment. The abundant life of the southern seas may contribute notably to the future of mankind. Development of Antarctica's mineral resources is a remote event. At present both the nature of these resources and their extent are imperfectly known. Even if the mineral resources prove to be valuable, the techniques for exploitation do not now exist. It would be, however, unwise to say that the necessary techniques cannot be developed. The Antarctic has modest prospects for tourism and its ses have real possibilities as a source of food but the pursuit of scientific knowledge will long be its main attraction. Scientific data will remain the chief export and the men who obtain it will continue to be the principal inhabitants. No monetary values can be placed on scientific discoveries but anything which expands man's understanding of his environment will help him improve his condition. In 1966, Peter Scott, son of the famous Captain Scott, visited the Antarctic and he pointed out that half the scientific research now drawing the explorer-scientitists to the area is on topics not even guessed at in his father's days. It is predicted that new fields requiring polar research will continue to appear because the future of Antarctica is strongly linked to the future of science itself.

Foundation of Acoustics

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ACOUSTICS is the science of sound. In the first century B.C., the Roman architect Vitruvius explained in De architectura, his famous 10-volume treatise on architecture, that sound "moves in an endless number of circular rounds, like the innumerably increasing circular waves which appear when a stone is thrown into smooth water ... but while in the case of water the circles move horizontally on a plane surface, the voice not only proceeds horizontally, but also ascends vertically by regular stages". While Vitruvius did not understand everything sound, he was correct about this particular point. Greek mathematician Pythagoras during the 6th century B.C. and Greek philosopher Aristotle during the 4th century B.C. had rudimentary knowledge of sound propagation. The subject has developed enormously during the last four centuries. The term sound implies not only the phenomena in air responsible for the sensation of hearing but also whatever else is governed by analogous physical principles. Thus, disturbances with frequencies too low (infrasound) or too high (ultrasound and hypersound) not to be heard by a normal person are also regarded as sound. In words of Keats, "Heard melodies are sweeter, but those unheard are even sweeter."

The broad scope of acoustics as an area of interest and endeavour can be ascribed to a variety of reasons. Acoustics is one of the most important branches derived from Physics. This is as old as humanity itself. Over the years the development has been wonderfully crafted to make this more an applied technology. Acoustics is a multi-faced discipline that has progressed into an application and has developed into many disciplines. Interesting feature of Acoustics is that we live with sound around us and each sound has a definitive meaning. Mellifluous flow of water, quiet waves, chirping of birds, tuned music of insects and sounds produced by tuned instruments were considered to be acoustics. Advent of technology has found many faceted applications of acoustics and this has been instrumental in having various disciplines of acoustics namely— Architectural Acoustics, Building Acoustics, Environmental Acoustics, Physical Acoustics, Machinery Acoustics, Musical Acoustics, Theatrical Acoustics, Speech Acoustics, etc. Thus in the present days of industrialisation, acoustics in general has wide application to many spheres of activity. Sound may be the means of measurement for diagnosis for one and may also be the means of recognition for another. Subjective nature of this energy is useful in deriving a definitive meaning for speech production and processing in Speech Acoustics. Sound of varied types as a mellifluous form of energy produced by the instruments could be well fused to suit sound of music to make listeners get themselves tuned to life to an escalating beating of drums in orchestrated sound. Also, with the power of spectra, ultrasound techniques have been influential in the science of human body in identification of foreign body to growth of any biological matter inside the same. With the greater emphasis on environmental health and safety, noise—the unwanted sound as put in the right perspective has become a strong source of severe health hazard in most parts of the globe. Specially, developing nations like India has had this pollutant with little or no control. The power of ultrasound, the power of artificial neural network, acoustics emission, signal processing, developments of new treatments, new testing a calibrating facilities are some of the latest contributions to the modern world. New processes and new techniques are being added to the list of the time-tested processes.

In general, sound radiates in waves in all directions from a point source until it encounters obstacles like walls or ceilings. Two characteristics of these sound waves are of particular interest to us in acoustics: intensity and frequency. Intensity is a physical measurement of a sound wave that relates to how loud a sound is perceived to be. We can also measure the frequency of a sound wave, which we perceive as pitch. For example, on a piano, the keys to the right have a higher pitch than those to the left. If a sound has just one frequency, it is called a pure tone, but most everyday sounds like speech, music, and noise are complex sounds composed of a mix of different frequencies. The importance of frequency arises when a sound wave encounters a surface: the sound will react differently at different frequencies. The sensitivity of the human ear also varies with frequency, and we are more likely to be disturbed by medium-to-high frequency noises, especially pure tones. Think of sound as a beam, like a ray of light, passing through space and encountering objects. When sound strikes a surface, a number of things can happen, including:

Transmission— The sound passes through the surface into the space beyond it, like light passing through a window glass.

Absorption— The surface absorbs the sound like a sponge absorbs water.

Reflection— The sound strikes the surface and changes direction like a ball bouncing off a wall.

Diffusion— The sound strikes the surface and is scattered in many directions, like pins being hit by a bowling ball. (Figure 1). Keep in mind that

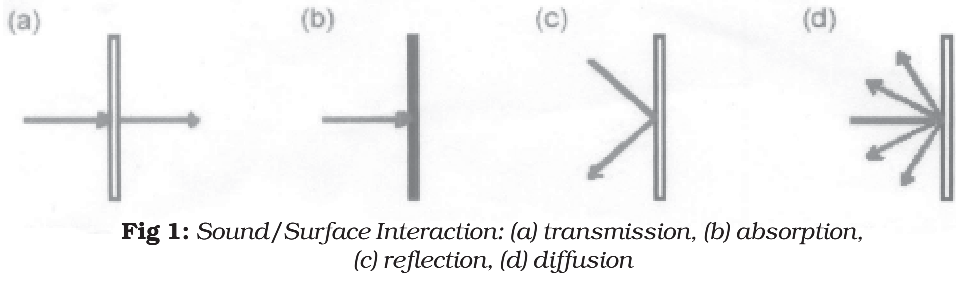

Fig 1: *Sound/Surface Interaction: (a) transmission, (b) absorption, (c) reflection, (d) diffusion*

several of these actions can occur simultaneously. For instance, a sound wave can, at the same time, be both reflected and partially absorbed by a wall.

As a result, the reflected wave will not be as loud as the initial wave. The frequency of the sound also makes a different. Many surfaces absorb sounds with high frequencies and reflect sounds with low frequencies. The Absorption Coefficient (a) and NRC (noise reduction coefficient) are used to specify the ability of a material to absorb sound. A special problem that results from reflected sound is that of discrete echoes. Most people are familiar with the phenomenon of shouting into a canyon and hearing one's voice answer a second later. Echoes can also happen in rooms, albeit more quickly. If a teacher's voice is continuously echoing off the back wall of a classroom, each echo will interfere with the next word, making the lecture difficult to understand. Echoes are also a common problem in gymnasiums. Another type of echo that interferes with hearing is flutter echo. When two flat, hard surfaces are parallel, a sound can rapidly bounce back and forth between them and create a ringing effect. This can happen between two walls, or a floor and ceiling. Sound intensity levels and sound pressure levels can be measured in decibels (dB). In general, loud sounds have a greater dB value than soft sounds. Because the decibel scale is logarithmic rather than linear, decibles cannot be added in the usual way. An important acoustical measurement called Reverberation Time [RT or RT(60)] is used to determine how quickly decays sound in a room. Reverberation time depends on the physical volume and surface materials of a room. Large spaces, such as cathedrals and gymnasiums, usually have longer reverberation times and sound "lively" or sometimes "boomy". Small rooms, such as bedrooms and recording studios, are usually less reverberant and sound "dry" or "dead". The Noise Reduction (NR) of a wall (also expressed in dB) between two rooms is found by measuring what percentage of the sound produced in one room passes through the wall into the neighbouring room (Figure 2). The NR is calculated by

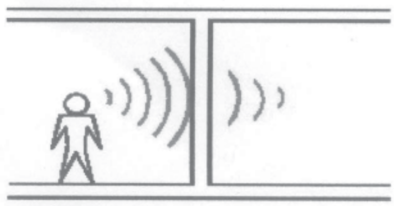

Fig 2: Noise Reduction between two spaces by a dividing wall

subtracting the noise level in dB in the receiving room from the noise level in the source room. Speech intelligibility can be evaluated in existing rooms by using word lists. Several tests are performed wherein one person recites words from a standard list, and listeners write down what they hear. The percentage of words listeners correctly hear is a measure of the room's speech intelligibility.

Frequency

Frequency is an important factor in most acoustical measurements. Sound occurs when a vibrating source causes small fluctuations in the air, and frequency is the rate of repetition of these vibrations. Frequency is measure in hertz (Hz), where 1 Hz = 1 cycle per second. A young person with normal hearing can detect a wide range of frequencies from about 20 to 20,000 Hz. In order to deal with such a large spectrum, acousticians commonly divide the frequency range into sections called octave bands. Each octave band is identified by its center frequency. For the standard octave bands these center frequencies are: 63, 125, 250, 500, 1000, 2000, 4000, and 8000 Hz. As you can see, the ratio of successive frequencies is 2:1, just like an octave in music. This also correlates with the sensitivity of the ear to frequency, since a change in frequency is more readily distinguished at lower frequencies than at higher ones. For example, the shift from 100 to 105 Hz is more noticeable than the shift from 8000 to 8005 Hz. Higher-frequency octave bands contain a wider range of frequencies than lower-frequency octave bands, but we perceive them as approximately equal. To obtain a more detailed indicator of the spectrum of sound power, measurements are often made in the one-third octave frequency bands. Standard center frequencies for the one-third octave bands are: 50, 63, 80, 100, 125, 160, 200, 250, 315, 400, 500, 630, 800 and 1000 Hz, etc. Note that an octave band contains the one-third octave band at the standard band center frequency plus the one-third octave bands on each side.

Decibels

The most common measure of a sound's level is Sound Pressure Level, or SPL, expressed in decibels, abbreviated dB. Decibels are not typical units like inches or pounds in that they do not linearly relate to a specific quantity. Instead,

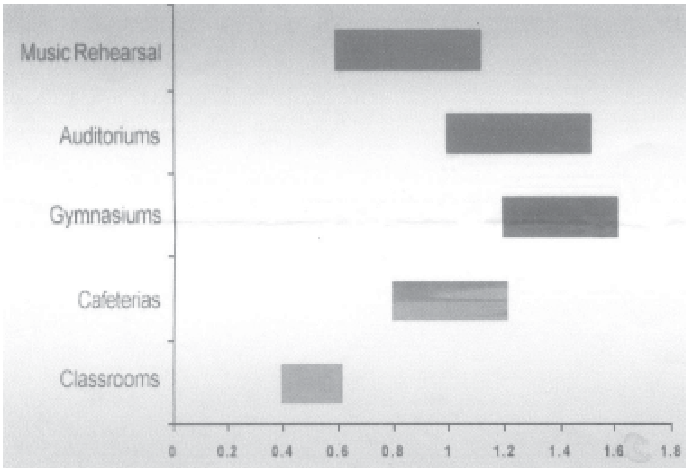

Fig 3: *Suitable Reverberation Times (in seconds) for various rooms typically found in educational facilities.*

decibels are based on the logarithmic ratio of the sound power or intensity to a reference power or intensity. Sound power and intensity are not easy to measure. However, sound pressure is easily measured with a sound level meter. Sound pressure may also be expressed in dB since sound pressure squared is proportional to sound power or intensity. We use dB instead of the actual amplitude of the sound in units of pressure because its logarithmic value represents the way our ears interpret sound and because the numbers are more manageable for our calculations. Most sounds fall in the range of 0 to 140 dB, which is equivalent to waves with pressures of 20 to 200,000,000 micropascals (or 2×10^{-10} to 2×10^{-2} atm). To help you get a feeling for sound pressure levels (in dB), the approximate SPLs of some common sound sources are given in Figure 4.

Source	***SPL (dBA)***
Faintest audible sound	0
Whisper	20
Quiet residence	30
Soft stereo in residence	40
Speech range	50–70
Cafeteria	80
Pneumatic jackhammer	90
Loud crowd noise	100
Accelerating motorcycle	100
Rock concert	120
Jet enjine (22.5m away)	140

Fig. 4: *Sound Pressure Levels of common sound sources.*

A simple sound level meter combines sound pressure levels over all frequencies to give the overall SPL in dB. More complex meters have filters that can measure the SPL in each octave band or one-third octave band separately so we can identify the level in each band, thus identifying the spectrum of the sound. Sound level meters can also "weight" the sound pressure level by adjusting the level in different frequencies before combining the levels into a weighted overall level. For example, A-weighting reduces the level of sounds at low frequencies to stimulate the variations in sensitivity of the ear to different frequencies. A-weighting slightly reduces the dBA to differentiate them from unweighted dB levels. Similarly, C-weighted values are labeled dBC. C-weighting slightly reduces the level of sounds below 50 and above 5000 Hz, but is nearly flat in between, and can be used to approximate an unweighted reading on sound level meters that only offer A- or C-weighting. Comparing A- and C-weighted levels for a noise source can provide a rough estimate of its frequency distribution. If the two levels are within 1 or 2 dB, most of the noise is above 500 Hz. If the two levels vary by more than a few dB, a significant amount of the noise is in the lower frequencies. To convert unweighted octave band sound pressure levels into weighted A or C levels, add or subtract the amounts noted in Figure 5 from the corresponding frequency bands. Next, sum the octave band levels (two at a time as explained below) to arrive at the overall dBA or dBC value.

	Octave Band Center Frequency (Hz)								
	31	63	125	250	500	1000	2000	4000	8000
A-weighting	-40	-26	-16	-9	-3	0	+1	+1	-1
c-Weighting	-2	0	0	0	0	0	0	-3	

Fig. 5: *Frequency Discrimination in dB for A and C weighting.*

As mentioned earlier, calculating the SPL of two sources together is not as simple as adding their individual decibel levels. Two people speaking at 70 dBA each are not as loud as a jet engine at 140 dBA. To combine two decibel values, they must be converted back to pressure squared, summed, and converted back to decibels. The mathematics may be approximated by using Figure 6.

Difference between two decibel values	***Amount added to higher value***
0 or 1	3
2 or 3	2
4 to 9	1
10 or more	0

Fig. 6: *Decibel "Addition"*

If one sound is much louder than the other, the louder sound drowns out the softer sound, and the combined decibel level is just the level of the louder sound. If the two sounds are equally loud, then the combined level is 3 dB higher. More than two sources can be combined, but they must be considered two at a time. For example, an unbuilt classroom is expected to have 34 dBA of mechanical system noise, a computer that generates 32 dBA of noise, and an overhead projector that generates 43 dBA. What will be the total sound pressure level from the three noise sources? The difference between the first two decibel values is: 34–32=2, so add 2 dB to the higher value: 34+2=36 dBA. Then combine this with the projector noise: 43–36=7, so add 1 dB to the higher value: 43+1=44 dBA total from the three noise sources. If the SPL of the teacher's voice is 55 dBA, what is the signal-to-noise ratio in the room? 55–44=+11 dB, which is sufficient for good speech intelligibility. How much louder is the total 44 dBA than each of the individual noise sources? Due to the response of our ears, we can just notice a different of 3dB. An increase of 10 dB sounds approximately twice as loud, and an increase of 20 dB sounds about four times as loud.

Reverberation Time

Over 100 years ago, a Harvard physics professor named Wallace Clement Sabine developed the first equation for reverberation time, which has since been named after him and is still used today. Reverberation time is defined as the length of time required for sound to decay 60 dB from its initial level. Sabine's simple formula is:

RT (60) = 0.05V / (?S?)

Where:

RT(60) = reverberation time (sec)
V = room volume (ft^3)
S = surface area (ft^2)
? = absorption coefficient of material(s) at given frequency
? indicates the summation of S times ? for all room surfaces

To use this formula, the volume of the room, surface area of each material in the room, and absorption coefficients for those materials must be known. Absorption coefficients are measured in specialized laboratories, and represent the fraction of sound energy (not sound level-dB) the material will absorb as a decimal from 0 to 1. A commonly used one-number rating called NRC (Noise Reduction Coefficient) is simply the average of the absorption coefficients at 250, 500, 1000 and 2000 Hz. This simple, one-number rating can be useful for comparing the relative absorption of two materials; however, examining absorption coefficients in each octave band gives a better idea of the performance of a material at various frequencies. Reverberation time is often calculated with the room unoccupied. Since people and their clothing provide additional sound absorption, an unoccupied room is the worst-case scenario, though not an unreasonable one, since occupancy of most classrooms varies. In a complete analysis, this calculation should be performed for each octave band, as the RT can vary widely at different frequencies. However, for a quick estimate, the RT of a classroom can be calculated for just one octave band representative of speech frequencies, such as 1000 Hz. If this RT is acceptable, then the RT throughout the speech range will likely be acceptable.

Speech Intelligibility

There are many methods for measuring or predicting speech intelligibility, ranging from a simple A-weighted sound level to the complex Speech Transmission Index (STI). Speech intelligibility can be predicted from reverberation time and signal-to-noise ratio. Speech intelligibility tests can be used to measure intelligibility in existing rooms. Such tests can take many forms. Typically, a speaker reads nonsense syllables, monosyllabic words, or sentences, and listeners record what they hear, or choose from a list of possible alternatives. The percentage of test items correctly heard is a measure of speech intelligibility. Standardized tests have been developed that outline test procedure, selection of listeners, training of speakers and listeners, and so on. Also available are recordings or standardized word lists that can be reproduced instead of having a speaker read from a list. This eliminates lip reading cues and variations in different speakers' speech characteristics and speech levels. Before beginning actual testing, listeners should practice taking the tests in a quiet environment until they are familiar with the procedure and their scores reach a stable level (Words used are randomly chosen from a standardized list so listeners cannot simply memorize the order of the words). If speech intelligibility in a classroom is less than 90 per cent, acoustical treatments should be implemented to reduce reverberation and/or improve signal-to-noise ratio.

Noise Criteria Rating

The noise level in a space can be effectively described with a single-number rating called the noise criteria (NC) rating. The NC rating is determined by measuring the sound pressure level of the noise in each octave band, plotting these levels on a graph, and then comparing the results to established NC curves. The lowest NC curve not exceeded by the plotted noise spectrum is the NC rating of the sound. On most graphs, NC curves are shown in intervals of 5 to save space, but the NC rating can be given as any whole number in between, not just as a multiple of 5.

Sound Level vs. Distance

We all know that sound level decreases as the distance from a sound source increases. This decrease in sound level is quantified by the inverse square law. That is, the sound energy decrease is proportional to the square of the distance increase. For example, if the listening distance from a sound source is increased by a factor of 2 (doubled), the direct sound energy is decreased by a factor of 4 or 2 squared (2 times 2). This translates to a 6 dB reduction in the sound intensity level and the sound pressure level of the direct sound for each doubling of the distance from the sound source.

Astronomy in Science and in Human Culture*

Jawaharlal Nehru Memorial Lecture 1969

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IT IS HARDLY necessary for me to say how deeply sensitive I am to the honour of giving this second lecture in this series founded in the memory of the most illustrious name of independent modern India. As Pandit Jawaharlal Nehru has written, "The roots of an Indian grow deep into the ancient soil; and though the future beckons, the past holds back."

I hope I will be forgiven if I stray for a moment from the announced topic of my lecture to recall, how forty-one years ago, I was one of thousands of students who went to greet young Jawaharlal (as we used to call him at that time) on his arrival to address the National Congress meeting in Madras that year.

I recall also how the dominant feeling in all of us at that time was one of intense pride in the men amongst us and in what they inspired in us. Lokamanya Tilak, Mahatma Gandhi, Lala Lajpat Rai, Motilal Nehru, Jawaharlal Nehru, Sardar Patel, Sarojini Naidu, Rabindranath Tagore, Srinivasa Ramanujan – names that herald the giants that lived amongst us in that pre-dawn era.

The topic I have chosen for this lecture, "Astronomy in Science and in Human Culture," is so large that I am afraid that what I can say on this occasion can at best be a collection of incoherent thoughts. In the first part of the lecture' I shall make some general observations on ancient Hindu astronomy, particularly with reference to the way it relates Hindu culture to the other cultures of antiquity. I am not in any sense a student of these matters. My knowledge is solely derived from the writings of a distinguished historian of science, Professor Otto Neugebauer, who has kindly helped me in preparing this part of my lecture.

In the second part of the lecture I shall say something about the particular role of astronomy in expanding the realm of man's curiosity about his environment.

One aspect of astronomy is certain: it is the only science for which we have a continuous record from ancient times to the present. As Abdul-Qasim Said ibn Ahmad wrote in 1068 in a book entitled, *"The Categories of Nations":* "The category of nations which has cultivated the sciences form an elite and as essential part of the creation of Allah." And he enumerated eight nations as belonging to this class: "The Hindus, the Persians, the Chaldeans, the Hebrews, the Greeks, the Romans, the Egyptians, and the Arabs".

Chronologically, the interactions between the leading civilizations of the ancient world are far more complex than this simple enumeration suggests. And a study of these interactions provides us with the most impressive testimony to man's abiding interest in the universe around him.

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We know today that Babylonian astronomy reached a scientific level only a century or two before the beginning of Greek astronomy in the fourth century B.C. The development of Hellenistic astronomy, after its early beginnings, to its last perfection by Ptolemy in 140 A.D. is largely unknown. Then about three centuries later Indian astronomy, manifestly influenced by Greek method., emerged. This last fact raises the question as to the way in which this transmission of information from Greece to India took place. Its answer is made particularly difficult since it implies possible Persian intermediaries. Some centuries later, in the ninth century, Islamic astronomy appears influenced by Hindu as well as Hellenistic sources.

While the Greek astronomy rapidly became dominant in the eastern part of the Muslim world from Egypt to Persia, the methods of Hindu astronomy persisted in Western Europe even as late as the fifteenth century, as I shall indicate later.

As far as Babylonian astronomy is concerned, we know very little about its earlier phases. But it appears that a mathematical approach to the prediction of lunar and planetary theory was not developed before the fifth century B.C.: that is to say barely prior to the corresponding stage of development of Greek astronomy. It is, however, generally agreed that the development of Babylonian astronomy took place independently of the Greeks.

An important distinction between the Babylonian and the Greek methods is this: Babylonian methods are strictly arithmetical in character and are not derived from a geometrical model *of* planetary motion; the Greek methods, on the other hand, have invariably had a geometric basis. This distinction enables us to identify their influence in Hindu astronomy.

Let me make a few remarks on Greek astronomy as it is relevant to my further discussion.

The earliest Greek model that was devised to account for the appearance of planetary motion is that of Eudoxus in the middle of fourth century B.C. On this model planetary motion was interpreted as a superposition of uniform rotations about certain inclined axes. In spite of, many glaring inadequacies, this model had a profound impact on subsequent planetary theory. The culmination of Hellenistic astronomy is, of course, contained in Ptolemy's "Almagest" – perhaps the greatest book on astronomy ever written; and it remained unsurpassed and unsuperceded until the beginning of the modern age of astronomy with Kepler.

Ptolemy's modification of lunar theory is of special importance for the problem of the transmission of Greek astronomy to India. The essentially Greek origin of the Surya Siddhanta which is the classical textbook of Hindu astronomy — cannot be doubted: it is manifested in the terminology, in the units used, and in the computational methods. But Hindu astronomy of the North does not appear to have been influenced by the Ptolemic refinements of the lunar theory; and this appears to be true with planetary theory also. This fact is of importance: a study of Hindu astronomy will give us much needed information on the development of Greek astronomy from Hipparchus in 150 B.C. to Ptolemy in 150 A.D.

In early Hindu astronomy, as summarised by Varaha Mihira in the Pancha Siddhantika, we can distinguish two distinct methods of approach: the trigonometric methods best known through Surya Siddhanta and the arithmetical methods of Babylonian astronomy in the astronomy of the South. The Babylonian influence has come to light only in recent years; and I shall presently refer to its continued active presence in the Tamil tradition of the seventeenth and the eighteenth centuries.

I should perhaps state explicitly here that the fact that Hindu astronomy was deeply influenced by the West does not by any means exclude that it developed independent and original methods. It is known, for example, that in Hindu astronomy the chords of a circle were replaced by the more convenient trigonometric function sin a – (Rsin a).

Before I conclude with some remarks on the simultaneous existence of two distinct astronomical traditions in India I should like to illustrate my general remarks by two specific illustrations which are of some interest.

In 1825 Colonel John Warren, of the East India Company, stationed at Fort St. George, Madras, wrote a book of over 500 quarto pages entitled *Kala Sankalita with a Collection of Memoirs on the Various Methods According to Which the Southern Part of India divided Time*. In this book, Warren described how he had found a calendar maker in Pondicherry who showed him how to compute a lunar eclipse by means of shells placed on the ground and from tables memorised as he stated "by means of certain artificial words and phrases." Warren narrates that even though his informer did not understand a word of the theories of Hindu astronomy he was nevertheless endowed with a memory sufficient to arrange very distinctly his operations in his mind and on the ground." And Warren's informer illustrated his methods by computing for him the circumstances of the lunar eclipse of May 31-June 1, 1825 with an error of + 4 minutes for the beginning, –23 minutes for the middle, and –52 minutes for the end. But it is not the degree of accuracy of his result that concerns us here; it is rather the fact that a continuous tradition still survived in 1825, a tradition that can be traced back to the sixth century A.D. with Varaha Mihira, to the third century in the Roman Empire and to the Seleucid cuneiform tablets of the second and the third centuries.

A second instance I should like to mention is an example of the survival of Hindu astronomy in parts of the Western world that were remote from Hellenistic influences during the medieval times. A Latin manuscript has recently been published which contains chronological and astronomical computations for year 1428 for the geographical latitude of Newminster, England. It used methods manifestly related to Surya Siddhanta. Obviously one has to assume Islamic intermediaries for a contact of this kind between England of the fifteenth century and Hindu astronomy.

While Surya Siddhanta manifests Greek influence, Babylonian influence has recently been established in the post-Vedic and pre-Surya Siddhanta period. For example, in the astronomy of that period, the assumption of a longest day of 18 muhurtas and a shortest day of 12 muhurtas were made. This ratio of 3:2 is hardly possible for India. But it is appropriate for Mesapotamia; and possible doubts about the Babylonian origin of this ratio were removed when the same ratio was actually found in Babylonian texts. In addition, a whole group of other parallels between Babylonian and Indian astronomy have since been established. Thus, the most characteristic feature of Hindu time reckoning—the tithis—occurs in Babylonian lunar theory.

Clearly all these facts must be taken into account in any rational attempt to evaluate the intellectual contacts between ancient India and the Western world. This problem of the foreign contacts is by no means the only, or even the most important, fact that is to be ascertained. One must consider the Dravidic civilisations of the South on par with the history, the language, and the literature of the Aryan component of Indian culture. It is, as Neugebauer has emphasised, this dualism of Tamil and Sanskrit sources that will provide for us, eventually, a deeper insight into the structure of Indian astronomy.

In his book *"Rome Beyond Imperial Frontiers."* Sir Mortimer Wheeler comes to the conclusion that "the far more extensive contacts with South India have been a blessing to the archeologists" but he adds that "these contacts had no influence on these cultures themselves." Hindu astronomy provides an example to the contrary. Exactly as it is possible to distinguish between commercial contacts which India had through the Punjab or through the Malabar and CoromandaI Coast, it is possible to distinguish the astronomy of the Surya Siddhanta on the one hand and the Tamil methods on the other. This distinction is indeed very marked. The Surya Siddhanta is clearly based on pre-Ptolemaic Greek methods while the Tamil methods, in their essentially arithmetical character, manifest the influence of Babylonian astronomy of the Selecuid – Parthian period.

One must not, of course, conclude that the Tamil methods were imported directly from Mesapotamia while the geometric methods came to the North via the Greeks and through, Persian intermediaries. And as I stated earlier, the fact that the Surya Siddhanta appears to have not been influenced by the Ptolemaic refinements, provides an important key to the development of Hellenistic astronomy between the times of Hipparchus and Ptolemy.

A proper assessment of the role of Hindu science in the ancient world has yet to be made. The problem is made more difficult, than is necessary, by the tendency of the majority of publications of Indian scholars to claim priority for Hindu discoveries and to deny foreign influence, as well as, the opposite tendency among some European scholars. These tendencies on both sides have been aggravated by the inadequate publication of the original documents: this is indeed the most pressing need.

Since no astronomy at an advanced level can exist without actual computations of planetary and lunar ephimerides, it must be the first task of the historian of Hindu astronomy to search for such texts. Such texts are indeed preserved in great numbers, though actually written in very late periods. But the publication of this material is an urgent need in the exploration of oriental astronomy.

Let me conclude this somewhat incoherent account, bearing on the ancient culture of India, by emphasising that its principal interest lies not in the sharing or in the apportioning of credit to one nation or another but rather in the continuing thread of common understanding that has bound the elite nations of Abul-Qasim ibn Ahmad in man's constant quest to comprehend his environment.

The pursuit of astronomy at the more sophisticated level of modern science, since the time of Galileo and Kepler, is concerned with the same broad questions even though that fact is often observed by the technical details of particular investigations.

Questions that may naturally occur to one often appear to be meaningless in the context of current science. But with the progress of science questions that appear as meaningless to one generation become meaningful to another. It is to this aspect of the development of astronomy in recent times that I should like to turn my attention now.

The first question that I shall consider concerns the assumption that is implicit in all sciences. Nature is governed by the same set of laws at all places and at all times, i.e. Nature's laws are universal. That the validity of this assumption must be raised and answered in the affirmative was the supreme inspiration which came to Newton as he saw the apple fall. Let me explain.

Galileo had formulated the elementary laws of mechanics governing the motions of bodies as they occur on the earth; and the laws he formulated were based on his studies of the motions of projectiles, of falling bodies, and of pendulums. And Galileo had, of course, confirmed the Copernican doctrine by observing the motions of the satellites of Jupiter with his telescope. But the question whether a set of laws could be formulated which governed equally the motions of all bodies, whether they be of stones thrown on the earth or of planets in their motions about the sun, did not occur to Galileo or his contemporaries. And it was the falling apple that triggered in Newton's mind the following crucial train of thought.

All over the earth objects are attracted towards the centre of the earth. How far does this tendency go? Can it reach as far as the moon? Galileo had already shown that a state of uniform motion is as natural as a state of rest and that deviations from uniform motion must imply force. If then the moon were relieved of all forces, it would leave its circular orbit about the earth and go off along the instantaneous tangent to the orbit. Consequently, so argued Newton, if the motion of the moon is due to the attraction of the earth, then what the attraction really does is to draw the motion out of the tangent and into the orbit. As Newton knew the period and the distance of the moon, he could compute how much the moon falls away from the tangent in one second. Comparing this result with the speed of falling bodies, Newton found the ratio of the two speeds to be about 1 to 3600. And as the moon is sixty times farther from the centre of the earth than we are, Newton concluded that the attractive force due to the earth decreases as the square of the distance. The question then arose: If the earth can be the centre of such an attractive force, then does a similar force reside in the sun, and is that force in turn responsible for the motions of the planets about the sun? Newton immediately saw that if one supposed that the sun had an attractive property similar to the earth, then Kepler's laws of planetary motion become explicable at once. On these grounds, Newton formulated his law of gravitation with lofty grandeur. He stated:

"Every particle in the universe attracts every other particle in the universe with a force directly as the product of the masses of the two particles and inversely as the square of their distance apart." Notice that Newton was not content in saying that the sun attracts the planets according to his law and that the earth also attracts the particles in its neighbourhood in a similar manner. Instead with sweeping generality, he asserted that the property of gravitational attraction must be shared by all matter and that his law has universal validity.

During the eighteenth century, the ramifications of Newton's laws for all manner of details of planetary motions were investigated and explored. But whether the validity of Newton's laws could be extended beyond the solar system was considered doubtful by many. However, in 1803 William Herschel was able to announce from his study of close pairs of stars that in some instances the pairs represented real physical binaries revolving in orbits about each other. Herschel's observations further established that the apparent orbits were ellipses and that Kepler's second law of planetary motion, that equal areas are described in equal times, was also valid. The applicability of Newton's laws of gravitation to the distant stars was thus established. The question whether a uniform set of laws could be formulated for all matter in the universe became at last an established tenet of science. And the first great revolution in scientific thought had been accomplished.

Let me turn next to the second great revolution in explicit context of astronomy that was accomplished during the middle of the last century.

During the eighteenth century the idealist philosopher Bishop Berkeley claimed that the sun, the moon, and the stars are but so many sensations in our mind and that it would be meaningless to inquire, for example, as to the composition of the stars. And it was an oft-quoted statement of Auguste Compte, a positivist philosopher, influential during the early part of the nineteenth century, that is in the nature of things that we shall never know what the stars are made of. And yet that very-question became meaningful and the centre of astronomical interest very soon afterwards. Let me tell this story very briefly.

You are familiar with Newton's demonstration of the chapter of white light by allowing sunlight to pass through a small round hole and letting the pencil of light so isolated fall on the face of a prism. The pencil of light was dispersed by the prism into its constituent rainbow colours. In 1802 it occurred to an English physicist, William Wollaston, to substitute the round hole, used by Newton and his successors to admit the light to be examined with the prism, with an elongated crevice (or slit as we would now say) 1/20th of an inch in width. Wollaston noticed that the spectrum thus formed, of light "purified" (as he stated) by the abolition of overlapping images, was traversed by seven dark lines. These Wollaston took to be the natural boundaries of the various colours. Satisfied with this quasi-explanation, he allowed the subject to drop. The subject was independently taken up in 1814 by the great Munich optician Fraunhofer. In the course of experiments of light, directed towards the perfecting of his achromatic lenses, Fraunhofer, by means of a slit and a telescope, made the surprising discovery that the solar spectrum is crossed not by seven lines but by thousands of obscure streaks. He counted some six hundred and carefully mapped over three hundred of them. Nor did Fraunhofer stop there. He applied the same system of examination to other stars; and he found that the spectra of these stars, while they differ in details from that of the sun, are similar to it in that they are also traversed by dark lines,

The explanation of these dark lines of Fraunhofer was sought widely and earnestly. But convincing evidence as to their true nature came only in the fall of 1859 when the great German physicist 'Kirchhoff formulated his laws of radiation. His laws in this context consist of two parts. The first part states that each substance emits radiations characteristic of itself and only of itself. And the second part states that if radiation from a higher temperature traverses a gas at a lower temperature, glowing with its own characteristic radiations, then in the light which is transmitted the characteristic radiations of the glowing gas will appear as dark lines in a bright background. It is clear that in these two prepositions we have the basis for a chemical analysis 'of the atmospheres of the sun and the stars. By comparisons with the spectral emissions produced by terrestrial substances, Kirchhoff was able to identify the presence of sodium, iron, magnesium, calcium, and a host of other elements in the atmosphere of the sun. The question which had been considered as meaningless only a few years earlier had acquired meaning. The modern age of astrophysics began with Kirchhoff and continues to the present. And we all know that one of the major contributions to our understanding of the spectra of stars and the physics of stellar atmospheres was made in our own times by Meghnad Saha.

Now I come to a question that man has always put to Nature: Was there a natural beginning to the universe around us? Or to put the question more directly: How did it all begin? All religions and all philosophical systems have felt the need and the urge to answer this question. Indeed, one may say that a theory of the universe, a theory of cosmology, underlies all religions and all myths. And one of the earliest cosmologies, formulated as such, occurs in the Babylonian epic Enuma Elish in the second millennium B.C. The poem opens with a description of the universe as it was in the beginning:

When a sky above had not been mentioned

And the name of firm ground below had not been thought of

When only primeval Apsu, their begetter,

And Mummu and Ti'amat—she who gave birth to them all—

Were mingling their waters in one;

When no God whosoever had appeared,

Had been named by name had been determined as to his lot,

Then were Gods formed within them.

Whether the question of the origin of the universe can be answered on rational scientific grounds is not clear. It might be simplest to suppose that in all aspects the astronomical universe has always been. Or, alternatively, following Compte we might even say that it is in the nature of things that we shall never know how or when the universe began. Nevertheless, recent discoveries in astronomy have enabled us for the first time to contemplate rationally the question: Was there a natural beginning to the present order of the astronomical universe? A related question is: If the astronomical universe did have a beginning, then are we entitled to suppose that the laws of Nature have remained unchanged? The two questions are clearly related.

Let me take the second question first. Have the laws of Nature remained the same? Can the universality of Nature's laws implied by Newton in his formulation of the laws of gravitation, be extended to all time in a changing universe?

It is clear that over limited periods of time the laws of Nature can be assumed not to have changed. After all, the motions of planets have been followed accurately over the past three centuries– and less accurately over all historical times – and all we know about planetary motions has been accounted for with great precision with the same Newtonian laws and with the same value for the constant of gravitation. Moreover, the physical properties of the Milky Way system have been studied over most of its extent—and its extent is 30,000 light years. It can be asserted that the laws of atomic physics have not changed measurably during a period of this extent. And on the earth geological strata have been dated for times which go back several hundreds of millions of years. In particular the dating of these strata by the radio-active content of the minerals they contain assumes that the laws of physics have not changed over these long periods. But if during these times the astronomical universe in its broad aspects has not changed appreciably then the assumption that the laws have not changed appreciably during these same periods would appear to be a natural one. The questions that I have formulated, to have meaning, must be predicted on the supposition that there is a time scale on which the universe is changing its aspect. And if such a time scale exists, the first question is: What is it?

That a time scale characteristic of the universe at large exists was first suggested by the discoveries of Hubble in the early twenties. There are two parts to Hubble's discoveries.

The first part related to what may be considered as the fundamental unit or constituents of the universe. It emerged unequivocally from Hubble's studies that the fundamental units are the galaxies of which our own Milky Way system is not an untypical one. Galaxies occur in a wide variety of shapes and forms. The majority exhibit extraordinary organisation and pattern.

To fix ideas, let me say that a galaxy contains some ten billion or more stars; its dimension can be measured in thousands of light years: our own galaxy has a radius of 30,000 light years. Further the distance between galaxies is about 50 to 100 times their dimensions.

The second part to Hubble's discovery is that beyond the immediate neighbourhood of our own Milky Way system, the galaxies appear to be receding from us with a velocity increasing linearly with the distance. In other words, all the galaxies appear to be running away from us as though, as Eddington once said, "we were the plague spot of the universe." Hubble's law that galaxies recede from us with a velocity proportional to the distance was deduced from an examination of their spectra.

Now suppose that we take Hubble's law literally. Then it follows that a galaxy which is twice as far as another will be receding with a velocity twice that of the nearer one. Accordingly, if we could extrapolate backwards, then both galaxies would have been on top of us at a past epoch.

More generally, we may conclude that if Hubble's relation is a strict mathematical one, then all the galaxies constituting the astronornical universe should have been together at a common point at a past calculable epoch. Whether or not we are willing to extrapolate by Hubble's law backward in this literal fashion, it is clear that the past epoch calculated in the manner I have indicated does provide a scale of time in which the universe must have changed substantially. Current analysis of the observations suggests that the scale of time so deduced is about seventy thousand million years.

With the time scale established, the question I stated earlier can be rephrased as follows: Have the laws of Nature been constant over periods as long as say thirty or forty billion years? And, what indeed was the universe like seventy thousand million years ago? These questions cannot be answered without some underlying theory.

While there are several competing theories that are presently being considered, I shall base my remarks on the framework provided by Einstein's general theory of relativity. This theory appears to me the most reasonable.

This is clearly not the occasion to digress at this point and describe the content of the theory of relativity. Suffice it to say that it is a natural generalisation of Newton's theory and a more comprehensive one. On Einstein's theory, applied to the astronomical universe in the large, it follows that at each instant the universe can be described by a scale of distance which we may call the radius of the universe. At a given epoch it measures the farthest distances from which a light signal can reach us. This radius varies with the time. Its currently estimated value is ten thousand million light years. But the most important consequence that follows from the theory is that this radius of the universe was zero at a certain calculable past epoch some seventy thousand million years ago. In other words, the conclusion arrived at by a naive extrapolation backwards of Hubble's law, interpreted literally, is indeed a valid one. That the theory predicts such a singular origin for the universe is surprising; but it has been established rigorously, with great generality, by a young English mathematician, Roger Penrose.

And finally, it is an exact consequence of the theory that the ratio of the wavelengths of an identified line in the light of a distant galaxy to the wavelength of the same source as measured here and now is the same as the ratio of the radius of the universe now and as it was when the light was emitted by the galaxy.

During the past few years a dozen or more objects have been discovered for which the ratio of the wavelengths I mentioned is about three. Precisely what has been found is the following. In a laboratory source hydrogen emits a line with a wavelength that is about a third of the wavelength of the visible extreme violet light. But this same line emitted by the stellar object in the remote past and arriving here on earth now is actually observed in visible light. The fact that all the identifiable spectral lines in these objects are shifted by a factor of about three, means that the radius of the universe at the time light left these objects was three times smaller and the density was some twenty-seven times greater than they are now. And a careful analysis of the spectrum shows that during this span of time at any rate the laws of atomic physics have not changed to any measurable extent. To have been able to see back in time when the density of the universe was thirty times what it is now is, of course, a considerable advance. But even this ratio is very far from what it would have been if we take the relativistic picture and go further back in time when the radius of the universe was say ten thousand million times smaller, not merely three times or a thousand times smaller. Does it appear that this extrapolation is meaningless and fanciful? But the general theory of relativity gives a theoretical meaning to such a question since a state of affairs attained by such extrapolation is predicted as an initial state for our present universe. In other words, the question is meaningful, and one can reasonably ask: Is there anything we can observe now that can be considered as the residue or the remnant of that initial singular past? But to answer this question we must take the relativistic picture seriously and determine what it has to say about that remote past. Such a determination has been made by Robert Dicke and his associates at Princeton.

Dicke calculated that at the time the radius of the universe was 10^o times smaller, the temperature should have been some ten thousand million degrees – in other words, a veritable fireball. And as the universe expanded, radiation of this very high temperature, which would have filled the universe at that time, would be reduced. For example, its temperature would have fallen to ten thousand degrees after the first ten million years. As the universe continues to expand beyond this point, the radiation will cool adiabatically, i.e. in the same manner as gas in a chamber will cool if it is suddenly expanded. And Dicke concludes that the radiation from the original fireball must now fill the universe uniformly, but that its temperature must be very low—in fact 3^o Kelvin, a temperature that is attainable in the laboratory only by liquefying helium. It corresponds to radiation at a temperature of 270^o of frost. How can we detect this low temperature radiation?

It can be shown that this radiation at 270^o of frost should have its maximum observable intensity at wavelength in the neighbourhood of 3 millimetres i.e. the radiation must be present in the microwave region. The remarkable fact is that radiation in these wavelengths has been detected; it comes with incredible uniformity from all directions; and they have all the properties that one might, on theoretical grounds, want to attribute to such fossil radiation from the original fireball.

With these discoveries I have described astronomy appears to have justified the curiosity that man has felt about the origin of the universe, from the beginning of time.

As I said at the outset, man's contemplation of the astronomical universe has provided us with the one continuous threat that connects us with antiquity. And might I add now that it has also inspired in him the best.

Social Insects—I. Ants*

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Insects are grouped under the Class Insecta of the' animal kingdom. More than a million different species of insects have been described and named so far. Individuals belonging to many of these species are numerous and are sometimes described as 'clouds darkening the sky' and 'swarms carpeting the ground for miles'. Some insects are large enough to be visible but a large majority are minute and can hardly be seen without the help of a magnifying glass. Notwithstanding their small size, the total bulk of animal matter in their bodies added together would exceed that of all the other land animals.

Most of the insects live on land, either on the surface, or in flight in the air above it. Many live in fresh water, mostly until they reach the adult stage; some live in water even as adults.

A few species dwell along the seashore above the low-water mark. Some of the land insects are migrants and make long flights over land and sea.

Insects differ in their food habits; some eat all types of plants, some every animal substance, some are selective, and yet others eat nothing at all. Mayflies and some moths and caddis flies eat nothing at all and are abstainers. Wood wasps, the majority of moths, beetles, and larvae of many insects are vegetarians.

Many beetles, flies, some bugs and grasshoppers are carnivorous, eating both living and dead animal food. Many insects, like some crickets, grasshoppers and beetles eat anything that comes in their way (omnivorous). Most of the social insects (ants, bees, wasps, termites) change from one type of diet to another in their life history: as larvae they are carnivorous and as adults vegetarians.

Some insects, like mosquitoes, are harmful to man, yet some like the honey bee and silkworm are useful.

Many insects make possible the cross-fertilisation of flowering plants, by visiting the flowers in search of nectar and carrying their pollen from one bloom to another.

Some insects help nature by cleaning the earth of animal excreta, and of dead bodies. Some provide food for fish and some are used as chicken feed. Some are beautiful to look at. Some are harmful, eat our clothes, bore wood, sting, or are pests of food grains. Many thrive on human blood which they suck mercilessly. Some insects eat other insects.

A social insect is one which lives in society: each society consists of the two parents, or at least the fecundated female, and their offspring, and the two generations live to a varying extent in

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mutual co-operation in a common abode or shelter. Thus it follows that there is a lengthening of the adult or parental life of social insects so as to allow this definitive association with the progeny.

Insect societies are based on the restriction of the reproductive function to one fertilised female, known as the queen. In ants, however, the queen may give birth to supernumerary queens. The progeny of the queen, except for those that are destined to perpetuate the species, are sterile. The sterile forms become the workers, and the soldiers, are endowed with special instinctive powers that enable them to do their duties. The workers are destined to work for the good of the society.

The insect society is thus the best organised social system, the queen being the mother of the colony. She lays the eggs and is the autocratic ruler of the colony. Since duties of individuals in a colony are fixed, there is never any internal trouble or revolt, nor are there any criminals. But colonies fight and rob each other just as do nations of human beings.

These insects perform their respective duties without having any previous experience, and are guided by instinct.

Insects living in well-knit societies are ants, bees, wasps and termites.

Ants

Characters: Ants have two or more 'waists' and elbowed antennae. They have three forms: the males, the females, and the workers. The workers differ in form amongst themselves according to their functions.

The adult ants differ from all other insects in having at least one enlargement in the waist-like part of the body which produces two waists, one before and one behind the enlargement. The two waists greatly help the ants in their mobility.

The ant has unusual mouth parts. The main jaws (mandibles) and the rest of the mouth have separate functions. In most insects when the jaws are used, the mouth is necessarily open. But in ants the lower lip can be closed over the upper, completely shutting the mouth, and yet leaving the jaws free, at each side, to open or close. Thus, the ants' jaws are used both as tools, as well as 'hands' independently of the mouth.

The heads of ants have a relatively large-sized brain. The wings are absent in the workers, and are only present in the male and female. Ants have rather specialised legs, having a device combining brush and comb at the junction between the shin and foot of the forelegs. In the abdomen there are at least three notable organs. Some ants have stings together with a gland which secretes poison to be injected by them. In others the poison is there, but the sting is replaced by a squirt with which it is discharged towards the enemy. All ants have two stomachs, the first is just the crop and the second the stomach proper. Some food in the crop passes to the stomach through a valve in between them, to be digested by the ant itself; the contents of the crop are meant to be used by the State, for the needs of the queen, the young, or the hungry.

The queen is the fully fertile female and her duty is to lay fertilised eggs for the rests of her life. These eggs are deposited in a pouch which is controlled by a valve and are fertilised one by one.

The males and females are of about the same size. The workers are smaller than these two and vary greatly in size. They lack wings, have much larger heads and much smaller eyes. The males have smaller heads, much larger eyes and are winged. The queens are winged first but wingless later, their eyes are larger than those of the workers, but smaller than those of the males.

Life History: Ants live together as a social community in large numbers in nests. They live as mutually dependent members of a State, or the nest. The latter may last for ever. The nest is built through common labour of some of its inhabitants.

Preparation for founding a new colony is initiated on a hot, midsummer day.

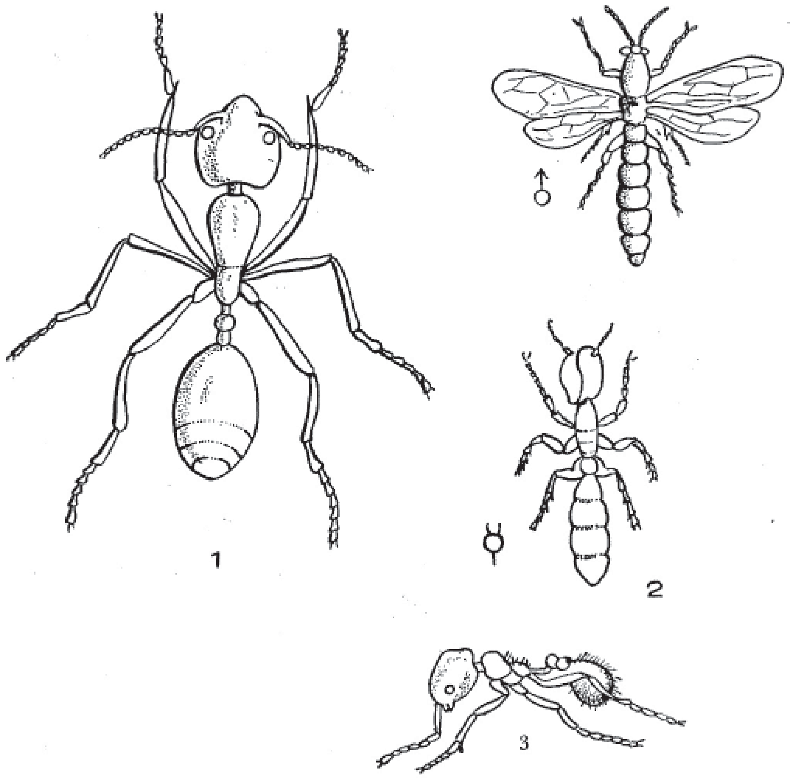

Fig. 1: *1. House ant (Worker); 2. Male and female ants; 3. Red ant (Worker)*

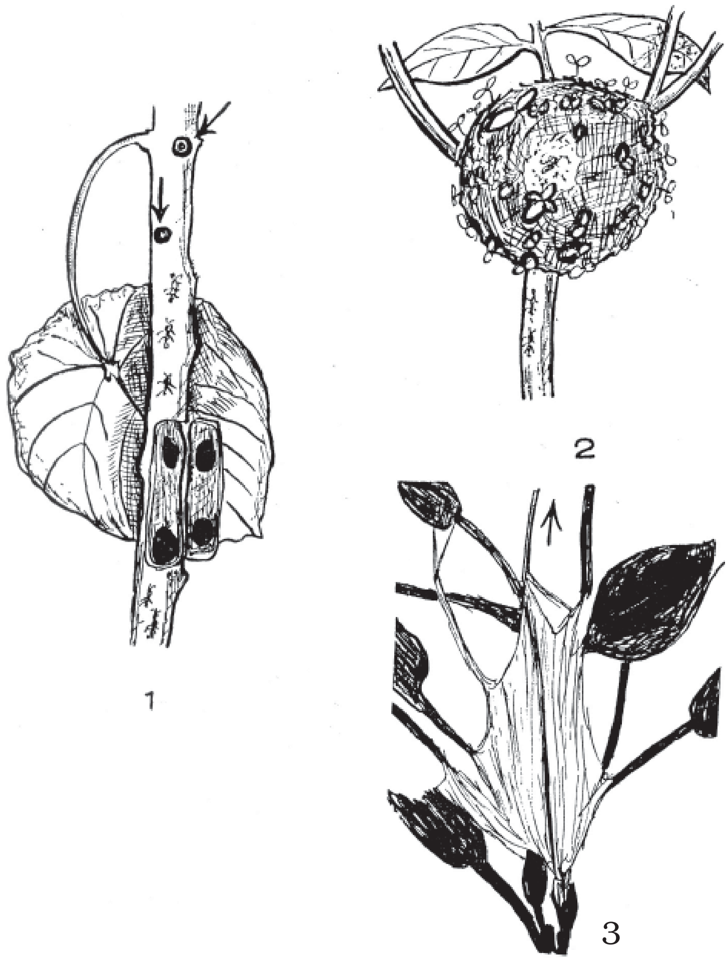

Fig. 2: *1. An ant colony in a stem, the opening is at the top. 2. Ant garden in Amazon, the nest is covered with seedlings. 3. A silky nest of ants in South India.*

The event is heralded by the flight of a winged female ant from an old nest. She is followed by other maiden queens and males from her and the neighbouring nests. Males and females pair either in the air during flight or after landing. The males die after this act. The female deposits the eggs in a pouch.

Soon the female loses her wings. She may find her way to her parent nest, or to a neighbouring nest, being welcome at both the places.

However, for founding a new colony she has to find a suitable place in the ground. She makes a hole and enlarges it into a small chamber. Here she remains in seclusion and starts fertilising her eggs.

The eggs hatched first give rise to ants which are workers. They lay the foundations of the nest. Now the queen is fed by her worker-daughters who pump the food into her. She lays one egg every ten minutes till she lives (6 to 7 years). Some queens are reported to have lived up to 13 years. The worker daughters manage the entire business of the nest: feeding, housing, nursing, and defending. They collect food for all, passing it from mouth to mouth, and thus ensure equality of rations. On some of them falls the duty of building and repairing the nest.

The nests of different species are variable. A nest is either dug into the soil or built with sticks, pine needles or leaves, or may be a combination of the two. In either case the nest is chambered.

The workers have specific duties: some build the nest and some feed the queen and carry her eggs to special chambers built for them. There the eggs hatch into larvae. The latter are moved from one chamber to another as cold and hot, dry and wet days succeed each other, so that they may have exactly the right temperature and atmosphere. Eventually they pupate and form new individuals. For defence of the colony, a staff of porters is set at the doors, which are closed at night, or in rain or severe cold, and opened in hot weather and, normally, by day. In the winter the nest is extended deeper underground. Some species keep two different nests, one for the winter and another for the summer. Once the nest is complete with its community, it is a permanent fixture.

There may be more than one queen in a nest but there is no sign of jealousy between them. When a newly fertilised queen finds her way into a nest, she is regarded as a welcome addition to the staff of the breeding department, and nothing more.

An ant nest is supposed to go on for ever. Some remain intact for over 80 years. In the larger nests more than one queen lives and .such nests may create satellite nests. But when population grows too big for a single nest, migration takes place. The surplus population moves out with one or more queens, and establishes itself in a new nest elsewhere. It is interesting to note that when the new nest is close to the old one and the ants remain in constant touch with each other, the new nest becomes a mere satellite town and citizenship is enjoyed in common between the two. But when the new nest is established far away, the communities soon become foreigners and lose the community smell by which friends are recognised. Sometimes, as in case of the fiercer species, they become enemies and are repelled and killed. The antennae are the organs through which friends and foes are known.

The ants have a long life, up to 16 years or more. During this period they learn and teach their successors. They receive guests and sometimes provide them board and lodge as well. But sometimes their permanent guests (beetles) work differently and cause the annihilation of ants. Yet when migration occurs, the guests and other lodgers may be seen as a procession of camp followers accompanying the ants on their march.

Sometimes more than one kind of ants live in the same nest. Thus, a small species builds its tunnels and chambers in the walls separating the much wider passages of a larger species. Some species live as slaves of others. A kind of martial race is also known. They only specialise in fighting.

Some do not feed themselves or build a nest. Some are slave hunters. They steal the worker pupae of another kind and when the latter grow up, they are made to do all housework and foraging for the nest. These ants mobilize their strength twice or thrice a year and issue forth to repeat their slave raids. The queens of this type behave normally but their eggs are brought up by the slaves.

Ants live mainly on the nectar from flowers, the juices of seeds, fruits, fungi, etc. The ants keep nectar aphids under their protection. Sentries are posted to defend the aphid-cattle from all invaders which belong to the nest. The paths leading to trees or shrubs on which such aphids live are also protected. Sometimes a large tree may be divided between two nests, and each will jealously defend its own side.

Social Insects—II. Bees and Wasps

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BEES LIVE in permanent communities.Their body has a marked waist. The head and thorax bear branched feathery projections which help them in collecting pollen from flowers. These projections cannot be seen by the naked eye but this character distinguishes bees from wasps. The honey bees have three types of individuals: males (drones), females (queens), and sterile females (workers) (Fig. 1). It is interesting to note that distinction between queens and workers is caused by the different food with which the larvae are fed. After hatching, the brood are fed alike for the first four days. Later, some i.e., the would-be queens are fed with richer food throughout their growth. They are finally provided with cells which are larger and better ventilated.

The males are large, stingless and bigeyed. The queen is smaller than the male. It continues to fertilise her eggs for the rest of her life which is three to four years. The workers are much smaller but have larger brains. They gather pollen in basket-shaped hind thighs and also possess the honey making and wax secreting organs. The egg-laying organ is developed and used as a weapon (sting) in the workers. After use, it is withdrawn; but if the bee is hastily shaken off, the sting and other organs are torn from her and she dies.

The adult bee feeds upon the nectar of flowers. Its larvae are fed upon the pollen of flowers mixed with honey, the latter being a substance made in the body of the bee out of nectar gathered from the blooms. The larvae of cuckoo-bees, before beginning to eat the stored honey, devour the eggs or larvae of another species of bees in whose nest they have earlier been placed!

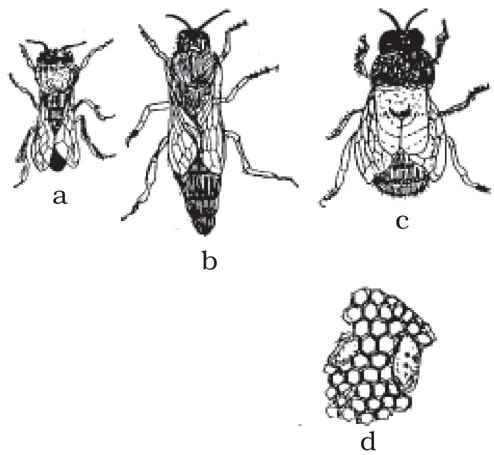

Fig. 1. *Bees: (a) worker, (b) queen, (c) drone, (d) comb – a portion of normal cells and two large queen cells*

Community Life

The permanent social community of the bees is called the hive. Here, each individual does its share of duties involved in the community life. However, communities of bees differ from those of

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ants in certain respects. The bees in the wild state build their home in a hollow tree. Under domestication, the hive is designed by man to enable him to rob the honey without killing all the bees. The 'comb', with which the hive is furnished, built of wax prepared in the bodies of the worker-bees. Such an architectural symmetry is not met within the ants' nest. In each hexagonal separate tubular cell is reared a single bee from the egg to the adult stage. Normally only one queen bee lives in a hive at a time. The hive is stored with garnered foods but the ants' nest does not usually store food. The bees fly out to gather food, but the ants walk for the same.

A new hive is founded more or less in the same way as that of the ants. In May, i.e., summer, when the hive becomes overcrowded, the community needs a new queen. At this time, the Queen Mother is led round the queen cells by her attendant workers and she is made to lay an egg in each cell. The larvae hatching from these eggs are supplied with special food or 'royal jelly'

Fig. 2. *Honey bees: a swarm clustered on a branch*

throughout their life. In about 18 days the first of the bees developed in a royal cell is crowned as the heir-apparent. She is the maiden queen. Before she leaves her royal apartment, the Queen Mother leaves the hive accompanied by a swarm (about 30,000) of faithful bees, mainly workers. The swarm flies for some time, then the queen alights and is wrapped in a protecting mass of bees as big as a watermelon. The bee-keeper, if he is lucky, collects them in this condition in a 'skep' and brings them home to a new manmade hive.

Immediately, the workers get busy in building the comb. They pluck the flakes of wax from between the segments of their bellies, mould it in their jaws, and build the exact cells they need. The wax is made from the honey which the workers carry in their crops while leaving the mother hive. The cells are of a standard size, those in the centre are the nursery cells for the young workers, those around them are the storage cells for honey and pollen. Drones are housed in larger cells and the still larger cells are the royal apartments meant for the future queens. Soon after the new hive is ready the routine life begins. The egg fertilising capacity of the queen can be increased or diminished by the amount of food given to her. In winter, she does not lay eggs but feeds herself on the storage cells.

Efforts are made to collect new stores and put these into the new comb as it is built. Each cell containing a larva is looked after well before it pupates; the cell is sealed up by the workers with a lid of pollen and wax, the latter is eaten by the emerging bee to get out.

Ventilation in the hive is provided by a novel method; the young workers, who have yet not flown, steadily fan with their wings so as to make a current of fresh inflowing air. This fanning also serves to evaporate the surplus water from the honey. The entrance is guarded by guardsman to stop intruders, particularly robbers from other hives. Some intruders which cannot be stung (such as ants) are fanned away from the entrance. The dead bees are removed by outgoing workers and dropped at a distance. The comb is repaired with a special glue which is obtained from resinous buds and twigs and secreted by workers. This is additional work for the workers who have also to collect nectar and pollen.

Incoming bees report to their fellows the discovery of any rich source of food by a dance of triumph. The scene of the dancing bee tells others what kind of flower they must seek, and once a bee has found nectar the colour of the flower helps to guide her back to it.

In the old hive, soon after the swarm departs, interesting events take place. The young queen emerges from her cell and at once dashes towards the cells in which her sister princesses are still in the pupal stage. She tears open their cells and stings them to death. How awful, yet true! Sometimes she is prevented from this murderous act by the workers and a second princess is allowed to emerge. She leads another swarm from the old hive. Thus, only one queen can stay in a hive. When the princess is the only female in the hive, she mates with a drone, returns to the hive as a feeds queen. Till she is fertile the workers do not pay any attention to her and she feeds herself at the comb. Before leaving the hive for her 'marriage' the would-be queen flies round and about the entrance to learn her way home.

The queen lives for three to four years and her end is a tragic event. As soon as it is noticed that she is no longer active, her escort ruthlessly crushes, (not sting) her to death; or she is allowed to be killed by a daughter princess. At the approach of winter another tragedy betakes the hive: there is a massacre of unwanted drones due to shortage of food. When they return to the hive hungry after their usual short unhurried flight in the sunlight, they are denied admittance and those still in the hive at the moment are attacked and thrown out. Drones still at large while the massacre is on die of cold and starvation after crawling helplessly about for a day or two.

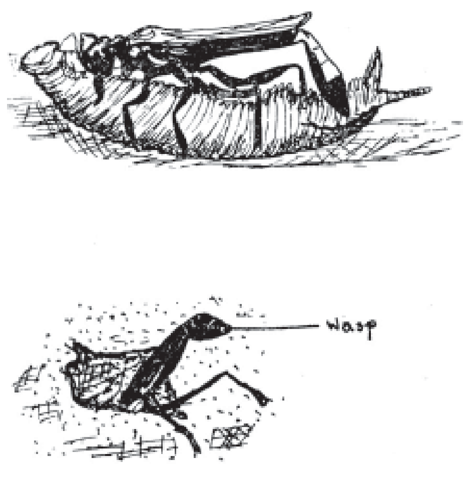

Fig. 3: *Wasps*

True Wasps

True wasps are social insects living in large colonies and producing males and females and a large number of sterile females or workers. Their social life is seasonal since the colony lasts only for a single season. The young fertilised females (queens) are the only survivors which live through winter. Each of the queens builds a new nest in the spring.

The adult wasps live on plant food, mostly nectar and sweet liquids (especially ripe fruits and jams). The young brood is fed mostly on insects captured by adults and chewed up by them before being fed to the larvae.

The mated females, like those of the ants and bees, fertilize their eggs for the rest of their lives. They hibernate during the cold weather by hanging by the jaws to curtains or other rough surfaces in some secluded spot (often in houses or sheds, in a hole in a wooden fence or a crevice in a tree). The dormant queens awake in the late spring and start constructing a nest alone. They try to find a hole under the roots of trees or shrubs and there begin to excavate a cavity, large enough to build the first comb of their nests. They do not have wax but build with wood pulp paper, filings of wood shaved from any wooden surface with their jaws and made into paper with the wasp's own saliva. The comb resembles in shape the bee hive only in that the cells are hexagonal tubes, set one beside the other, and each destined for one egg and its development into an adult wasp. The top layer is the first to be built. It has few cells to begin with and forms a solid hanging rod. It sustains the whole nest when completed. Later, layers are built below the first, each hanging from the one above it by similar rods and forming a platform upon which the wasps can walk with access to the open ends of the cells above their heads. The comb when completed is surrounded and enclosed in a very thick envelope which is constantly enlarged.

The queen after having built parts of the comb lays an egg in each cell and when the larvae hatch out, she feeds them all on countless caterpillars, flies, and other insects which she chews up and deals out from her own tongue to her hungry brood. While the larvae grow, she goes on completing their cells. Before they pupate, they themselves close the lid of the cell. Through it, they eat their way out as adult wasps. From egg-laying to emergence of the adult, it takes about a month.

The first eggs develop into workers and when they are strong enough they relieve the queen of her manual duties. She at last rests from foraging and building and gives herself exclusively to egg-laying. For a month more the nest increases and prospers and then manual comb is built with larger cells for the production of male and female wasps. With this increase in population, insect food for the brood begins to run short and it is hard for the workers to collect nectar for themselves. Besides, as their own life is drawing to a close, they set about a "reign of terror; the unhatched larvae are thrown away from their cells to the bottom of the nest hole and allowed to die there. Soon winter sets in and the whole population of the nest dies of cold and starvation. The few mated queens left to survive start fresh nests the following year.

Understanding 'Children's Construction of Biological Concepts' and Its Educational Implications

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YOUNG children possess knowledge about biological phenomenon. It enables them to make sense of what they observe about animals and plants.Motoyoshi (1979) reported that a five year old girl summarised her accumulated experiences with raising flowers by using the following analogy: "Flowers are like people. If flowers eat nothing (are not watered), they will fall down of hunger. If they eat too much (are watered too often), they will be taken ill. Motoyoshi (1979) has also reported an anecdotal example of causal attribution for an animal's unusual physical reaction. He reported an example of five year old children in a day care centre. These children were taking care of a rabbit. When one day they observed an unusual excretion, they concluded that it might be suffering from diarrhoea, as a person might suffer from diarrhoea. After a discussion amongst themselves they decided that the rabbit must be given some medicine for its diarrhoea.

Major investigations of young children's understanding of biological phenomenon agree that young children possess "theories" about biological phenomenon. The term 'theory' means a coherent body of knowledge that involves causal explanatory understanding. These theories concern internal processes involved in individual survival and reproduction of animals and plants and their external behaviours and properties relevant to these processes. Young children though are totally ignorant of physiological / behavioural mechanisms involved. They know that excessive eating leads to becoming fat but they do not know the biochemical or the physiological processes involved. The issue under debate here is whether young children possess naïve biology, a children's version of endogenous biology similar to ethno biology or folk biology which is separated from biology.

The acquisition of biological concepts can be divided as: (1) the "naïve theory of biology" that young children have before schooling and (2) naïve biology interacts with school biology to result in intuitive biology that ordinary adults in modern societies have.

Researchers have found that young children before being taught in school possess a fairly well developed body of biological knowledge that enables them to make reasonable predictions and explanations regarding biological phenomenon.

Many concepts that children develop about natural phenomenon derive from their sensory experiences. Researches undertaken in various countries have identified common features in children's ideas and developmental studies are giving useful insights into development of ideas during childhood years.

Children's understanding of the concept of Living

Researches in children's ideas of living have been carried out since 1920. The pioneering studies on children's ideas of living have been carried by Piaget who observed that children tend to regard many inanimate objects as capable of sensations, emotions and intentions. This was called as 'animism' by Piaget. Carey suggests that progression in the concept of living is linked to child's developing conceptual framework about biological processes. Young children (4-7 years) have little biological knowledge. By the age of 9-10 years, there is a marked increase in the knowledge of biology. Younger children explain bodily functions of living things and the activity of inanimate objects using a naïve psychology of human behaviour rather than the concepts of biological function. The naïve psychology is characterised by intentional causal reasoning in the child's explanations, for example, 'the sun shines in order to keep us warm'. As the biological function develops apart from human intentional causality, the animistic reasoning declines.

Some researches (e.g., Bullock, 1985; Massey and Gelman, 1988) have revealed that young children can distinguish animals and non living things in terms of ability to make self initiating movements.

Researches have also found that children use personification to identify living objects. Personification means using person analogy. Young children are familiar with humans and use their knowledge about humans to analogically attribute characteristics to less familiar animate objects. Vasniodou (1989) has reported that children tend to apply an analogy on the basis of salient similarity between the target (object to be identified) and the source. The closer the target object is biologically to a human being, the more often children recognise its similarity and thus apply the person analogy.

Some students have found that young children attribute human characteristics to targets in proportion to the extent that they are perceived to be similar to people (Carey, 1985; lnagaki and Sugiyama, 1988).

The authors of this paper had undertaken an action research in a primary school run by the Government of Delhi. It is located on the outskirts of Delhi. The research question was 'How do primary school children construct biology concepts?' The aspect of biology taken up to understand this was that of living and non living objects. The classes chosen were from I-V. Only one section of each class was taken up. Photographs of six living and six non living objects were shown to the students. They were asked to mark the objects that they consider as living. The students of classes III-V were interviewed on the responses they had given. The next two portions of this paper are based on (1) the data collected and its analysis and (2) its educational implications.

Method

Photographs of six living and six non living objects were shown to the students of classes I–V. The photographs 'are given in Appendix I. The photographs of living objects shown to the students were: tree, butterfly, flower, elephant, dog and eagle. The photographs of non living objects shown were that of sun, teddy bear, radio, clouds, train and kite. A total of 54 students were taken up for study. The number of students taken up is a delimitation of the study. The socio-economic status of the students taken up for the study was similar. They all belonged to the lower socio-economic background. Random selection procedures were used to select students for the present study. The classwise distribution of students taken up for the study is given in Table 1.

Table 1: Number of students taken in each class

Class	*No. of Students*
I	3
II	10
III	12
IV	21
V	8
Total	54

Out of the 54 students taken up for the study, 34 were interviewed in detail regarding the answers given by them. This was the other limitation. The students were asked to give the reasons for why they considered a photograph shown as that of a living object. The data was collected in February 2006.

Data Interpretation

The data collected was tabulated class wise for percentage responses. The percentage responses show the percentage of students who have considered an object living. This data was

Table 2: Shows the percentage responses of students regarding the picture being considered as that of a living object.

Cla-sses	*Sun*	*Teddy Bear*	*Tree*	*Radio*	*Clo-uds*	*Butter-fly*	*Ele-phant*	*Train*	*Flow--er*	*Dog*	*Kite*	*Eagle*
1	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*	*11*	*12*	*13*
I	100	66.6	0	100	66.6	0	100	100	0	100	100	0
II	80.0	40.0	30.0	70.0	80.0	10.0	90.0	60.0	20.0	100	40.0	10.0
III	58.0	25.0	33.3	41.7	50.0	0	100	41.7	33.3	100	16.6	8.3
IV	71.4	14.2	14.2	38.0	57.1	4.7	100	38.0	17.2	100	28.6	0
V	75.0	37.5	12.5	75.0	62.5	12.5	100	37.5	37.5	100	37.5	12.5

then analysed for classwise trends if any. The data was also analysed for changes, if any, in conceptual understanding across classes I to V. The responses given in interviews were similarly analysed class wise and across classes I to V. The responses were analysed to see the accuracy of responses as well as the correctness of the reasons attributed for calling an object living.

Classwise Analysis of Percentage Responses

The delimitation of this study especially the less number of students at the class I and class V level is a big hindrance in generalising the results at every level. Yet an effort has been made to remain objective.

The percentage of students considering an object as living or non-living can be analysed classwise to see whether any trend emerges. In this section, classwise analysis of percentage responses of an object being considered living has been taken up.

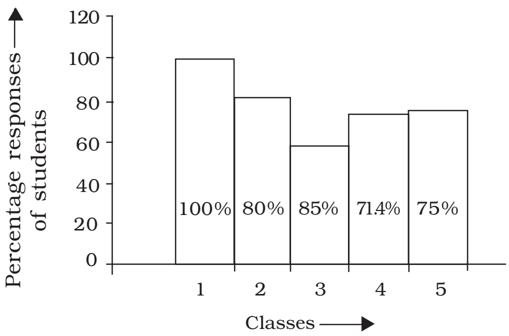

Figure 1: *Histogram showing percentage responses of students considering sun as living.*

By looking at Table 2, column 2 and Figure 1, it can be seen that the percentage of students considering sun as living comes down steadily from class I to class III and then increases from class I to class V. There is no consistent pattern of the percentage going down from class I to class V. But a broad conclusion can be drawn that with the exception of Class III, the percentage of students considering an object as living is fairly high in classes I to V.

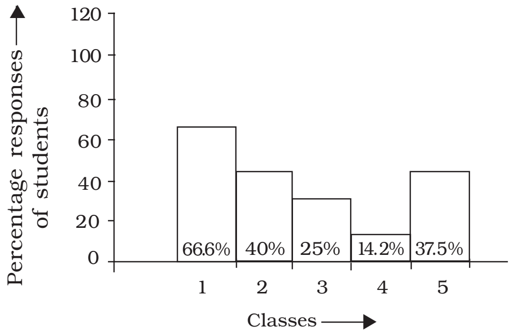

Figure 2: *Histogram showing percentage responses of students considering Teddy bear as living.*

Table 2, column 3 and Figure 2 clearly indicate that though the percentage of students considering Teddy bear as living has gone down from class I to class V, no trend has emerged. The percentage of students considering Teddy bear as living is the least amongst the class IV students.

Referring to Table 2, column 5 and Figure 3, it can be clearly seen that the percentage of students considering radio as living goes down from class I to class V. No particular trend though has emerged. The least percentage of

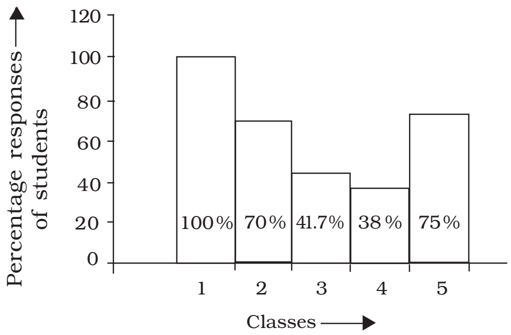

Figure 3: *Histogram showing percentage responses of students considering radio as living*

students considering radio as living is in class IV where only 38% students have considered radio as living.

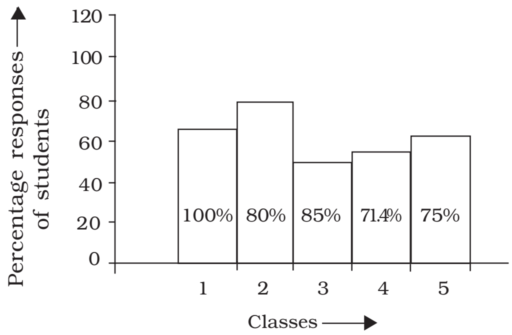

Figure 4: *Histogram showing percentage responses of students considering clouds as living*

From Table 2, column 6 and Figure 4, it emerges clearly that the percentage of students considering clouds as living decreases from class I to class V. There is a marginal increase in percentage in class IV and class V. In class III only half of those who were part of the study considered clouds as living. There, of course, is no trend that has emerged.

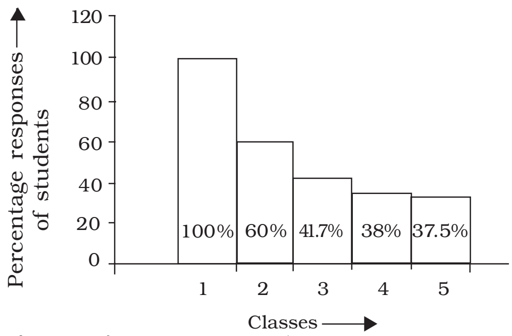

Figure 5: *Histogram showing percentage responses of students considering train as living*

From Table 2, column 9 and Figure 5, it emerges clearly that the percentage of students who consider train as living goes down steadily from class I to class V. In class V, only about one third students consider train as living. Here a trend has clearly emerged.

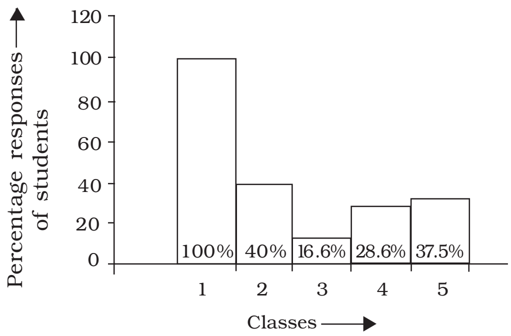

Figure 6: *Histogram showing percentage responses of students considering kite as living*

It can be seen from Table 2 column 12 and Figure 6 that all students of class I consider kite as living. The least percentage of students who consider kite as living is in class III.

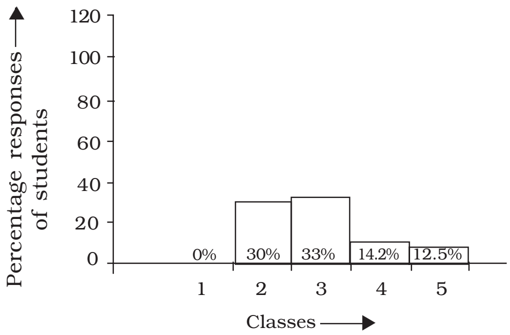

Figure 7: *Histogram showing percentage responses of students considering tree as living*

Taking up Table 2, column 4 and Figure 7, it can be seen that none of the students of class I have considered tree as living. The percentage of students considering tree as living increases in classes II and III but comes down again in classes IV and V.

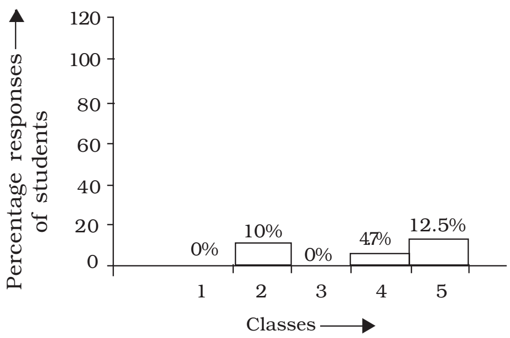

Figure 8: *Histogram showing percentage responses of students considering butterfly as living*

None of the students in classes I and III have considered butterfly as living. For rest of the classes II, IV and V no pattern has emerged. The percentage of students considering butterfly as living is though the greatest in class V. This can be seen from Table 2, column 7 and Figure 8.

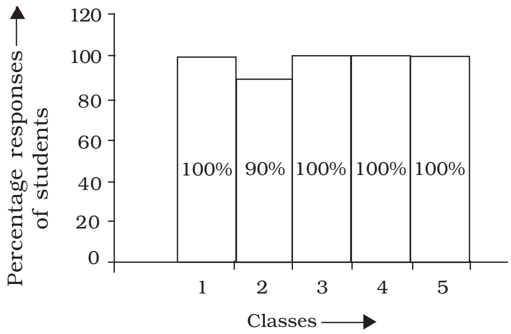

Figure 9: *Histogram showing percentage responses of students considering elephant as living*

Table 2, column 8 and Figure 9 show that except for class II where 90% students have considered elephant as living, all students (100%) of other classes have considered elephant as living.

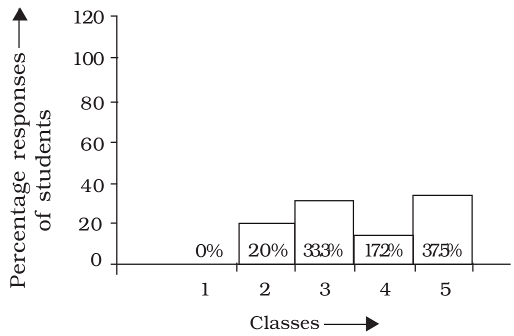

Figure 10: *Histogram showing percentage responses of students considering flower as living*

From Table 2, column 10 and Figure 10, it becomes clear that none of the class I students considers flower as living. No trend has emerged from classes II to V. The least percentage of students considering flower as living is in class IV and the maximum percentage is in class V.

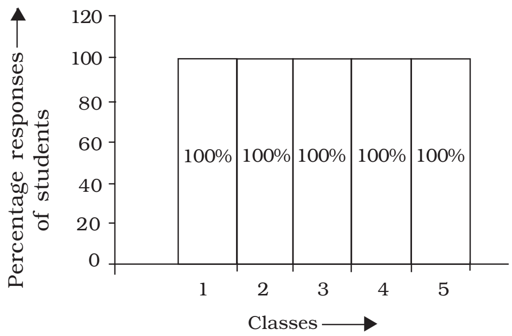

Figure 11: *Histogram showing percentage responses of students considering dog as living*

It can be clearly seen from Table 2, column 11 and Figure 11 that all students of all classes have considered dog as living.

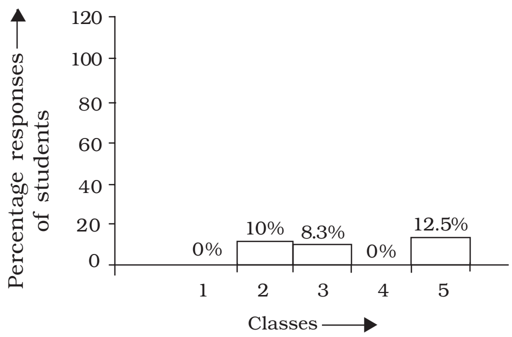

Figure 12: *Histogram showing percentage responses of students considering eagle as living*

Eagle has not been considered living by class I and class IV students as is evident from Table 2, column 13 and Figure 12. The maximum percentage of students considering eagle as living is in class V.

From the above classwise analysis of percentage responses it becomes clear that no particular trends have emerged but on the whole the following broad conclusions can be drawn:

- The percentage of students considering non living objects as living decreases from class I to class V although no trend can be established. Only in the case of train a trend of increasing percentages can be seen.
- The percentage of students considering living objects as living increases from class I class V though no trend could be established.
- Dog and elephant have been considered living by almost all students from class I to class V.

Classwise Analysis of Interviews

Students of classes I and II could not be interviewed. Only students of classes III to V could be interviewed. They were interviewed on why they considered a particular object as living.

For class III. some of the responses to the question asked have been listed below:

- Sun is living because it moves. *(Suraj zinda hai kyunki chalta hai)* - Locomotion.
- Tree is living because it moves in wind. (*Ped zinda hai kyunki hawa mein hilta hai)* - Locomotion.

- Clouds are living because they move. (*Badal zinda hai kyunki chalta hai*) Locomotion.
- Elephant is living because it moves. (*Haathi zinda hai kyunki chalta hai)* Locomotion.
- Teddy bear is not living because it does not move. *(Gudda zinda nahi hai kyunki nahi chalta*) - Locomotion.
- Train moves. (*Rail chalti hai)* - Locomotion. Sun grows. *(Suraj ugata hai)* - Growth.
- Tree grows. *(Ped ugata hai)* - Growth. Flower grows. *(Phool ugata hai)* - Growth.
- Tree grows, has green leaves. (*Ped bada hota hai, hare patte rahte hai)* - Growth.

From the above quoted examples it can be seen that in class III the students have considered two characteristics of growth and locomotion to call an object shown as living. The characteristics have been taken separately and not together to consider an object as living. Sun is therefore considered living because "it moves during the day". For the same reason clouds, train and kite have been considered living by many of the Class III students. Teddy bear according to some students is not living as it does not move. Tree and flower have been considered living as they grow. Growth to them means becoming big in size. By the same logic some students have considered sun as living According to them the sun grows bigger during the day and hence is living. The attribute of locomotion in living is their common observation of their natural surroundings. This observation has been extended to the generality that everything that moves is living. As an extension of this therefore sun, clouds, train and kite have been considered living. The other reason of attributing locomotion to these non living objects is use of erroneous language at home and later in school. Hindi is the mother tongue of these students and is also the medium of instruction in school. In Hindi, *sura} ugata hai* is used for sun rises. For flower and tree also the same term *ugata hai* is used. The children therefore erroneously consider sun as living. Similarly, use of *sura} chalta hai* in common language attributes the characteristic of locomotion to sun. The children therefore consider sun as living in the same way as dog and elephant are considered living. Dog and elephant have been considered living as they can move.

Teddy bear has been considered living by some students. They have considered the open eyes of teddy bear as a characteristic of living *(Gudde ki aankhe khuli hai).* Another student has quoted "Teddy bear sees" *(Gudda dekh raha hai).* These examples show that students have considered seeing as an attribute of living. They know that animate objects can see through their eyes. This is derived from their common everyday experience of watching dogs, cats and other animals that they come across in their lives. There are some students who have considered teddy bear as non living as it is a toy.

For class IV some of the responses to the question asked are as follows:

- Eagle flies, breathes, and eats food. *(Cheel udati hai, saans leti hai, khana khati hai).* – Locomotion, breathing, nutrition.
- Elephant runs, breathes, and eats food. *(Haathi bhagata hai, sans leta hai, khana khata hai).* – Locomotion, breathing, nutrition.
- Butterfly flies, eats food. *(Titli udati hai, khana khati hai).* – Locomotion, nutrition. Eagle breathes, makes noise, and flies. *(Cheel saans leti hai, bolti hai, udati hai).* Breathing, making noise, locomotion.
- Elephant walks, breathes. *(Haathi chalta hai, saans leta hai).* – Locomotion, breathing.
- Flower breathes. *(Phool saans leta hai).* – Breathing.
- Butterfly flies, breathes. *(Titli udati hai, saans leti hai).* – Locomotion, breathing. Tree breathes. *(Ped saans leta hai).* - Breathing.
- Flower grows. *(phool bada hota hai)* – Growth. Tree grows. *(Ped bada hota hai).* – Growth.
- Dog takes birth. *(Kutta janam leta hai).* – Reproduction.

The characteristics of living taken up by students of class IV are: locomotion, breathing, nutrition, growth, and reproduction. The students have attributed breathing and growth to both animals and plants. Some of the students have considered three characteristics together to term an object as living. For example, locomotion, breathing and nutrition to term an object as living. One of the characteristics of making noise considered by one student to term an object living is not considered as a characteristic of living by biologists. Reproduction has been taken up as a characteristic of living by one student. E.g. dog takes birth.

Many students in class IV have considered sun, train, clouds, kite, teddy bear and radio as living. The reasons quoted are the same as that quoted by students of class III. The characteristic of locomotion has been accorded to train, clouds, kite and sun for considering them as living. Radio is living for some because 'radio chalta hai'. Again the use of faulty language leads to erroneous conclusion of radio being a living object.

Students of Class V have taken up attributes of nutrition, death, growth and locomotion to consider objects shown as living. Some examples are given below:

- Eagle eats meat. *(Cheel maans khati hai)* - Nutrition.
- Flower gives fragrance and *on* cutting dies. *(Phool khushboo deta hai aur kata ho to marjata hai)* – Death.
- Trees and plants grow in (sun) light. *(Roshni se ped, paudhe badhte hai)* – Growth.
- Tree grows and if its root is cut it dies. *(Ped badhta hai aur agar jad kaat dein to mar jata hai)* – Growth and death.
- Elephant walks and eats food. *(Haathi chalta hai aur khana khaata hai)* – Locomotion and nutrition.
- Tree grows. *(Ped badtha hai)* – Growth.

- Flower grows and blooms. *(Phool badhta hai, khilta hai)* – Growth.
- Dog runs. *(Kutta bhagta, daulta hai)* – Locomotion.
- Eagle flies and eats things. *(Cheel udati hai aur cheezon ko khati hai)* – Locomotion and nutrition.
- Tree breaks when it dies and its leaves dry up. *(Ped marne par apne aap tut jata hai, pattiyan sookh jaati hai)* – Death.
- Elephant walks and eats food. *(Haathi chalta hai, khaana khaata hai)* – Locomotion and nutrition.
- Elephant roars, walks and eats sugarcane. *(Haathi dahata hai, chalta hai, ganne khaata hai).* – Locomotion, nutrition.
- Eagle eats food just as we eat food. *(Cheel hamari tarah khaana khati hai)* – Nutrition.
- Butterfly flies and sucks nectar from flowers. *(Titli udati hai, phoolon ka ras choosti hai)* – Locomotion and nutrition.
- Tree gets strength from water (grows) and it breathes. *(Ped ko jal se taakat milti hai aur woh saans leta hai)* – Growth and breathing.
- Tree uses fertile soil, sun's rays and gives fruits. *(Ped upjao mitti, sooraj ki kirne leta hai, phal deta hai)* – Nutrition.

The students of class V have been able to specify the type of food eaten by animals. E.g. eagle eats meat; Elephant eats sugarcane. Though the characteristic of death is not included in the biological definition of living, the students implicitly understand that living objects die. This might be their common observation. They have exemplified this through statements such as: flowers die on cutting, tree breaks up when it dies and leaves dry up. One of the causes of death cited is – if the root is cut the tree dies. This is termed as the use of vitalistic causality (Inagaki and Hatano, 1993) to differentiate between living and non living. The student understands that growth is associated with living and that roots are vital for life. Cutting down of roots therefore leads to death. It is different from intentional and mechanical causality. When intentions are attributed to a biological phenomenon, it is called as intentional causality, e.g. "we take in air because we want to feel good". When mechanical explanations are attributed to a biological phenomenon, it is called as mechanical causality, e.g. "lungs take in oxygen and give out carbon dioxide". Another example of vitalistic causality is: the tree uses fertile soil and sunlight and gives fruits. The student here is able to understand the process behind the formation of fruit at least in vitalistic terms. This also helps in building a living - non-living distinction.

Personification (person analogy) has also been used to term the picture of an object shown as that of a living object. One example is: "The eagle eats food just as we eat food".

The living - non-living distinction has also been made in terms of the ability to make self initiating movements by Class

V students. An example is the statement given by one student: train runs by electricity and therefore it is non living. That is, train does not make self initiating movements. The student has applied the external agent principle, which is applied to objects which do not move on their own.

To summarise, major findings of the interview conducted can be listed as follows:

- Class III students have taken up locomotion and growth as characteristics of living. Both the characteristics have been taken up separately. Common experience has helped the learners to differentiate correctly between living and non living. But, the use of faulty language at home and in the school has also led learners to reach faulty conclusions about the distinction between living and non living.
- Students of class IV have considered locomotion, breathing, nutrition, growth and reproduction as characteristics of living. More than one characteristic has been taken up by many students to distinguish between living and non living. The use of faulty language at home and in school has again led to erroneous conclusions of distinction between living and non living.
- Class V students have taken up characteristics of nutrition, death, growth and locomotion to distinguish between living and non living. Besides this, vitalistic causality, personification (person analogy), ability to make self initiating movements have also been considered by students to differentiate between living and non living. The use of faulty language has led again to erroneous conclusions of distinction between living and non living at many places.
- There are seven characteristics of life: movement, respiration, sensitivity, growth, reproduction, excretion and nutrition as considered by biologists. Children from Classes I to V have considered only five of these seven characteristics to consider an object as living. Excretion and sensitivity have not been taken as characteristics by any student.
- The students were asked to give more examples of living. These are summarised classwise below:

  I. Class III: Cat, birds, animals, crow, truck.

  II. Class IV: Camel, pigeon.

  Ill. Class V: Man, lion, snake, monkey, parrot, donkey, horse, cow, pigeon, aero plane, ox.

Discussion

From the findings discussed above, a few more broad generalisations can be drawn:

- The children in class I (5-6 years) do not possess an adequate living non living distinction. Though no generalisations can be drawn as the data available is also not adequate. Plants are not considered living by these children.

- Some of the children in class II start recognising plants as living
- Non-intentional causality and personification start developing by the time the child reaches ten years of age.

It is clear from the data collected that children at six years of age have acquired some form of biology. Biology is not taught in classes I and II. The early acquisition of biology may be due to their wide ranging interactions with the environment. The children may also have pets at home. Some form of gardening / cultivation practices may also have been followed at home. Naïve biology is thus gradually constructed through daily experiences during early years. There are of course many innate constraints as children seldom need biological knowledge, since they do not have to find food or take care of their health. By innate constraints we mean cognitive constraints. Acquired prior knowledge which is limited in young children especially regarding biological phenomena, may therefore pose an innate constraint. It is possible that young children in whom biological knowledge is limited may borrow psychological knowledge to interpret biological phenomena.

Naïve biology may also be affected by cultural and linguistic constraints. The activity based experiences in the culture the children are brought up in contributes to the formation of naïve biology. For e.g. if children are actively involved in raising animals, they acquire a rich body of knowledge about them. This knowledge can then be used by them along with the knowledge about humans as a source for analogical predictions and explanations for other biological kinds. Similarly children who are involved in gardening/ cultivation will acquire a rich knowledge about plants as living organisms. This knowledge can be used by them in analogical predictions. This does not mean that the children acquire a richer knowledge about animals or plants in general. They acquire only a richer procedural, factual and conceptual knowledge about the animal they have raised. But, in effect, this knowledge can be used to make analogical predictions.

The use of language also affects the acquisition of biology concepts in young children. Use of language that erroneously provides a living status to non living objects makes children reach wrong generalisations. Many examples have been discussed in classwise analysis of interviews of children. On the other hand, language many a times helps in the proper concept formation.

Biology is a subject which is based on complex, hierarchically organised categories. It relies on mechanical causality. As children grow older, the personifying and vitalistic biology gradually changes towards truly "non - psychological" biology. The development of category based inferences and mechanical causality takes place. Intentional causality is rejected. A fundamental restructuring of knowledge takes place.

Educational Implications

Many conclusions regarding educational implications can be drawn from this study:

- In school while teaching as well as in books care must be taken about the linguistic aspect. For eg, the use of *Suraj Chalta hai* is incorrect. The correct sentence for sun rises is *suryodaya hota hai.* Also, while building a curriculum for biology instruction, the cultural perspectives must be taken into account. The children coming from an agricultural background will carry with them a rich procedural knowledge about the animals and plants that are raised on the farm. The curriculum designers can keep this in mind while framing the curriculum. Examples with which children are familiar due to their cultural backgrounds should be incorporated in the text.
- For classroom, teaching concept attainment (Jerome Bruner, 1956 and Joyce and Weil, 1972) could be followed where concepts are taught using exemplars and non-exemplars. This method can be used in classes IV and V. One example is described below:

The teacher announces in the class that "I have a category in mind. I am going to show you some examples that fit into the category and I am also going to show you some examples that do not fit into the category. What you must do is to figure out the category for the positive examples that I show you". She then pastes pictures on a flannel board as follows:

Dog ☺ Yes (A smiling face with examples enhances interest in children)

Train No

The students start their discussion as follows:

Manu says : I think we are talking about pet animals.

The teacher then shows:

Eagle ☺ Yes
Kite No

Rakesh says : I think, it cannot be about pets. It is about all animals.

The teacher then pastes pictures as follows:

Elephant ☺ Yes Neem Tree ☺ Yes
Teddy-bear No

It is very confusing as neem tree is a 'Yes' says Manu.

The teacher intervenes at this point and asks learners to identify the commonality in the examples cited:

Mamta who was sitting perplexed says: Ma'am they all can walk but the eagle flies.

Deepak who was very quiet till this intervenes and says: But, neem tree cannot walk. So, this can not be the commonality.

Rakesh: But, they all grow from small to big.

The teacher can use pictures here of a pup, baby elephant, small neem-plant etc. The discussion continues along with more examples and non-examples till all the characteristics of living are identified. At the end the teacher lists out all the characteristics and declares that these are all examples of living objects. The non-examples are all non-living objects. The non-living objects do not show the characteristics shown by living objects. The movement of living and non-living will be differentiated by telling the difference between self-initiated movement and movement due to external agent. Plants do not show movement of the same kind as of animals yet they are considered as living can also be discussed. The concluding event of this concept attainment procedure will be asking learners to quote more examples of living.

- The stories that the children read or hear should have less of animism i.e the inanimate objects should not be associated with intentions, sensations and emotions.
- Children tend to generalise this impression.
- Field trips to various zoological and botanical parks can be organised to create awareness about the living world. Field trips within the school campus can also be arranged. The children can become familiar with plants as living beings. These should be followed by classroom discussions.
- Educational CDs can be used to create more awareness about the living and the non-living world. MCD/Government Schools also have access to at least one/two computers. These computers can be used for group instructions. The only requirement here is a lot of pre-planning associated with group instructions. A follow-up to assess the understanding of the children can also be organised. The students can be asked to give more examples of living objects along with their characteristic features by which these objects have been termed living.

Conclusions

Further research by taking up more number of students can be carried out for better generalisation of results. Also, various misconceptions regarding concepts as animals, plants, cell, rusting, gravitation can also form the basis of further research. The educational applications derived from such research will go a long way in improving teaching methods. Also, curriculum designers will be able to incorporate corrections of language in books so that such misconceptions are taken care of. Examples of concepts keeping in mind the cultural background of students can be incorporated in books by curriculum designers.

APPENDIX-I

NAME :____________________ **CLASS :** ________ **ROLL NO. :** _____________

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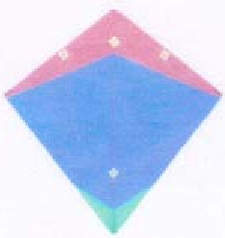

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Process of Problem Solving in Physics in the Context of Projectile Motion

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WHEN SOLVING the problems in Physics, multiple ideas come to the mind of the learners (Gandhi, Varma, 2004) . Their cognitive thinking may follow these sequences –

- They try to fit the problem in their existing cognitive schemes.
- They try to correlate the problem with their earlier experiences.
- They describe the problem by identifying the given quantities and the quantity/quantities to be found out.
- They prepare suitable hypothesis for solving the problem.
- They plan for action by identifying scientific principles and formula to be applied in the given situation.
- They analyse and/ or synthesise the relationship between the components of the problem and form a mental model of the relationship and concept.
- They apply the principles and formula with reasoning to arrive at the solution.
- They verify the result by going back to the problem to confirm that solution is correct.

As teaching of problem solving skills is one of the basic aims of Physics Instruction (Huffman, 1997), learners should be empowered to reflect on the problems independently. It becomes all the more important in the light of the fact that solving different types of problems requires attacking the problems using different strategies and different steps. Teachers' role is to guide the learners to decide

- which strategy is to be chosen;
- how it should be applied;
- why that particular strategy is being used; and
- when that strategy is to be applied (Gandhi, Varma, 2004).

It facilitates the learners in self-exploration and recognition of a suitable strategy. Becoming aware of their own strategies, they learn to orient their cognitive thinking to solve the problem by organising their thought in logical sequence and solve the problem independently.

Teacher has to make the process of problem solving transparent by exposing her own thinking patterns and sequences in dealing with the problem. She should discuss her own thinking process clearly to attack the problem. It would serve as a model to the learners. Simultaneously she should encourage the learners to give their ideas followed by the reasons and explanations for suggesting those ideas. By weaving thinking patterns for different steps of the solution of the problem with the help of learners, problem solving performance and hence conceptual networks pertaining to principles of Physics can be strengthened. It develops cognitive schema of the learners facilitating constructive learning. Also learners become able to describe the problem first qualitatively, then quantitatively, which is a sound technique of problem solving in Physics (Duncan, 1997). In this process, they evaluate their strengths and weaknesses related to problem solving skills. Thus the highest level of learning of creative self-direction takes place and learners can solve the problems at their own initiative.

In this paper, an attempt is made to look for a simplistic approach to problem solving process in the context of projectile motion. It is suggested to work out the sequential steps for problem solving in teaching learning process as given below.

Let us now project the process of problem solving in projectile motion.

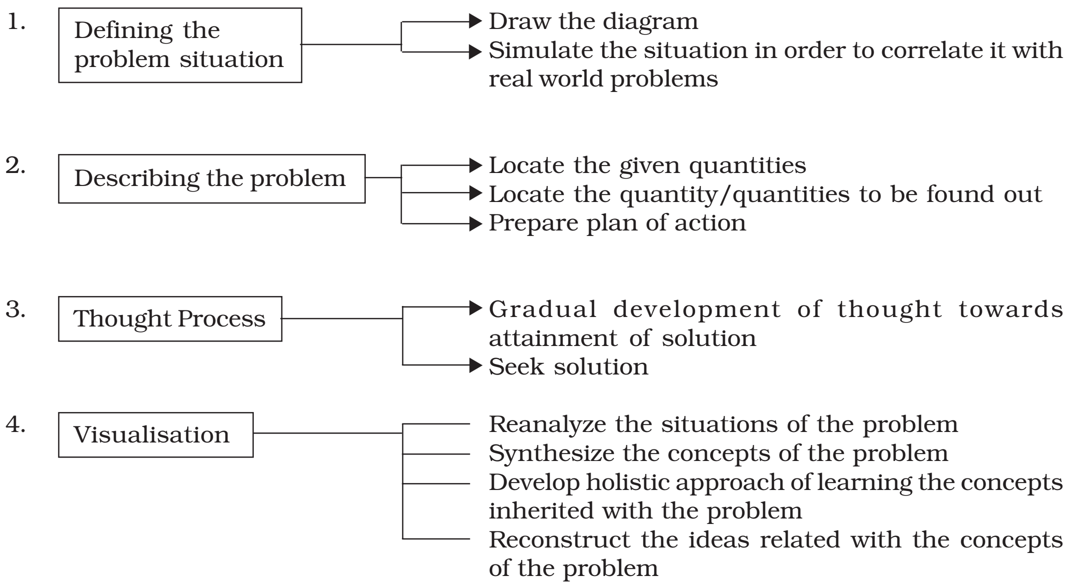
Exemplar Problem – 1

A person aims at a target on the ground from a horizontal distance of 100 m. If the gun can impart a velocity of 500 ms^{-1} to the bullet, at what height above the ground must he aim his gun to hit the target?

Solution

A. Defining Problem Situation

Draw a diagram of the situation and simulate the situation in the classroom in order to make the learner visualise the nature the problem.



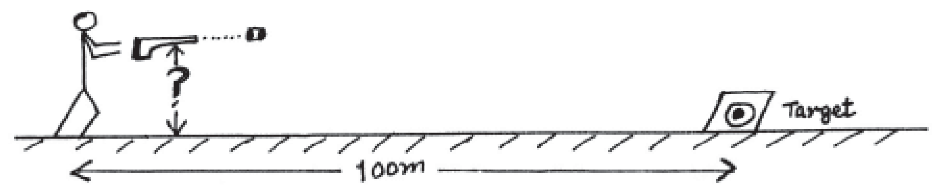


Fig. 1

B. Describing of Problem

Given quantities	*Quantity to be found out*
• Distance between the man and the target on the ground = 100 m • Velocity of the bullet = 500 ms^{-1}	• Height of the gun above the ground to hit the target?

C. Thought Process

- Vertical distance of the projectile from the ground can be determined by the expression

  $y = (u \sin \theta)\, t - (½)\; gt^2$
- But t is not given.
- t can be calculated by using the given data as

  t = distance/velocity = 100 m / 500 ms^{-1} = 0.2 s
- Substituting the value of t in this equation for y, we get

  $y = (0 \times 0.2) + (½) \times 10 \times (0.2)^2$

  = 0.2 m

  = 20 cm.
- Here initial velocity is zero and acceleration due to gravity is taken as 10 ms^{-1}.

D. Visualisation of the Problem

- Now let us write the calculated value of height in the language form for clarifying the situation of the problem as—

The person should aim his gun at a height 20 cm from the ground to hit the target.

Exemplar

Problem–2

It is possible to project a particle with a given velocity in two possible ways so as to make it pass through a point at a distance r from the point of projection. Determine how the product of the time taken in both ways to reach the point is related with r.

Solution

A. Defining the Problem

Simulate the situation in the classroom by taking an object and specifying x and y coordinates with respect to it.

Draw the diagram representing the situation.

B. Describing the Problem

As given in the box below.

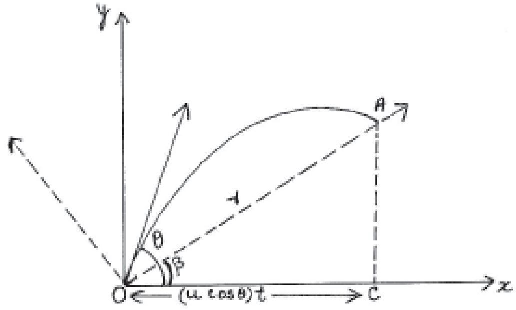


Fig. 2

C. Thought Process

- First determine the value of initial velocity, then that of r.
- Let the time taken by the particle at point A in two different cases be t_1 and t_2 respectively.
- Initial velocity can be determined by the equation of vertical displacement of the particle.

  $y = u\,(\sin q)\,t - (½)\,gt^2$ ....(1)
- In the given situation u needs to be resolved into two rectangular components as –

  Component along OA = u cos (Q - β)

  Component along OB = u sin (Q - β)
- Components of acceleration due to gravity

  along OA = - g sin B

  along OB = - g cos B

Given quantities	*Quantities to be found out*
● A particle can be projected from point O in two different ways but with same velocity so as to reach at a point A. (OA = r)	● Relation between ($t_1 \times t_2$) and r
● The particle reaches at A in two different times.	● For this the value of r is to be determined
● Since initial velocity of the particle remains same in two different cases, it is being thrown at two different angles	● In order to determine r, which is measurement of distance OA, we need to know the value of initial velocity. Hence we have to first find velocity of the particle.

Here, the problem demands that we need to develop the solution backwards.

- Now displacement of the particle along the direction perpendicular to OA is zero. Therefore substituting these values in equation (1), we get

  $0 = u \sin (q - b) t - (½) (g \cos b) t^2$ ....(2)

  or, $t = 2 u \sin (q - b) / g \cos b$ ....(3)

  and $u = gt \cos b / 2 \sin (q - b)$ ....(4)

- To find OA = r

  From the right angled triangle OCA

  $OA = OC/\cos b = (u \cos q) t / \cos b$

  Putting the value of u from equation (4).

  $OA = r = (t \cos q / \cos b) [gt \cos b / 2 \sin (q - b)]$

  or $r = (g \cos q)t^2 / 2 \sin (q - b)$ ....(5)

- Now, since the particle is projected with the same initial velocity in the second case, its angle of projection and time taken to reach upto point A would be different.
- Let it be t_1 for angle of projection q_1 and t_2 for angle of projection q_2.
- Now $r = (g \cos Q_1) t_1^2 / 2 \sin (Q_1 - \beta)$

  also $r = (g \cos q_2) t_2^2 / 2 \sin (Q_2 - \beta)$
- $t_1^2 \; t_2^2 \; \alpha \; r^2$

D. Visualisation of the Problem

Hence the product of the time taken by the projectile with same initial velocity but thrown with different angle of projection is directly proportion to its distance r from the point of projection.

Above exemplar problems are suggestive and not prescriptive, as the thought processes vary from person to person depending upon his experiential knowledge, interest and aptitude. Also, one person may go through different thought processes at different time. Hence a problem may be tackled by a number of different approaches.

For the gradual development and growth of the solution, reasoning pattern of the thinking need to be strengthened. But it is worth mentioning that no matter how strong is the reasoning and how well woven the thinking patterns of the learner are, they must have clear concepts of the underlying principles of Physics.

It is said that a problem is a problem because there is no set steps for arriving at the solution. Hence it is imperative for the teacher to inculcate in the learner the values of self-awareness about their thought processes thereby leading to self-exploration, self-instruction and self-evaluation.

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A Study of Pre-service and In-Service Teachers' Understanding of Electrochemical Cells

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A survey of recent literature reveals that a good number of research reports/articles appeared in national and international journals on students' understanding of various science concepts. The researchers have evolved different terms to describe these understandings. Driver and Easley (1978) preferred to call them pre-conceptions; Gilbert, Osborne and Fensham (1982) used the term children's science; Cho, Kahle and Nordland (1985) evolved the term misconceptions; Driver and Erickson (1983) used the term alternative frameworks and Fischer and Lipson (1986) preferred to address the same as students' errors. The term to be used to reflect on students' understandings depends much on the context of concept development and the quantity of knowledge concerned. According to the fundamental views of epistemology expressed by Driver (1989), Piaget (1972) , Pines and West (1986), students constructor generate their knowledge through a set of preconceptions based on previous knowledge and experience and it is termed as constructivist perspective. The net result is that some constructions by students may be erroneous and such misconstructs adversely affect subsequent learning of related concepts.

Electrochemistry is an important branch of chemistry and its knowledge is essential to understand corrosion principles, electrolytic refining and electroplating. There has been hardly any contribution in the area of electrochemistry education till later part of eighties except for some studies like Pfundt and Duit (1991) which documented students' misconceptions in chemical education. Finley, Stewart and Yarroch (1982) have reported that students find the topic of operation of electrochemical cells difficult. Garnett and Treagust (1992) in their article focused on students' understanding of electric currents and the identification and balancing of oxidation reduction equations. Sanger and Greenbowe (1997) reported common student misconceptions in galvanic, electrolytic and concentration cells. Prompted by this study, Sanger (2000) investigated the use of computer animations and instructions based on conceptual change theory to counter students' misconceptions in electrochemistry. Sanger and Greenbowe (1999) analysed ten college chemistry textbooks, identified vague, misleading or incorrect statements in oxidation — reduction and electrochemistry chapters and came out with suggestions concerning electrochemistry instructions intended for teachers and textbook writers. Ogude and Bradley

(1994) investigated on pre-college and college student difficulties regarding qualitative interpretation of the microscopic processes that take place in operating electrochemical cells. Greenbowe (1994) studied the effectiveness of an interactive multimedia software programme and reported that the programme helped students achieve a better conceptual understanding of the processes occurring in electrochemical cells.

The present study investigates the understanding of electrochemical cells held by in-service and pre-service secondary level science teachers and compares their ideas with senior secondary level students' under-standings of electrochemical cells. An attempt has been made to remove certain misconceptions held by in-service teachers by inviting them to participate in a teaching-learning sequence for conceptual change. Cho, Kohle and Nordland (1985) defined misconception as conceptual and prepositional knowledge that is inconsistent with accepted scientific consensus. Smith, Blakeslee and Anderson (1993) described conceptual change as a process in which learner realigns, reorganises and replaces the existing misconceptions to accommodate new concepts/ideas. Posner, Strike, Hewson and Gertzog (1982) proposed four conditions to be satisfied before a learner can replace existing misconception. These conditions include:

1. Learner must experience dissatisfaction with the existing conception
2. Learner should understand the new conception
3. The new conception should appear to be plausible
4. The new conception should appear to be better in explaining experiences/ observations.

To bring in conceptual changes in the participating in-service teachers, an opportunity was provided to the teachers to experiment and verify for themselves their own conceptions on the topic. This was followed by discussion on possible misconceptions on electrochemical cells held by different groups as reported in various research reports/articles. The implications for teaching and learning of the topic based on the findings of the research are also discussed.

Method

The study was conducted on a sample consisting of 22 in-service teachers who were Trained Graduate Teachers (TGTs) working in different Jawahar Navodaya Vidyalayas in the country, 90 pre-service teachers (undergoing secondary level teachers' training) and 38 pupils from class XII of Jawahar Navodaya Vidyalaya, Munduli. The in-service teachers were undergoing training in a camp as a part of quality improvement programme. Out of 90 pre-service teachers, 28 were from the final year of 4 year integrated B.Sc. B.Ed. Course, who have opted for applied chemistry subject and the rest were from the final year of 2 year B.Ed. course, who have opted for physical science as one of the method subjects. Except for the pupils of class XII, all others in the sample viz., in-service and pre-service teachers had their schooling and college studies from different institutions of the country. This aspect indirectly has taken care of the possibility of teachers' misconceptions affecting the study.

What concepts are to be taught in the area of electrochemistry at secondary level is decided by the chemistry syllabus framed by the Central Board of Secondary Education (CBSE). The following topics are prescribed for study at secondary level:

1. Sources of Electric current
   (a) Voltaic cell
   (b) Daniel cell
   (c) Dry cell
2. Electric current - charges in motion
3. Chemical Effect of Electric current
   (a) Conductivity of solutions
   (b) Electrolysis
   (c) Electroplating
4. Faraday's laws of Electrolysis

The test items were developed largely based on the syllabus related to electrochemical cells and the principles investigated by the test are generally of basic/fundamental in nature. Each of the nineteen items constituting the test was either multiple-choice or true - false type and investigated teachers'/pupils' understanding of electrochemical cells. For a clear reflection on the understanding of chemical processes at molecular level, some of the multiple-choice type items included visual conceptual questions (especially on electrode reactions).

Results and Discussion

As it is not practically possible to discuss in detail the results of the analysis of all the test items item-wise, only significant findings are described along with comments on the overall performance of in-service teachers, pre-service teachers and pupils.

The Mean scores and standard deviation for each of the groups that participated in the study is presented in Table 1.

There was no significant difference between the Mean score of in-service teachers and that of pre-service teachers and pupils. The research studies of Butts and Smith (1987), Finley, Stewart and Yarroch (1982) suggest that the students find the topic on operation of cells

Table 1: Group Means and Standard Deviation for all items in the Questionnaire

Group	*N*	*Mean*	*SD*	*t-values*	
				1 and 2	*1 and 3*
In-service Teachers (1)	22	8.81	2.57	0.55	0.97
Pre-service Teachers (2)	90	8.43	2.97		
Pupils (3)	38	9.47	2.36		

difficult. The inability of students to master certain basic concepts in the topic, perhaps, handicaps them even after taking up teaching assignments at secondary level. Another interesting finding of the study is that among the pre-service teachers, the four-year integrated B.Sc.B.Ed. students appeared to possess a better understanding of the basic principles of electrochemical cells. This is evident from Table 2 in which the Mean score of Four year integrated B.Sc.B.Ed. students is significantly different from that of two-year B.Ed. students. The pupils' Mean score did not differ significantly from the Mean score of pre-service teachers undergoing B.Sc.B.Ed. course. However, the pupils' Mean score differed significantly from that of pre-service teachers undergoing two-year B.Ed. programme.

The reasons for this significant difference could be many. One of the possible reasons could be that the four-year integrated students join the course after +2 and study the content integrated with methodology all through the four years where as two-year B.Ed. students join the course after graduation/post-graduation and concentrate more on pedagogical aspects and less on content competencies.

The pre-test was administered to in-service teachers, who were undergoing training in a camp. According to Champagne, Gunstone and Klopfer (1985), Roth, Anderson and Smith (1987) and Smith, Blakeslee and Anderson (1993) any conceptual change instructions involve discussions on possible students' misconceptions. As a follow-up, the participants were exposed to experiments on electrochemical cells and it was followed by a thorough discussion on the general misconceptions of pupils in the area as reported by Sanger and Greenbowe (1999) and (2000), Garnett and Treagust (1992). This session enabled the teachers to come across a variety of pupils' misconceptions in the area and compare their own understandings with those of pupils. This exercise brought in a visible conceptual change in the participating teachers and this was evident from the post-test scores as summarised in Table 3.

Table 2: Comparison of Mean Scores of Pre-service Teacher Groups and Pupils

Group	*N*	*Mean*	*SD*	*t-values*		
				1–2	*1–3*	*2–3*
4 - yr B.Sc.B.Ed (1)	28	9.82	2.90	3.08*	0.52	3.19*
2 - yr B.Ed (2)	62	7.8	2.81			
Pupils (3)	38	9.47	2.36			

* Significant at 0.01 level

Table 3: Comparison of Pre-test and Post-test Scores of In-service Teachers

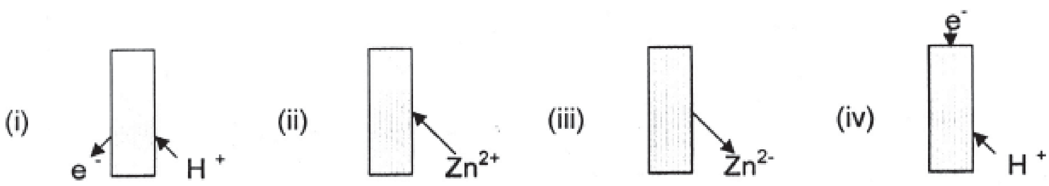
Group	*N*	*Before activity*		*After activity*		*t-value*
		Mean	*SD*	*Mean*	*SD*	
In-service Teachers	22	8.81	2.57	11.86	3.34	3.37*

* significant at 0.01 level

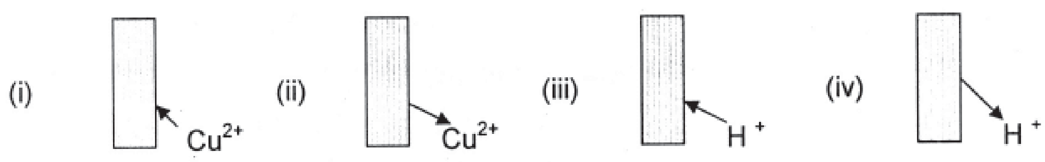
Since chemical processes taking place on molecular level can't be practically seen during experimentation, one of the effective ways to understand such processes is through either computer animation or static visuals. In the absence of animations, the authors used static visual conceptual questions to investigate into the in-service teachers', pre-service teachers' and pupils' understanding of reactions taking place at the electrodes in simple voltaic and Daniel cells. Some of the questions, which led to the identification of misconceptions in teachers, are as follows:

On simple Voltaic Cell (a diagrammatic representation given)

Q. 1. Which of the following describes best the reaction-taking place in solution at the zinc electrode?



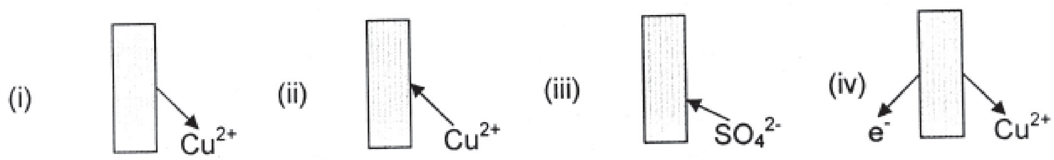
Q.2. Which of the following best describes the reaction-taking place in solution at the copper electrode?



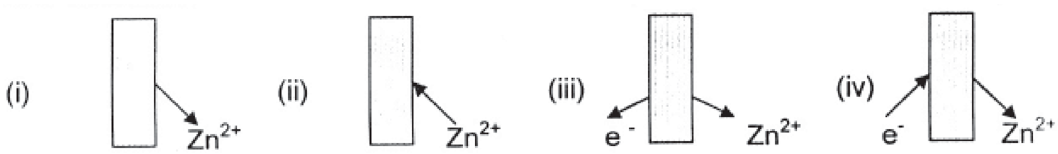
True or False Type Questions	True	False	I don't Know
Q.3. Electrons flow through the wire towards zinc electrode	( )	( )	( )
Q.4. The electrode sign convention in electrochemical cells and Electrolytic cell is same	( )	( )	( )
Q.5. Graphite can be used instead of copper electrode	( )	( )	( )

On Daniel Cell (a diagrammatic representation given)

Q.6. Which of the following best describes the reaction-taking place in solution at the copper electrode?



Q.7. Which of the following best describes the reaction-taking place in solution at the zinc electrode?



True or False Type Questions	True	False	I don't Know
Q.8. The electrons flow from copper electrode to zinc electrode in the external circuit.	( )	( )	( )
Q.9. The function of salt bridge is to allow the migration of electrons from one solution to another.	( )	( )	( )
Q.10. If zinc (s) and zinc sulphate (aq) are replaced with silver (s) and silver nitrate (aq), copper is oxidized.	( )	( )	( )

The results of the analysis of responses to the above static visual conceptual questions and True or False type questions are summarised in Table 4.

Table 4. Spread of views on Electrochemical Cells held by In-service and Pre-service Teachers and Pupils

Question No.	*Group*	*Response (%)*			
Visual Questions		(i)	(ii)	(iii)	(iv)
1.	In-service	4.5	4.5	36	40.5
	Pre-service	18.8	12.2	46.6	14.4
	Pupils	29	29	31.5	10.5
2.	In-service	31.5	54	—-	9
	Pre-service	22.2	32.2	20	6.6
	Pupils	34	26	23.6	15.8
6.	In-service	27	36	4.5	22.5
	Pre-service	25.5	25.5	8.8	28.8
	Pupils	21	36.8	29	13.2
7.	In-service	10	4.5	36	18
	Pre-service	15.5	26.6	24.4	18.8
	Pupils	26.3	31.5	15.8	26.3

Question No.	*Group*	*Response (%)*		
		True	*False*	*I don't Know*
True/False Type Questions				
3.	In-service	41	50	9
	Pre-service	43	55	2
	Pupils	40	60	—
4.	In-service	23	41	38
	Pre-service	45	42	13
	Pupils	21	74	5
5.	In-service	64	27	9
	Pre-service	27	58	15
	Pupils	26	63	11
8.	In-service	45	36	19
	Pre-service	60	36	4
	Pupils	53	47	—-
9.	In-service	72	5	23
	Pre-service	49	40	11
	Pupils	68	32	—-
10.	In-service	54	23	23
	Pre-service	39	38	27
	Pupils	42	47	11

Visual Conceptual Questions

Q.1. About 40% of in-service teachers and 18% of the total sample believed that hydrogen ions in solution accept electrons at zinc electrode in voltaic cell. On further probing, different reasons were cited for this view and they are summarised below:

(a) Hydrogen gas is liberated at zinc electrode because we see gas bubbles surrounding this electrode

(b) Hydrogen ions in solution accept electrons at zinc electrode liberating hydrogen gas

(c) Electrons are available around zinc electrode in solution

(d) Zinc reacts with acid giving zinc ions. The electrons lost from zinc are available at the zinc electrode for hydrogen ions.

Q.2. About 54% of in-service teachers and 40% of total population believed that copper ions are produced from copper electrode in the voltaic cell. On further probing, the following reasons were cited for the option:

(a) Copper is cathode and so electrons lost by copper move to anode in the wire

(b) Electrons lost by copper move to zinc electrode through solution and then to copper through wire

(c) Electrons are available in solution around copper electrode.

Q.6. On Daniel cell, about 25% of the sample opted for (i) whereas 22% opted for (iv). The reasons quoted for the choice include:

(a) Copper ions are formed from copper at this electrode

(b) The electrons lost by copper move through wire to zinc electrode — leading to flow of current. Current flow detected by deflection in ammeter

(c) Copper ions are formed by the loss of electrons and these electrons move into solution.

Q.7. About 36% of in-service teachers and 25% of total population believed that the electrons lost from zinc would move into solution.

True or False Type Questions

Q.3. About 42% of the population believed that the electrons flow through the wire towards zinc electrode in voltaic cell.

The reasons cited for the response include the following:

(a) Zinc is anode (+) as it loses electrons and Copper is cathode (-) as it gains electrons. Electrons flow from cathode to anode

(b) Zinc loses electrons and these electrons reach the copper electrode through solution and then pass from copper to zinc through the wire

Q.4. About 30% of the sample believed that the electrode sign convention in electrolytic cells and electrochemical cells is same. The reason quoted for the belief was —

- Anode is always positive and cathode is always negative.

Q.5. A majority of the sample – 63% of pupils and 58% of pre-service teachers believed that graphite couldn't be used instead of copper electrode for the reasons:

(a) Graphite may not work, as it is an inert electrode

(b) Graphite being non-metal, it will not conduct electricity.

Q8. About 60% of pre-service teachers 53% of total sample believed that in Daniel cell, electrons flow from copper electrode to zinc electrode in the external wire. The reasons for holding this view include:

(a) Zinc loses electrons. These move towards copper in solution and then flow from copper to zinc through wire

(b) Copper is cathode here. That's why electrons flow from copper to zinc.

Q.9. A major group corresponding to 72% of in-service teachers, 68% of pupils and 49% of pre-service teachers were of the opinion that salt bridge allows migration of electrons from one solution to another. The explanations given for holding the view include

(a) Without salt bridge how electrons move to complete the circuit?

(b) There will be flow of current only if electrons could flow through salt bridge

(c) Salt bridge establishes a connection between two half cells by allowing flow of electrons.

Q.10. About 38% of pre-service teachers and 47% of pupils had a notion that in Daniel cell, when copper and silver are used as electrodes, copper is not oxidized because –

(a) Among silver and copper, silver is more reactive and so it can be easily oxidized

(b) Copper is very less reactive than many metals like zinc, iron, etc.

(c) Standard oxidation potentials decide this. Oxidizing strength of copper appears to be higher.

The analysis of responses given by the pre-service teachers and pupils and the ensuing discussion with them led the authors to believe that the under-standings held by pre-service teachers and pupils were more or less similar to the understandings of in-service teachers.

The in-service teachers, after the administration of Questionnaire on Electrochemical cells, were exposed to conceptual change instructions as a part of inservice training. The instructions include experimentation on Voltaic and Daniel cells, representation of chemical processes on molecular level through visual pictures and discussion on possible misconceptions of students in electrochemical cells. The post-test was conducted after a gap of one week on the last day of the training programme. Although there was a marked improvement in the overall performance, the participants did not fare much better as expected particularly in the visual conceptual questions category. On investigation, it was found that teachers were not comfortable in answering static visual questions because of unfamiliarity and confusing nature of the pictures depicted. This could be due to the fact that the visual conceptual questions are not generally used in textbooks and classrooms for teaching-learning processes. Nurrenbern and Pickering (1987), Pickering (1990) and Sawrey (1990) have also expressed similar views in their research reports. Willows (1978) and Dwyer (1979) reported about the distractive nature of static visual pictures and Dwyer concluded that such pictures need more processing time and better abilities to understand and work with.

Conclusions

The present study enabled the investigators to identify some misconceptions that are common to the whole sample, which consisted of in-service teachers, pre-service teachers and pupils. The most commonly encountered misconceptions in the sample are summarised in Table 5.

The results also suggest that the conceptual change instruction strategy adopted in the study is effective in removing misconceptions of in-service teachers. The implications of the present study for teaching and learning of electrochemical cells at secondary level are as follows:

- Electrochemistry being a difficult topic for students to understand, simple chalk and talk method will not facilitate learning of basic concepts
- Experimentation on galvanic cells, explanation of various chemical processes at electrodes through static visual pictures and a thorough discussion on possible misconceptions in learners would help students to learn the basic concepts better.

Table 5: Some Misconceptions of In-service and Pre-service Teachers and Pupils in Electrochemical Cells

1. Electrons flow in solution
2. Electrons flow from anode to cathode in solution
3. The flow of electrons in solution and in external circuit constitute an electric current
4. Electrons flow through the Salt bridge
5. Salt bridge facilitates migration of electrons from one half cell to another
6. Anode is always positively charged and cathode is always negatively charged.
7. Silver is more easily oxidized than copper
8. Cathode is negatively charged and electrons move from copper (cathode) to zinc (anode) in Daniel cell
9. Inert electrodes can't be used as no reaction takes place at these electrodes 10.
10. Anode is positively charged due to loss of electrons and cathode is negatively charged as it gains electrons
11. Hydrogen gas is liberated at zinc electrode in voltaic cell
12. Copper ions are formed at copper electrode in voltaic cell.

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Teaching Aids in Mathematics and Manual for their Construction

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THE FASCINATING world of mathematics provides an unlimited scope to mathematicians to percive problems pertaining to three situations visualised in the forms of concrete, abstraction and intuition. However due to abstraction and intuition some of the mathematical concepts become more complicated sometimes even for teachers also who are actively engaged in mathematics teaching at different stages. This needs the exhaustive training in methods as well as in contents. This also needs the clarifications of mathematical concepts using teaching aids, eperimentation, observation and practicals etc. in mathematics to avoid the abstraction at different stages of schooling.

In the present paper, manuals have been given for some of the teaching aids, which can help in preparing the teaching aids to conduct the demonstration and practicals in mathematics at school level. Many more activities may be designed by the teacher in classroom to motivate the students to prepare and conduct the same by their own.

1. Topic – The sum of internal angles of a triangle is 180°.

Material Required – Drawing sheet (thin ply board), Tape, Knife, Blade and Scale.

Method of Construction

1. Cut drawing sheet in a triangular shape.
2. Now cut this triangular drawing sheet according to the lines DE, EF and DG.
3. Join the cutting parts by tape.
4. Fold the three angles ∠ 1 , ∠ 2, ∠ 3 along the line DG, DE ad EF. We see that ∠ 1, ∠ 2, ∠ 3 make a straight line, i.e., sum of the internal angles of a triangle is 180°.

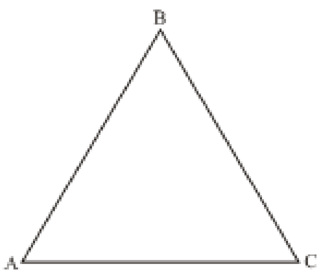


Fig. 1

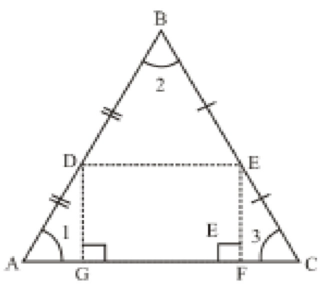


Fig. 2

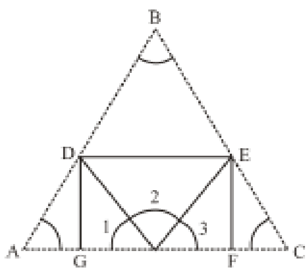


Fig. 3

II. Topic – The total surfac area of a cylinder is $2\pi r(r + h)$.

Material Required – Thick paper sheet.

Method of Construction

1. Take a thick rectangular paper sheet of length l and breadth b. Then area of this sheet will be $l \cdot b$
2. Fold this sheet to make cylinder

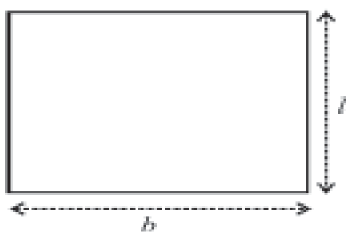


Fig. 1

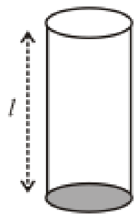


Fig. 2

3. Now we see that cylinder has two circular ends. If radius of these ends are r then area of each circular end $= \pi r^2$.
4. If cylinder is made by folding thick paper sheet along length then height of cylinder $h = l$ (say) and circumference of circular end is $2\pi r = b$ (say)
5. Now curved area of cylinder will be equal to the area of rectangular paper sheet.

Now, area of the curved part = area of thick rectangular paper sheet

$= l \cdot b$

$= h \cdot 2pr$

$= 2prh$

6. Hence total surface area of cylinder

$= 2 \cdot (pr^2) + 2prh = 2pr(r + h)$ square unit.

III. Topic – Minimum five things are essential to construct a definite quadrilateral.

Material Required – Five very thin long strips of wood, Nails.

Method of construction

1. Take such four strips of wood and join them with nail end to end.
2. Now we see that we can change the shape of formed quadrilateral by changing the direction of strips.
3. Join another strip diagonally in the quadrilateral.
4. New quadrilateral has a definite shape and no other quadrilateral can be formed by given five measurements.

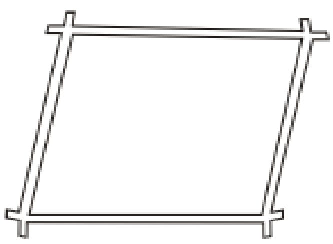


Fig. 1

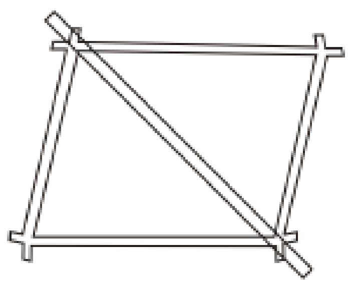


Fig. 2

5. Hence we can prove by this model that minimum five things are necessary to construct a definite quadrilateral.

IV. Topic – To approve the identity : $(a + b)^2 = a^2 + 2ab + b^2$

Material Required – Drawing sheet, Tape, Coloured paper, Knife, Blade and Scale.

Method of Construction

1. Cut a square of length a (say) of drawing sheet. So the area of this square ABCD will be a^2.

2. Cut another square of length b. So area of this square FGHC will be b^2.

4. Total area of these four quadrilaterals

= area of squre ABCD + area of square FGHC + area of rectangle EFCD + area of rectangle CHIB

= $a^2 + b^2 + ab + ab = a^2 + b^2 + 2ab$

5. Now, join these four quadrilaterals with the help of tape as shown in Fig. 5.

6. Now length of new big quadrilateral AIGE is $(a + b)$ and breadth is also $(a + b)$.

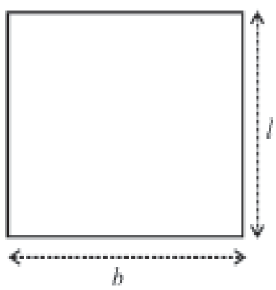


Fig. 1

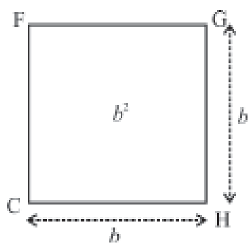


Fig. 2

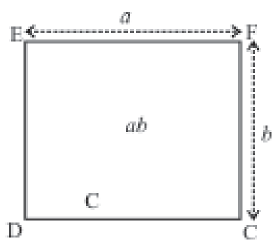


Fig. 3

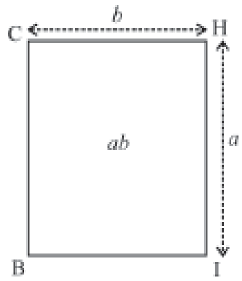


Fig. 4

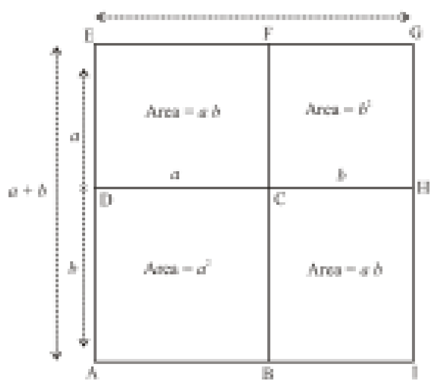


Fig. 5

So the area of new quadrilateral = $(a + b)^2$

Hence $(a + b)^2 = a^2 + 2ab + b^2$

V. Topic – The area of a circle of radius r is πr^2.

Material Required – Paper sheet, Fevicol, Knife, Blade and Scale.

Method of Construction

1. Make a circle (say, of radius r) with the help of knife.

2. Now we fold the circular paper sheet as shown in the Figure 2. Now we press and open the sheet and write numbers 1 to 16 on divisions.

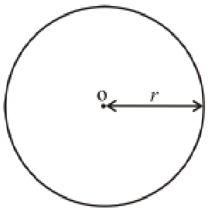


Fig. 1

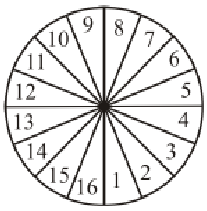
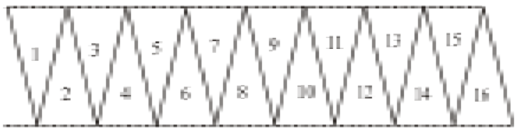


Fig. 2

3. We cut the 16 divisions and arrange them as shown in the figure.



4. This is quite obvious that the ultimate figure is rectangle. Therefore the area of this rectangle will be the area of circle.
5. Now, area of rectangle = length . breadth

$$= \frac{1}{2} \text{(Circumference of circle)} . \text{(Radius of circle)}$$

$$= \pi r^2$$

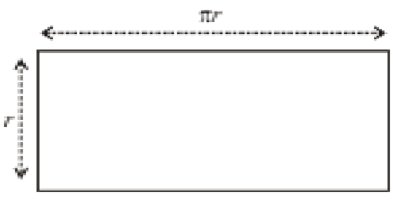


Fig. 3

6. Hence the area of circle = πr^2

VI. Topic – Area of a parallelogram is the product of length of any parallel line and the distance (perpendicular) between them.

Material Required – Drawing sheet, Tape, Knife, Blade and Scale.

Method of Construction

1. Cut drawing sheet in the shape of parallelogram ABCD with the sides *a* and *b*.

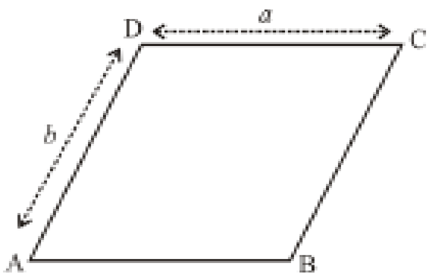


Fig. 1

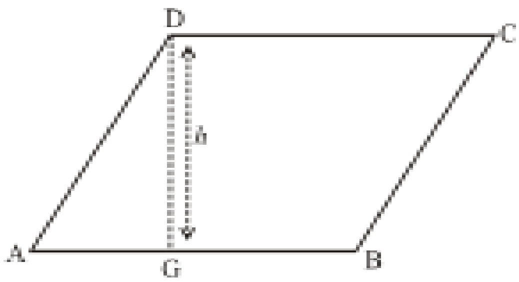


Fig. 2

2. Draw a line DE perpendicular on AB and cut the triangle ADG. Now join Δ ADG and quadrilateral DGBC with tape.
3. We cut another triangle CBE congruent to Δ ADG and join it with tape as shown in the Figure 3.

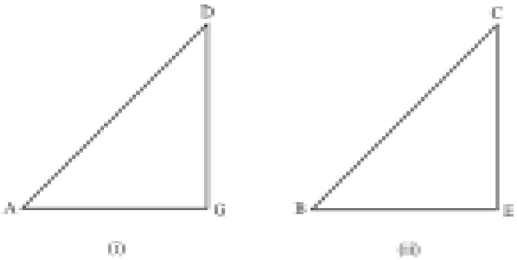


Fig. 3

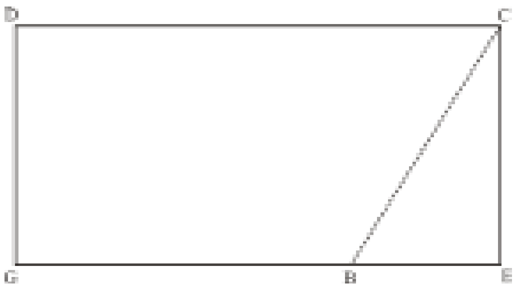


Fig. 4

4. Now we fold the Δ CBE in back side. Now we have to find out the area of parallelogram ABCD.

   But area of parallelogram ABCD = Area of Δ ADG + Area of quadrilateral DGBC

   = Area of Δ CBE + Area of quadrilateral DGBC

   (∵ Δ ADG ≅ D CBE)

   = Area of rectangle DGEC

5. Now we fold Δ ADG in back side and open the Δ CBE

   Therefore, area of parallelogram = Area of rectangle DGCE

   = CD . DG

   = $a \cdot h$

VII. Topic – Angles inscribed in the same arc of a circle are equal.

Material Required – Plyboard, Nails, Thread, Protractor and Scale.

Method of Construction

1. Take a plyboard of rectangular shape. Then we draw a circle with centre O on plyboard.
2. We mark the points P, Q, R, A, B, C, D, E on the circle and fit the nails on these points.
3. Now, we choose an arc let P Q R. After this we show the angle inscribed in the arc P Q R by hanging the threads.
4. We measure the different angle inscribed in arc PQR with the help of protractor.
5. We see that all angles have same measure. Hence angles inscribed in the same arc of a circle are equal.

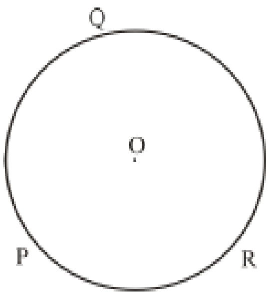


Fig. 1

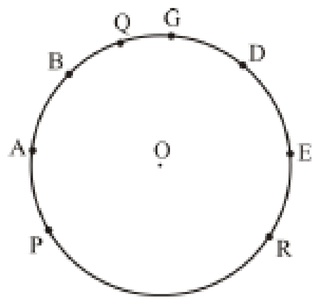


Fig. 2

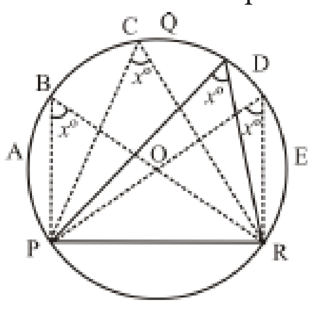


Fig. 3

VIII. Topic – Angle in a semi-circle is always right angle.

Material Required – Plyboard, Nails, Thread, Protractor and Scale.

Method of Construction

1. Take a plyboard of rectangular shape. Then we draw a circle with centre O on plyboard.
2. Now, we take a diameter PQ on the circle and fasten the nails on P and Q points.

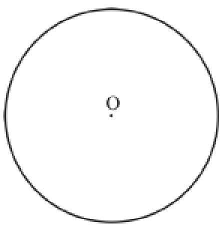


Fig. 1

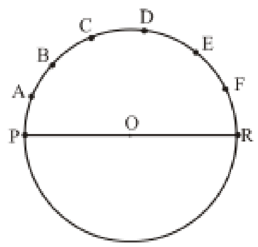


Fig. 2

3. We fasten the nails on circle at point A, B, C, D, E, F, . .
4. Now by hanging the thread we show the angle subtended by the (semi-circle) diameter.
5. After this we measure the angle values of different angles subtended by the diameter.

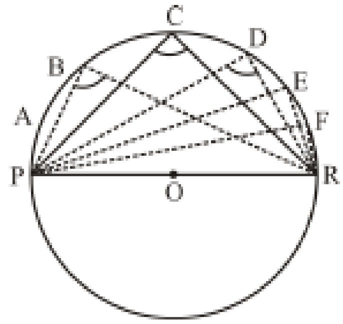


Fig. 3

6. We find that all angles are right angle. Hence angle in a semi circle is always right angle.

IX. Topic – Angle subtended by an arc at the centre is always double the angle it subtends at any point of the remaining part of circle.

Material Required – Plyboard, Nails, Thread, Protractor and Scale.

Method of Construction

1. Take a plyboard of rectangular shape. Then we draw a circle with centre O on plyboard.
2. Now we mark the points P, Q, R, A, B, C, D on the circle as shown in Figure 2.

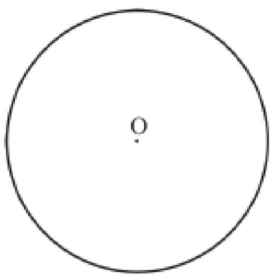


Fig. 1

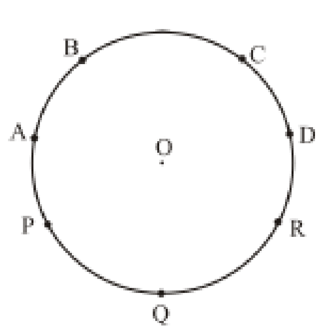


Fig. 2

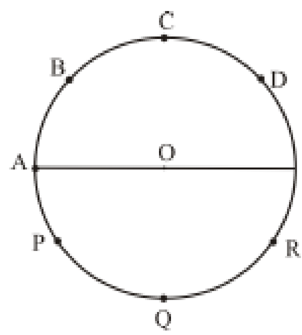


Fig. 3

3. Now we choose an arc let PQR and we fasten the nails on P, Q, R, A, B, C, D, . . .
4. After this we get subtended angle by arc PQR at the centre and measure it.
5. Then we measure subtended angles by arc PQR at any point of the remaining part of circle.

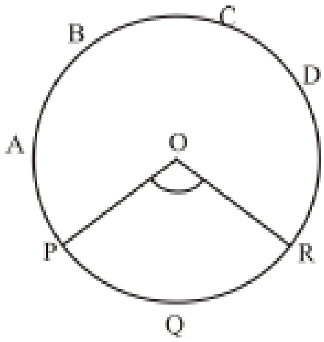


Fig. 4

6. We get that this angle is the half of angle subtended at the centre.
7. Hence angle subtended by an arc at the centre is always double the angle it subtends at any point of the remaining part of the circle.

X. Topic – To prove the identity : $(a - b)^2 = a^2 - 2ab + b^2$

Material Required – Drawing sheet, Tape, Coloured tape, Knife and Scale.

Method of Construction

1. Cut a square of length suppose a of drawing sheet. So the area of this square will be a^2.

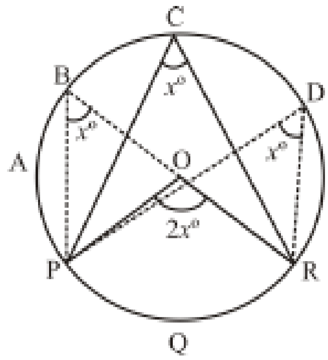


Fig. 5

2. Cut a square AGEF of length b from square ABCD as shown in the Figure 2.
3. We cut the square ECHI and rectangle DIEF and EHBG from remaining part.

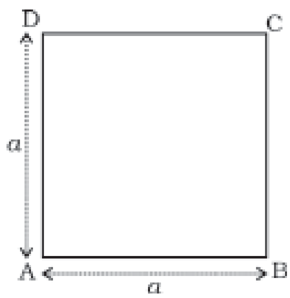


Fig. 1

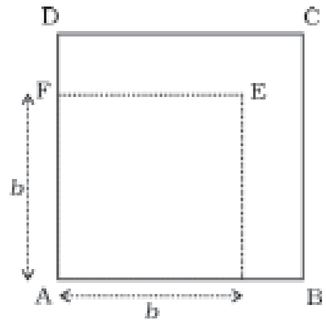


Fig. 2

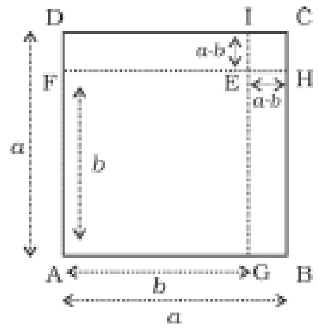


Fig. 3

4. We join all parts as to make square ABCD with the tape.
5. Now we have to find out the area of square CHEI.

So, Area of square CHEI = area of square ABCD – [area of square AGEF + area of rectangle DIEF + area of rectangle GBHE]

or, $(a - b)^2 = a^2 - [b^2 + (a - b)\, b + (a - b)\, b]$

$= a^2 - [b^2 + ab - b^2 + ab - b^2]$

$= a^2 - [2ab - b^2]$

or $(a - b)^2 = a^2 - 2ab + b^2$

XI. Topic – Sum of interior angles of a quadrilateral is 360°.

Material Required – Thin plyboard, Knife, Fevicol and Scale.

Method of Construction

1. Cut a quadrilateral ABCD with knife and denote its angles by writing 1, 2, 3 and 4.
2. Now, divide the quadrilateral ABCD into four parts as denoted by the thin lines in the adjoining figure.

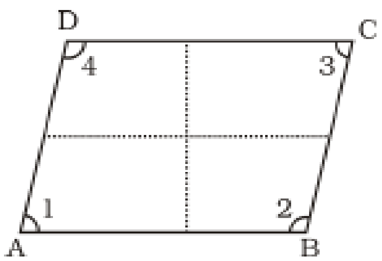


Fig. 1

3. We draw a line OX on another plyboard sheet.

Fig. 2

4. Now, we paste the angle 1 on this sheet such that vertex A imposed on O and one side on OX.
5. After this we paste the another three parts such that vertex of each part (angle) imposed on O and sides touch the sides of other angle.

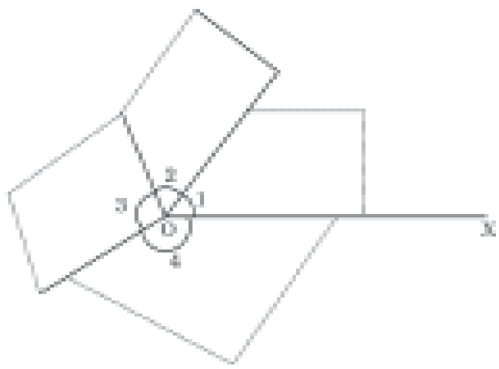


Fig. 3

6. Now, we may see that Δ 1, Δ 2, Δ 3, Δ 4 makes 360°. Hence Δ 1 + Δ 2 + Δ 3 + Δ 4 = 360°.

XII. Topic – In a right angled triangle the square of hypotenuse is the sum of square of remaining two sides of the triangle.

Material Required – Plyboard, LEDs, LED circuits, Wire and Battery.

Method of Construction

1. We take a plyboard and construct the right angled triangle ABC on it.

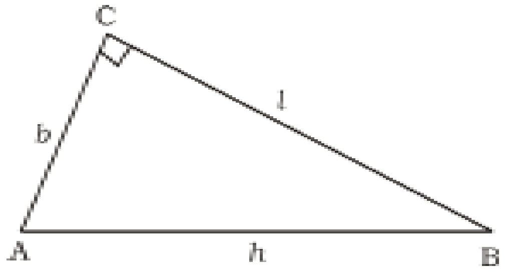


Fig. 1

2. Now, we construct a square on sides AB, BC and CA respectively as shown in the Figure 2 and put the sticks showing the lines KB and CD respectively. After this we put a stick showing the line CM which is perpendicular to AB.

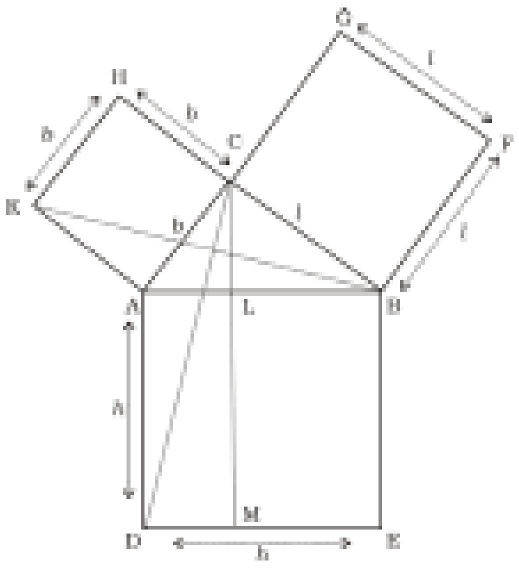


Fig. 2

3. We fix the LED on A, B, C, D, E, F, H, K, L and M and make different circuit for D ABC, D KAB, D CAD, □ ACHK, □ GCBF, □ ABED and rectangle □ ALMD.
4. Now we have to demonstrate by this particular aid that area (□ ABED) = area (□ BCGF) + area (□ ACHK).

   For this purpose we show by LED circuits that

   Δ KAB $\cong$ Δ CAD ......(i)

   and area (Δ CAD) = $\frac{1}{2}$ area (□ ALMD) ......(ii)

Similarly we can show that

area (D KAB) = $\frac{1}{2}$ area (□ ACHK) ......(iii)

But area (D KAB) = area (D CAD) ......(iv)

Thus,

area (□ ALMD) = area (□ ACHK) (v)

Similarly we can prove that

area (□ LBEM) = area (□ GCBF) (vi)

Now area (□ ABED) = area (□ ALMD) + area (□ LBEM)

= area (□ ACHK) + area (□ GCBF)

or $AB^2 = AC^2 + BC^2$

or $h^2 = b^2 + l^2$

XIII. Topic – The sum of all exterior angles of a convex polygon is 360°.

Material Required – Thin plyboard, Knife, Scale and Blade.

Method of Construction

1. First of all we cut the different types of polygons on this plyboard, say, pentagon as shown in Figure 1.

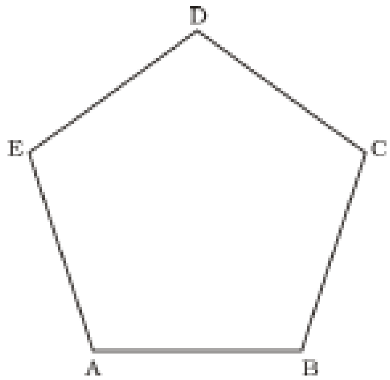


Fig. 1

2. Now we take any one of polygons and cut the angles from polygon as shown in Figure 2 on plyboard.

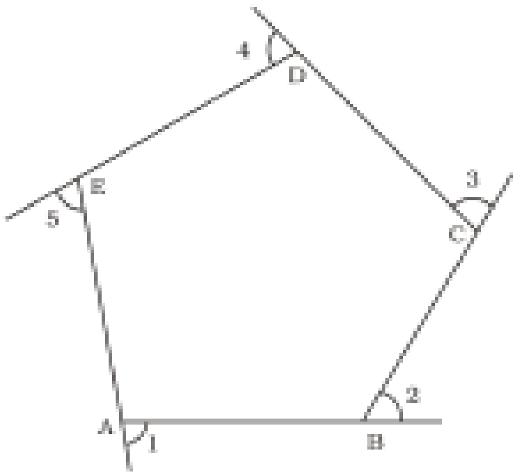


Fig. 2

3. We touch the vertex of all angles.
4. We see that all angles make a circle as shown in Figure 3. Hence we can say that sum of exterior angles of a polygon is 360°

   i.e., $\angle 1 + \angle 2 + \angle 3 + \angle 4 + \angle 5 = 360°$

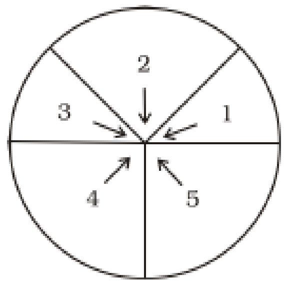


Fig. 3

XIV. Topic – To introduce the different types of quadrilaterals.

Material Required – Thin plyboard, Knife, Tape and Scale.

Method of Construction

1. Cut three shapes of right angled triangle on plyboard as the measurement given in Figure 1.

   Now cut two trapeziums of same measurement on plyboard as measurement given in the following Figure.

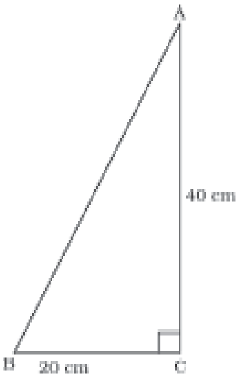


Fig. 1

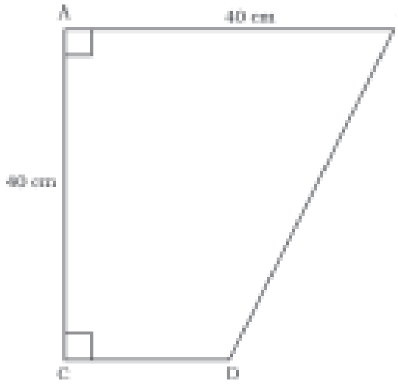


Fig. 2

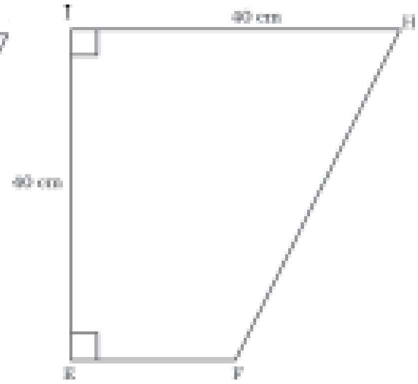


Fig.3

2. Join three triangles and two trapeziums by hinges or tape in the following sequence.

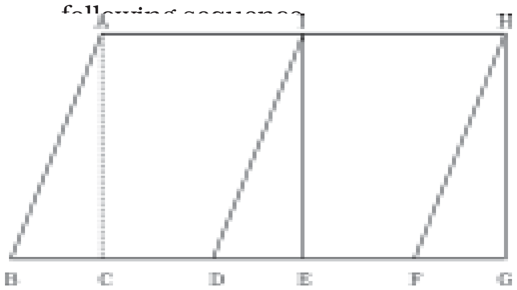


Fig. 4

3. If we fold ABEI part we get a square IHGE.

   If we fold Δ ABC, we get rectangle AHGC.

4. If we fold Δ HGF, we get the parallelogram ABFH.

5. If we fold IDGH we get rhombus ABDI.

6. If we fold EGHI we get trapezium ABEI.

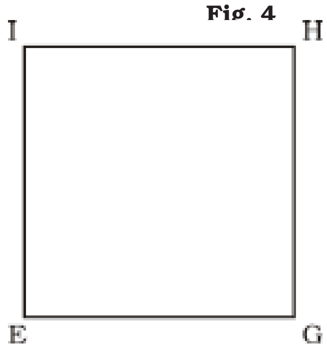


Fig. 5

Fig. 6

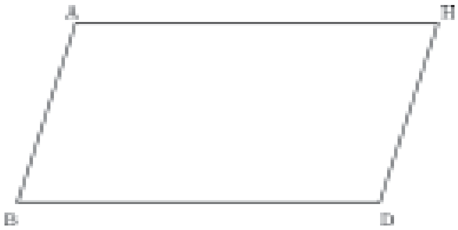


Fig. 7

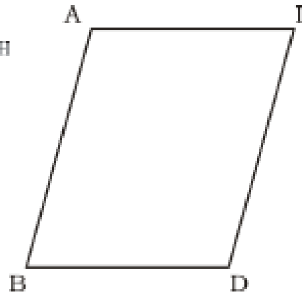


Fig. 8

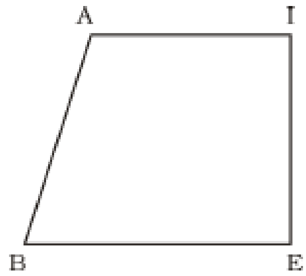


Fig.9

Also we can verify the properties of different types of quadrilaterals with the help of above arrangements.

XV. Topic – To introduce the various types of angles.

Material Required – Thin wooden strips and Hinges.

Method of Construction

1. Join the wooden strips by hinges so that strips can move on each other.
2. Now as shown in Figures 1, 2, 3, and 4 we can introduce the different types of angles.

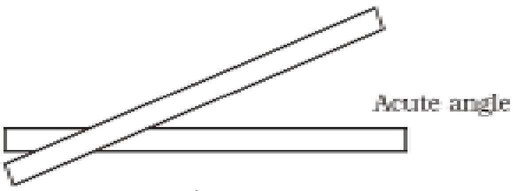


Fig. 1

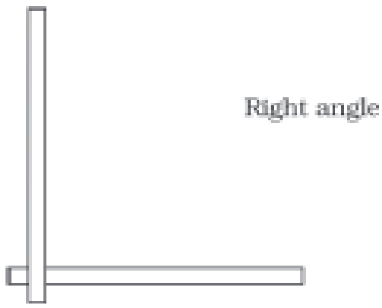


Fig. 2

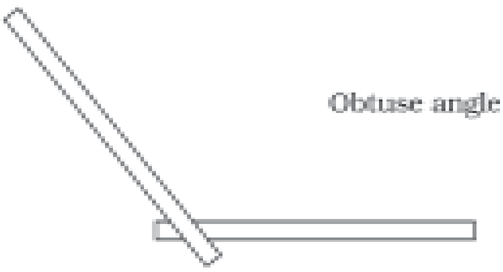


Fig. 3

Fig. 4

XVI. Topic – To introduce the concept of percentage.

Material Required – Chart paper, Scale, Pen.

1. Draw a square on a chart paper.
2. Divide the length and breadth in ten equal part.

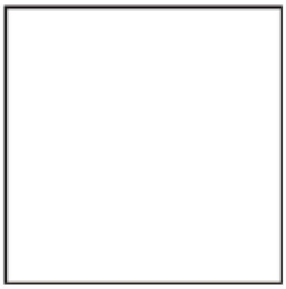


Fig. 1

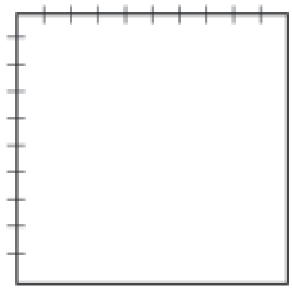


Fig. 2

3. Divide the whole area of square in 100 equal parts as shown in Fig. 3

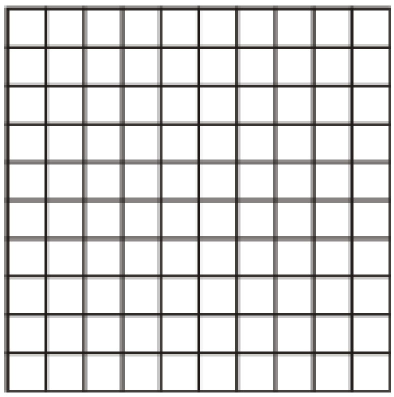


Fig. 3

4. Now if we want to show 4% we colour four boxes out of 100.

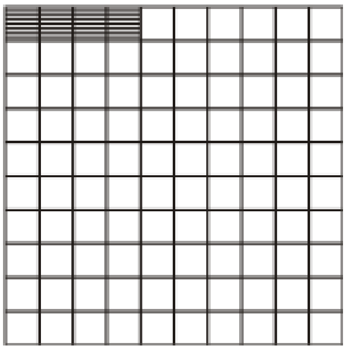


Fig. 4

5. Again if we want to show 15% we colour 15 boxes out of hundred and so on.

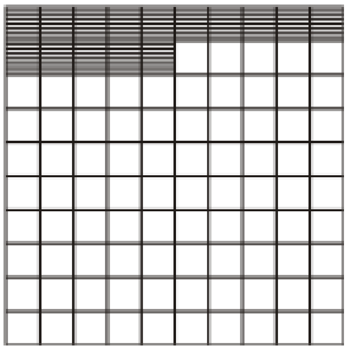


Fig. 5

This is just a sample of some of activities/practicals which can be carried out in a classroom situation with low cost material using waste material from surroundings or enviroment. A teacher may explore many more based on the mathematical concepts at different stages of schooling. Such activities can instantly motivate the students and create an environment for mathematics learning. The teacher may encourage students to perform similar activities to make mathematics learning more joyful.

Scieence Student–Teacher's Reflection Upon Intelleectual and Procedural Honesty on Conducted Practicals

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Science for all up to secondary stage was envisaged making future citizens literate and endowed with scientific temper. Teaching of the prescribed scientific content and remembering it by the students neither develops nor nurtures scientific outlook and attitude in them. Proper understanding and appreciation of scientific concepts can only come by engaging learners in processes and procedures that unearth unknown characteristics possessed by the physical, chemical or biological realities that they can investigate at their level of cognitive functioning.

Brown and Brown (1972) conducted a study on the American Professors of Science regarding what constitute scientific values according to them. On the basis of semantic differential technique of Osgood et al, they delineated ten scientific values. Intellectual and procedural honesty was ranked III by them. Other values ranked I to X were Curiosity; Integrity; Creativity; Open-mindedness; Experimental verification; Commitment and persistence; Cause-and-effect; and Skepticism. Sampled Indian Science-teachers had marked intellectual and procedural honesty from ranks III to VIII; (Pachaury, 1973; 2003a, b, 2004). Students develop this and other scientific values when they conduct, biology, chemistry and physics practicals during their higher secondary; B.Sc. and M.Sc. courses. The main concern of present study has been to ascertain how intellectual and procedural honesty had been practised by the science student-teachers when they had engaged themselves in performing science practicals during their schooling and undergraduate/post-graduate studies.

Sample: 30 graduate and post graduate science student-teachers who were studying in a B.Ed. College of new Bhopal township participated in this study (18 men and 12 women). Their modal age was 22 years.

Data collection: An opinionnaire constructed by the investigator formed the tool for data collection. The participants were requested to mark their responses on the following five point percentages. A 0-10%; B 11-25%; C 26-50%; D 51-75% and E 76-100%.

When you did biology, chemistry and physics practicals/ experiments during higher secondary, B.Sc. or M.Sc. courses, how often did you

(i) wrote objectives of the experiment/ practical in your own language?

(ii) collected your data step-by-step?

(iii) analysed and did calculations on the collected data?

(iv) interpreted/ reported on your own data?

(v) took help from external sources in writing objectives, data collection, analysis/ calculations, interpretation and reporting?

Results: The accompanying table provides how often the sampled science student teachers had responded on the five administered queries. They are all expressed in percentage.

Question	**A**	**B**	**C**	**D**	**E**
I	30	33	30	03	03
II	27	17	23	20	13
III	20	17	23	40	–
IV	13	17	33	33	03
V	30	33	17	17	03

(Percentages have been rounded off)

In all 93% (A, B and C) of the sampled science student-teachers accepted that for about half of all the experiments done by them, they did not write objectives in their own language. Similarly 67% did not collect their data step-by-step. This percentage was 20 and 13 for up to 761100 times, respectively. 60% of these student-teachers also did not analyze, did calculations on their collected data. However, 40% did so for 50-75 times of experiments done by them. A little more than 60% of them did not interpret or report on their own collected data. Only 33% and 3% did so for 76/100 times, respectively. As many as 97% of them admitted that they resorted to the use of external sources in writing objectives, collection of data, analysis and calculations, interpretation and reporting up to 75% of time. By any criterion, this is very low index of intellectual and procedural honesty displayed by the sampled science student-teachers on the practicals conducted by them.

Discussion: From the point of view of development of scientific temper among the science student-teachers, this is not encouraging at all. It appears the verificatory character of the conducted practicals failed to tempt their awe for knowing something new. This, therefore, dampened their enthusiasm and epistome in investigating already known facts. Apart from this, it was thought useful to ascertain the reason that caused this situation. Five subjects from each gender category of the respondents' interview revealed interesting facts. Non-monitoring of the practicals by the concerned staff being one of them. The other is related with the staff biases in both the internal and external assessments. The respondents asserted that this thwarted their self-esteem as well.

Educational implications: In the opinion of the investigator, all these observations to a very large extent can be easily tackled. In order to shake students' monotony in engaging verificatory exercises/practicals, it is suggested to modify the nature of the practicals. Experimental/investigatory activities can be conceived by the teaching staff on the basis of the scientific concepts learnt in the theory classes. It shall be useful only when some orientation of the students is first done with regard to

- the nature of scientific investigation
- generation of a hypothesis
- its experimental testing by isolation and control of variables
- conducting the experiment
- analysis and drawing of data based inference and
- collection and reporting of data honestly

Besides these, issues like what is objectivity, how law of parsimony works, and why replicability are essential ingredients of an experiment need to be thoroughly discussed before students embark on exploration of new relationships constructed in the form of a hypothesis. A slender percentage of the students in all possibility would be prone for violating rules of doing an experiment properly. Such incidences can be reduced by individual monitoring and through interactive dialogue on the reasons for resorting to dishonest practices.

Lastly, but not the least, staff displaying intellectual and procedural honesty in their day-to-day behavior shall provide a positive and reinforcing role model for the development and nurture of these scientific values in their students.

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Water Pollution

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POLLUTION is one of the major environmental problems these days. The term pollution has been defined in a variety of ways.

According to E.P. Odum, pollution is an undesirable change in the physical, chemical or biological characteristics of our air, land and water that will harmfully affect the human life and the desirable species, or that may waste or deteriorate our raw material resources.

In Environmental (protection) Act, 1986 of India "environmental pollutant" means any solid, liquid or gaseous substance present in such concentration as may be or tend to be injurious to environment; and 'environmental pollution" means the presence in the environment of any environmental pollutant. There are two basic types of pollutants.

Non-degradable Pollutants— The materials and poisonous substances such as aluminium cans, mercurial salts, long chain phenolic chemical, and DDT that either do not degrade or degrade only extremely slowly in the natural environment are called non-degradable pollutants.

The non-degradable pollutants also combine with other compounds in the environment to produce additional toxins. The obvious and sensible solution, which is of course not so easy to practice, is to ban the dumping of such materials into the environment, or to stop production of such substances entirely by replacing them with degradable substances.

(b) **Biodegradable Pollutants**— Pollutants such as the domestic sewage can be rapidly decomposed by the natural processes or some artificial systems that enhance nature's great capacity to the decompose and recycle are called biodegradable pollutants.

Heat or thermal pollution can be considered in this category since it is dispersible by the natural means. However, serious problems arise with the degradable type of pollutants when their quantity into the environment exceeds the decomposition or dispersal capacity of the environment.

Water Pollution— Water is one of the most important natural resources and a regular supply of clean water is very essential for the survival of all living organisms. Any physical, biological, or chemical change in water quality that adversely affects living organisms or make water unsuitable for desired uses can be considered pollution. There are many natural sources that contaminate water such as poison springs, oil seeds and sedimentation from erosion.

Pollution control standards and regulations usually distinguish between point and non-point pollution sources. Factories, power plants, sewage treatment plant, underground coal mines, and oil wells are classified as *point sources* because they discharge pollutants from specific locations, such as drain pipes, ditches, sewer outfalls. These sources are discrete and identifiable, so they are relatively easy to monitor and regulate. It is generally possible to divert effluent from the waste streams of these sources and treat it before it enters the environment.

In contrast, *nonpoint sources* of water pollution are scattered or diffuse, having no specific location where they discharge pollutants into a particular body of water. Nonpoint sources include runoff from farm fields and feedlots, golf courses, lawns and gardens, construction sites, logging areas, roads, streets and parking lots. Whereas point sources may be fairly uniform and predictable throughout the year, nonpoint sources are often highly episodic.

Sources of Water Pollution

Although the types, sources and effects of water pollutants are often interrelated, it is convenient to divide them into major categories. Let's look more closely at some of the important sources of pollution and the effects of each type of pollutant.

Infectious Agents

The most serous water pollutants in terms of human health worldwide are pathogenic organisms. Among the most important water borne diseases are typhoid, cholera, bacterial and amoebic dysentery, enteritis, polio, hepatitis and schistosomiasis. Malaria, yellow fever, and filariasis are transmitted by insects that have aquatic larvae. Altogether at least 25 million deaths each year are directly or indirectly due to these water related diseases. Nearly two-thirds of the mortalities of children under 5 years age are associated with water borne diseases.

The main source of these pathogens is from untreated or improperly treated human wastes. Animal wastes from feedlots or fields near waterways and food processing factories with inadequate waste treatment facilities also are sources of disease-causing organisms. The United Nations estimates that 90 percent of the people in developed countries have adequate sewage disposal, and 95 per cent have clean drinking water.

The situation is quite different in less-developed countries 2.5 billion people in these countries lack adequate sanitation, and that about half these people also lack access to safe drinking water. Conditions are especially bad in remote, rural areas where sewage treatment is usually primitive or nonexistent, and purified water is either unavailable or too expensive to obtain. *The world Health Organisation estimates that 80 per cent of all sickness and disease in less-developed countries can be attributed to waterborne infectious agents and inadequate sanitation.*

Oxygen-Demanding Wastes

The amount of oxygen dissolved in water is a good indicator of water quality and of the kinds of life it will support.

- Water with an oxygen content above 6ppm will support game fish and other desirable forms of aquatic life.
- Water with less than 2ppm oxygen will support mainly worms, bacteria, fungi and other detritus feeders and decomposers.

Oxygen is added to watery diffusion from the air, especially when turblence and mixing rates are high, and by photosynthesis in green plants, algae, and cyanobacteria. Oxygen is removed from water by respiration and chemical processes that consume oxygen.

The addition of certain organic materials, such as sewage, paper pulp, or food-processing wastes, to water stimulates oxygen consumption by decomposers. The impact of these materials on water quality can be expressed in term of *biochemical oxygen demand* (BOD): a standard test of the amount of dissolved oxygen consumed by aquatic micro organisms over a five-day period. An alternative method, called the chemical oxygen demand (COD) uses a strong oxidising agent to completely break down all organic matter in a water sample. This method is much faster than BOD test, but normally gives much higher results because it oxidises compounds not ordinarily metabolized by bacteria. A third method of assaying pollution levels is to measure *dissolves oxygen* (DO) content directly using an oxygen electrode. The DO content of water depends on factors other than pollution. But it is usually more directly related to whether aquatic organisms survive than is BOD. The effect of oxygen –demanding wastes on rivers depend to a great extent on the volume flow and temperature of their water. In cold water dissolved oxygen can reach concentrations up to 10 ppm, even less can be held in warm water. Aeration occurs readily in a turbulent, rapidly flowing river, which is therefore, often able to recover quickly from oxygen depleting processes. Downstream from a point source, such as a municipal sewage plant discharge, a characteristic decline and restoration of water quality can be detected either by measuring dissolved oxygen content or by observing the flora and fauna that live in successive sections of the river.

Plants Nutrients and Cultural Eutrophication

Rivers and lakes that have clear water and low biological productivity are said to be oligotrophic (oligo = little + trophic = nutrition). By contrast, eutrophic (Eu + trophic = truly nourished) water are rich in organism and organic materials. Eutrophication is an increase in nutrient levels and biological productivity. The rate of eutrophication and succession depends on water chemistry and depth volume of inflow, mineral content of the surrounding watershed and the biota of the lake itself.

Human activities can greatly accelerate eutrophication. An increase in biological productivity and ecosystem succession caused by human activities is called cultural eutrophication. Cultural eutrophication can result from increased nutrient flows, higher temperature, more sunlight reaching the water surface or a number of other changes. Increased productivity in an aquatic system sometimes can be beneficial. Fish and other desirable species may grow faster, providing a welcome food source.

Eutrophication, thus denotes the enrichment of a water body by input of organic material or surface run-off containing nitrates and phosphates. Elevated phosphorus and nitrogen levels stimulate "blooms" of algae or thick growths of aquatic plants, Bacterial population also increase fed by larger amounts of organic matter. The water after these changes becomes cloudy or turbid and has unpleasant tastes and odors. In extreme cases, plants and algae die and decomposers deplete oxygen in the water. Collapse of the aquatic ecosystem can result.

Inorganic Pollutants

Some toxic inorganic chemicals are sometimes released from weathering of rocks and are carried by run off into lakes or rivers or percolate into ground water aquifers. This pattern is part of natural mineral cycles. Humans often accelerate the transfer rates in these cycles thousands of times above natural background levels through mining; processing, using and adopting improper methods of disposing minerals and mineral wastes.

In many areas, toxic, inorganic chemicals introduced into water as a result of human activities have become the most serious form of water pollution. Among the chemicals of greatest concern are heavy metals, such as mercury, lead, tin and cadmium. Super toxic elements such as selenium and arsenic, also have reached hazardous levels in waters in some regions. Other elements are normally not toxic at low concentrations. However, their higher concentration may lower water quality or adversely affect biological communities.

Metals

Many metals such as mercury, lead, cadmium, and nickel are highly toxic. Levels in the parts per million range – so little that you can not see or taste them – can be fatal. Because metal are highly persistent, they accumulate in food chains and have a cumulative effect in humans.

Mercury Pollution

Among the naturally occurring and the industrial pollutants, mercury is one of the worst offenders and a dangerous pollutants. The element is poisonous, both in the form of inorganic and organic compounds. Methyl mercury gives off vapours. There are many records of fatal poisoning from mercury vapours. It has been found responsible for the spread of fatal mercury poisoning called Minamata epidemic that caused several deaths in Sweden, and Japan. The cause of death was due to the presence of excess of mercury in fish (27 to 102 ppm) with an average of 50 ppm (on dry weight basis) that comprised a large part of the villagers diet in these countries. The safe level of mercury in surface water for domestic use as prescribed by Central Pollution Control Board, New Delhi (1985) is < 0.002 ppm, the limit prescribed by the WHO (1971) is < 0.001 ppm.

Mercury readily penetrates the central nervous system causing teratogenic effect among children born in the Minimata area of Japan i.e. the infants whose mothers were exposed to large amounts of methyl mercury were liable to be affected with mental retardation, cerebral palsy and convulsions. Methyl mercury penetrates to the fetus through the placenta. The concentration of mercury in the blood and the brain of the fetus was about 20% higher than in mother.

Fluoride Pollution

Sources of fluorine compounds in nature and from man's activities, and the air-borne fluoride toxicity are one of the major source of air pollution. Water and soil borne problems of fluoride compounds are also equally hazardous. Fluorine is universally present in varying amounts in soil, water, atmosphere, vegetation and animal tissues. Because of its chemical reactivity, it is found in nature only in combined form.

In Rajasthan, fluorosis problem has reached threatening proportions, according to a study by the Defense Science Laboratory in Jodhpur. The study notes that fluoride has permanently crippled over 3.5 lakh inhabitants and is likely to cripple many more. In some cases, due to the compression of nerves by awkwardly growing bones, paralysis sets in. Fluorosis is prevalent in the district of Jodhpur, Bhilwara, Jaipur, Bikaner, Udaipur, Nagaur, Barmer and Ajmer. Nagaur is among the districts where in several villages in fluoride pollution poses serious health hazards. Rajasthan is believed to have the maximum numbers of the humped back because of high fluoride concentration in water sources in arid and semi-arid zones. Apart from water, the arid and semi-arid soils are also said to contain fluorides. Due to this reason food grain cultivated in these regions contains relatively higher level of fluorides.

Lead Pollution

Lead poisoning is common in adults. Lead and processing industries constitute the major sources of serious lead pollution. Though the lead paints are greater hazards to children, who are prone to ingest and chew on painted articles as lead toys, painters also may run a risk from continual use and exposure. The lead used as stabilises in some plastic pipes is extracted by water thereby polluting the drinking water. Lead in glazing putty may be another source of pollution, especially for children. Lead used in insecticides, food beverages, ointments and various medicinal concoctions for flavouring and sweetening is also an important source of lead poisoning.

Lead pollution causes liver and kidney damage, reduction in hemoglobin formation, mental retardation and abnormalities of fertility and pregnancy. The chronic lead poisoning causes Gastrointestinal troubles, Neuro-muscular Effect, Central Nervous System effect or CNS syndrome.

Arsenic in Drinking water

Arsenic, a natural toxin and a common contaminant in drinking water, may be poisoning millions of people around the world. Arsenic has been known since the fourth century B.C. to be a potent poison. It has been used for centuries as a rodenticide, insecticide and weed killer, as well as a way of assassinating enemies. Because it isn't metabolized or excreted from the body, arsenic accumulates in hair and fingernails, where it can be detected long after death. The largest population to be threatened by naturally occurring groundwater contamination by arsenic is in West Bengal, India and adjacent areas of Bangladesh. Arsenic occurs naturally in the sediments that make up the Ganges river delta. Rapid population growth, industrialization, and intensification of agricultural irrigation however have put increasing stresses on the limited surface water supplies. Most surface water is too contaminated to drink, so groundwater has all but replaced other water sources for most people in this region.

Non-metallic salts

Desert soils often contain high concentrations of soluble salts, including toxic selenium and arsenic. You have probably heard of poison springs and seeps in the desert where these compounds are brought to the surface by percolating groundwater. Irrigation and drainage of desert soils mobilize these materials on a large scale and can result in serious pollution problems. Such salts as sodium chloride that are nontoxic at low concentration also can be mobilized by irrigation and concentrated by evaporation, reaching levels that are toxic for plants and animals.

In many countries close to polar regions, millions of tons of sodium chloride and calcium chloride are used to melt ice from roads in winters. The corrosive damage to highways and automobiles and the toxic effects on vegetation are enormous. Leaching of road salt into surface waters may have a devastating effect on the aquatic ecosystems.

Sediments

A certain amount of sediment enters streams and rivers. However, erosion from farmlands, deforested slopes, overgrazed lands, construction sites, mining sites, stream banks, and roads can greatly increase the load of sediment entering water ways. Sediments (sand, silt and clay) have direct and extreme physical impacts on streams and rivers. When erosion is slight, streams and rivers of the watershed run clear and support algae and other aquatic plants that attach to rocks or take root in the bottom. These producers, alongwith miscellaneous detritus from fallen leaves and so on, support complex food web of bacteria, protozoa, worms, insect larvae, snails, fish, crayfish and other organisms which keep themselves from being carried downstream by attaching to rocks or seeking shelter behind or under rocks; even fish that maintain their position by active swimming occasionally need such shelter to rest.

Sediments entering waterways in large amounts have an array of impacts, and, silt, clay and organic particles are quickly separated by the agitation of flowing water and are carried at different rates. Clay and humus are carried in suspension, making the water muddy and reducing the amount of light penetrating the water hence photosynthesis.

Thermal pollution and Thermal shocks

Raising or lowering water temperatures from normal levels can adversely affect water quality and aquatic life. Water temperatures are usually much more stable than air temperatures, so aquatic organisms tent to be poorly adapted to rapid temperature changes. Lowering the temperature of tropical oceans by even one degree can be lethal to some corals and other reef species. Raising water temperatures can have similar devastating effect on sensitive organisms. Oxygen solubility in water decreases with rise in temperature. At normal temperature water has an oxygen content of about 14.5 ppm, but at 80 °C it contains only 6.5 ppm, so species requiring high oxygen levels are adversely affected by warming water.

Human cause thermal pollution by altering vegetation cover and runoff patterns as well as by discharging heated water directly into rivers and lakes.

The most convenient way to remove excess heat from an industrial facility is to draw cool water from a source like an ocean, a river, a lake or an aquifer, run it through heat exchanger to extract excess heat, and then dump the heated water often back into the original source. A thermal plume of heated water is often discharged into rivers and lakes, where rise in temperature of water can disrupt many processes in natural ecosystems and drive out sensitive organisms. Nearly half the water we draw from various sources is used for industrial cooling. Electric power plants, metal smelters, petroleum refineries, paper mills, food-processing factories, and chemical manufacturing plants all use or large amount of water for cooling and release water that gets heated in the process.

To minimize thermal pollution, power plants are often required to construct artificial cooling ponds or cooling towers in which heat is released into the atmosphere and water is cooled before being released into natural water bodies.

Ground Water Pollution

An exhaustive study of urban water supply system in 75% developing countries by Dietrich and Henderson (1963) suggested that at least 60% of the population, especially in outer city areas and distant villages, is still dependent on underground sources for drinking water. This very important source of water is now threatened with pollution from seepage pits, refuse dumps, septic tanks, barnyard manures, transport accidents, and with diverse agricultural, chemical or biological pollutants. Other major sources of groundwater pollution include sewage and soluble salts. The widespread practice of dumping raw sewage in shallow soak pits has resulted in pollution of ground water in many cities. It attributes in the rise of cholera, hepatitis, dysentery and other water borne diseases, especially in the regions where the water table is high.

Most ground water in the country contains trace levels of naturally occurring radioactive substances or their by-products. In addition, radioactive substances in ground water can result from the nuclear energy programme. At present there are eight functional nuclear power stations in the country and six more projects are in the pipeline. Operations like mining and milling of radioactive ore, chemical reprocessing and radioactive waste disposal can also be source of radioactive pollution in underground water.

Ocean Pollution

Coastal zones, especially bays, estuaries, shoals, and reefs near large cities or the mouth of major rivers, often are overwhelmed by human caused contamination. Suffocating and sometimes poisonous blooms of algae regularly deplete ocean water of oxygen and kill enormous numbers of fish and other marine life. High levels of toxic chemicals, heavy metals, disease-causing organisms, oil, sediment, and plastic refuse are adversely affecting some of the most attractive and productive ocean regions. The potential losses caused by this pollution amount to billion of dollars each year.

Oceanographers estimate that between 3 million and 6 million metric tons of oil are discharged into the world's oceans each year from both land- and sea-based operations. About half of this amount is due to maritime transport. Most oil spills result not from catastrophic, headlines accidents, but from routine open-sea bilge pumping and tank cleaning. These procedures are illegal but are easily carried out once ships are beyond sight of land. Much of the rest comes from land-based municipal and industrial runoff or from atmospheric deposition of residues from refining and combustion of fuels.

Water Pollution Control

Appropriate land-use practices and careful disposal of industrial, domestic, and agricultural wastes are essential for control of water pollution.

(i) *Source Reduction* – The cheapest and most effective way to reduce pollution is usually to avoid producing it or releasing it to the environment in the first place. Elimination of lead from gasoline has resulted in a widespread and significant decrease in the amount of lead in surface waters in the United States. Careful handling of oil and petroleum products can greatly reduce the amount of water pollution caused by these materials. Although we still have problems with persistent chlorinated hydrocarbons spread widely in the environment, the banning of DDT and PCB in the 1970's has resulted in significance reduction in their levels in wildlife.

Modifying agricultural practices, can substantially reduce pollution due to excessive use of fertilizers and pesticides. Similarly, industry can reduce pollution by recycling or reclaiming materials that otherwise might be discarded in the waste stream. Both of these approaches usually have economic as well as environmental benefits.

It turns out that a variety of valuable metals can be recovered from industrial wastes and reused or sold for other purposes.

(ii) *Non-point Source and Land Management*

Among the greatest remaining challenges in water pollution control are diffuse, nonpoint pollution sources. Unlike point sources, such as sewer outfalls or industrial discharge pipe, which represent both specific locations and relatively continuous emission, nonpoint sources have many origins and numerous routes by which contaminants enter ground and surface water. It is difficult to identify let alone monitor and control – all these sources and routes. Some main causes of non point pollution are being presented here to give an idea.

The EPA estimates that 60 percent of all impaired or threatened surface waters are affected by sediment from eroded fields and overgrazed pastures. Pollutants are also carried by runoff from streets, parking lots, and industrial sites that may contain salts, oil residues, pieces of rubber, metals, besides many industrial toxins. New buildings and land development projects such as highway construction affect relatively small areas but produce vast amount of sediment, their disposal when done carefully, can help in reclaiming land. Generally, soil conservation methods also help protect water quality. Applying precisely determined amounts of fertiliser and pesticides and proper irrigation not only saves money but also reduces contaminants entering soil and water sources. The water preserving wetlands that act as natural processing facilities for removing sediment and contaminants helps protect surface and groundwater. In urban areas, citizens can be encouraged to recycle waste oil and to minimize use of fertilizers and pesticides. Runoff can be diverted away from storms and lakes. Many cities are separating storm sewers and municipal sewage lines to avoid flow of contaminants to water sources.

Human Waste Disposal

As we have already seen human and animal wastes usually create the most serious health related water pollution problems. More than 500 types of disease-causing (pathogenic) bacteria, viruses and parasites can travel from human or animal excrement through water. The term sewage refers to the contents of sewers carrying the waterborne waste of a community.

The process of treatment has the following advantages:

(i) The water and nutrient components of the sewage are recycled through crop irrigation or other industrial usages.
(ii) Pollution sources can be eliminated.
(iii) Pollution load can be reduced, and
(iv) Economic benefits can be achieved through crop yield at low cost.

Municipal Sewage Treatment

Over the past 100 years, sanitary engineers have developed ingenious and effective municipal wastewater treatment systems to protect human health, ecosystem stability and water quality. This topic is an important part of pollution control and is a central focus of every municipal government: The sewage treatment includes the following four steps:

1. *Primary Treatment*– This involves the removal of floating and suspended solids, paper, rags etc. by physical and chemical means i.e. screaming, shredding, flocculating and sedimentation. Suspended matter as well as some oxygen demanding waste are removed in the process.

Primary treatment begins as the sewage flows or pumped through the sewer pipes, bacteria initiate its breakdown. Partially decomposed sewage is than filtered as it enters the sewage processing plant. The sewage is allowed to pass through a series of coarse and fine screens to remove the large floating objects. The screens are usually consists of a series of parallel bars. The waste so removed is often passed to a comminutor/shredder where paper and rags used to shred to an acceptable size.

Though nearly 50 per cent of the materials suspended in sewage are removed by this treatment if water to be used for drinking purpose, it has to be treated further.

2. *Secondary Treatment*

This involves decomposition of the organic material of the sewage through metabolic action of organisms accelerated with abundant of oxygen. The breakdown is accomplished with a wide variety of organisms, including bacteria, protozoans, worms and snails. The techniques most commonly used are: trickling filter process and the activated sludge process.

Trickling filters, also known as biological filters, consist of thick bed of gravel containing bacteria over which the sewage is sprinkled at a uniform rate. The filters are not less than two metres deep and circular on rectangular in plan. When the waste water spreads over the bed, it makes contact with abundant of oxygen. As a result, the organic molecules in the waste get decomposed. In the activated sludge process, organic waste and the decomposing organism are suspended as a flocculent mass in the liquid by mechanical agitation in aeration tanks or by diffuse air. The waste continuously flows through the sludge tanks of about 10 feet deep, 20 feet wide and hundreds of feet long. Algae in the sludge generate oxygen to be required for the growth and multiplication of the bacteria.

Despite the secondary treatment, some toxic chemicals, phosphate containing detergents and radioactive substances passed out unaltered. If such water is discharged, toxic substances may accumulate in rivers or lakes killing plants and animals.

3. *Tertiary Treatment*

This involves removal of some of the suspended matter which escapes from final settling tanks in the process of secondary treatment. Some of the techniques which assist in their removal include chemical coagulation, filtration, carbon absorption and chemical oxidation with strong oxidizing agents such as addition of hydrogen peroxides and chlorine.

Fine particles are combined into conglomerates by the process of coagulation the filtered out by passing the wastewater through a bed of gravel or finally graded coal. For instance treatment by addition of alumina-ferric followed by sand filtration and chlorination will yield a clear colourless water almost free from bacterial contamination.

4. *Sludge disposal*

This involves the processing and ultimate disposal of the sludge produced in sedimentation tanks. This increases about half of the cost of sewage treatment. In small works, the sludge is run on the drying beds in a thin layer of about 150 mm deep. Their drying of the sludge takes place partly due to drainage through the sludge into the drains below the bed and partly due to evaporation by sun and wind. Within a few weeks the sludge dries. However, if the volume of the sludge is large, it has to be dried by mechanical means. Nowadays, most sewage works, digest ad sludge an-aerobically to produce more stable products and to kill pathogenic organisms, if present there in. Digestion may be carried out in closed tanks.

The processed sludge is then disposed off at some suitable sites. Disposal of sludge to farmland is practised at many places since nutrients are returned to the land.

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Science News

Pluto Demoted

Pluto was stripped of its status as a planet on 24 August 2006 when astronomers from around the world redefined it as a "dwarf planet", leaving just eight major planets in the solar system.

The status of Pluto as a planet came under a clout when in 1979 it temporarily moved closer to the sun than Neptune in the solar system. It may be recalled that Pluto moves in a highly elliptical orbit around the sun. Every 248 years the two planets, Neptune and Pluto, swap places and for about 20 years, which implies that Pluto becomes the eighth planet and Neptune the ninth in terms of their distance from the sun. This topsy-turvy situation was rectified on 11 Feb. 1999 when Pluto crossed Neptune's orbit and became the ninth planet once again.

But is Pluto really a planet? That's what astronomers have been discussing for last decade or so when some members of the International Astronomical Union (IAU) suggested that Pluto be given the status of a minor planet. Why? For one thing Pluto is very small. It is 6 times smaller than the Earth, and even smaller than seven of the solar system's moons (the Moon, Io, Europa, Ganymede, Callisto, Titan and Triton). Pluto's own moon, Charon, is larger in proportion to its planet than any other satellite in the solar system. Some astronomers consider the pair to be a double planet.

The other reason that questioned the status of Pluto has been its unusual elliptical orbit. It is the only planetary orbit which crosses that of another planet (Neptune), and it is tilted 17 degrees with respect to the plane of the solar system. Astronomers once thought that Pluto may have been a satellite of Neptune that was ejected to follow a tilted elliptical path around the sun. However, careful simulations of the orbits and dynamics of Pluto and Neptune indicate that this is not likely to be so.

Pluto's composition is unknown, but its density (about 2 g/cm^3) indicates that it is probably a mixture of rock and ice. All the other rocky planets — Mercury, Venus, Earth and Mars — are located in the inner solar system, close to the Sun. Except for Pluto; all of the outer planets — Jupiter, Saturn, Uranus and Neptune — are gaseous giants. Once again, Pluto is a misfit.

Despite its well-known peculiarities, Pluto's official status as a planet was never in jeopardy until 1992 when David Jewitt and J. Luu discovered a curious object called 1992 QB1. QB1 is a small icy body, similar in size to an asteroid, orbiting 1.5 times further from the sun than Neptune. QB1 was the first hint that there might be more than just Pluto in the distant reaches of the solar system. Since then nearly 100 objects like QB1 have been found. They are thought to be similar to Pluto in composition and, like Pluto, many orbit the sun in a 3:2 resonance with Neptune. This swarm of Pluto-like objects beyond Neptune is known as the Kuiper Belt, after Gerard Kuiper, who first proposed that such a belt existed and served as a source of short period comets. Astronomers estimate that there are at least 35,000 Kuiper Belt objects greater than 100 km in diameter, which is several hundred times the number (and mass) of similar sized objects in the main asteroid belt.

So, is Pluto really a planet or is it more like a dormant comet, simply the largest known member of the Kuiper Belt? That's the question that astronomers have recently been debating.

Other than its relatively large size, Pluto is practically indistinguishable from the other Kuiper Belt Objects (KBOs) and short period comets. The main difference is Pluto's reflectivity, which is much higher than that of known KBOs. According to Dr David Jewitt, University of Hawaii, USA, Pluto has a higher albedo (60%) than envisaged for the other KBOs. Albedo, it may be recalled is the fraction of sunlight that is reflected back into the space from the surface of a planet or a moon. But this is an artifact of size - Pluto has enough mass and gravity to retain a tenuous atmosphere from which bright surface frosts may be deposited on the surface.

In a press release dated 3 February 1999 the International Astronomical Union stated that "No proposal to change the status of Pluto as the ninth planet in the solar system has been made by any Division, Commission or Working Group of the IAU responsible for solar system science. Lately, a substantial number of smaller objects have been discovered in the outer solar system, beyond Neptune, with orbits and possibly other properties similar to those of Pluto. It has been proposed to assign Pluto a number in a technical catalogue or list of such Trans-Neptunian Objects (TNOs) so that observations and computations concerning these objects can be conveniently collated. This process was explicitly designed to not to change Pluto's status as a planet". However, this view of IAU stands revised in the last week of August 2006.

After a heated debate among 2,500 scientists of the International Astronomical Union (IAU) that met in Prague in August, 2006, a majority voted in favour of the proposal to demote Pluto to a dwarf planet instead of a planet. This followed the adoption of a new definition for a celestial body to be classified as a planet of the solar system. According to the new definition of planets adopted by the IAU, a planet is an object that orbits the sun, forms itself into a sphere by its own gravitational field and has enough gravitational pull to clear its path ff space debris. The IAU definition also requires that a classical planet should be the sole occupant of its orbit. Unlike other eight planets of the solar system, the orbital path of the Pluto overlaps with other objects such as the planet Neptune and asteroids.

The IAU has, therefore, now classified Pluto as a dwarf planet and accordingly assigned it the asteroid number 134340, by which it will be referred from now onwards. With this decision it seems that not only the toys and models of the solar system would become instantly obsolete, but would also compel teachers and publishers to update textbooks and lessons used in classrooms for decades. Discovered in 1930 by the American Clyde Tombaugh, the icy rock of Pluto has traditionally been considered the ninth planet, farthest from the sun in the solar system.

The definition of a planet, approved after a heated debate at the International Astronomical Union (IAU) meeting in Prague, drew a clear distinction between Pluto and the other eight planets. The need to define what a planet is was driven by technological advances enabling astronomers to look further into space and measure more precisely the size of celestial bodies. According to Richard Binzel, Professor of Planetary Sciences at The Massachusetts Institute of Technology and a member of the planet definition committee this is all about the advancement of science changing our thinking as we get more information. The significance of the decision is that new discoveries and new science have told us that there is something different about Pluto from the other eight planets and as science learns more information, we get new results and new considerations.

In fact, the decades-old debate on the definition of a planet received impetus when Brown discovered UB313 in 2003. Xena, as it is nicknamed, is larger than Pluto, instantly leading to a worldwide debate whether a new planet had been discovered. The scientists agreed that, to be called a planet, a celestial body must be in orbit around a star while not itself being a star. It must be large enough in mass for its own gravity to pull it into a nearly spherical shape and have cleared the neighborhood around its orbit. Pluto was disqualified because its oblong orbit overlaps Neptune's. Xena also does not make the grade of being a planet, and will also be known as a dwarf planet.

However, everybody does not seem to share with the views of the IAU about Pluto. Many members of IAU were amazed that the agreed-upon definition, the first time the IAU has tried to define scientifically what a planet is, comes in sharp contrast to the draft circulated amongst the delegates at the General Assembly. Alan Stern of the Southwest Research Institute in Boulder, Colorado, overseer of science investigations on NASA's New Horizons mission to Pluto, called the reclassification rash and illogical. He is confidant that people would continue to consider Pluto a planet regardless of the decision taken at IAU meeting. That document, which kept Pluto as a planet and would have added three others, touched off a revolt that grew daily. Some delegates appeared downright hostile to the notion. Michael Shara, Astrophysics Curator at the American Museum of Natural History in New York revealed that the Museum had received enormous numbers of telephone calls, many of which are on the verged on hate mail from second-graders — very angry children who said, 'what have you done?' This is the cutest, most Disney-esque of the planets. 'How could you possibly demote it'?

Tombaugh's 94-year-old widow Patricia thinks that the discoverer, like any good scientist, would have accepted the demotion as inevitable. In her opinion her husband Clyde would have said, 'Science is a progressive thing and if you're going to be a scientist and put your neck out, you're apt to have it bitten upon. She added that a small amount of her husband's ashes were now on a spacecraft bound for Pluto.

The new definition creates a second category called "dwarf planets," as well as a third category for all other objects, except satellites, known as small solar system bodies. From now on, or at least for the time being, traditional planets will be restricted to eight: Mercury, Venus, Earth, Mars, Jupiter, Saturn, Uranus and Neptune. Whether Pluto remains to be classified as a planet or a dwarf planet, the fact is that it is there deep in the solar system and to continue to revolve around the sun in its known orbit.

(*Source:* NASA website)

Pluto's Two Small Moons Christened Nix and Hydra

What seems to be an irony of fate that on 22 June 2006, just two months before being stripped of the status of a planet, the two small satellites of Pluto discovered in May 2005, were named Nix and Hydra by the International Astronomical Union (IAU), the internationally recognized authority for assigning designations to celestial bodies. In Greek mythology Nyx was the goddess of darkness and the night, a very appropriate name for a moon orbiting Pluto - the god of the underworld. To avoid confusion with the asteroid (3908) Nyx, the Egyptian spelling Nix was chosen. Hydra is the serpent with nine heads that guarded the underworld.

A team of researchers from Southwest Research Institute (SwRI) in Boulder, Colorado, the Johns Hopkins University Applied Physics Laboratory (APL) in Laurel, Md., the Space Telescope Science Institute in Baltimore and Lowell Observatory in Flagstaff, Ariz., used Hubble Space Telescope images to make the discovery in support of NASA's mission to Pluto and beyond the Kuiper Belt that has been named 'New Horizons'. Alan Stern, co-leader of the discovery team and the New Horizons principal investigator from SwRI expressing his pleasure on the decision of the IAU, optimistically commented that one is going to be hearing a lot more about Nix and Hydra in coming years as the astronomers are already applying for telescope time to study their orbits and physical properties. And when New Horizons flies by Pluto in the summer of 2015, each will be mapped in detail.

(*Source:* NASA News on line)

TAPP-3 Synchronized with the Grid

Unit-3 of the Tarapur Atomic Power Project (TAPP) was synchronized with the grid on 15 June 2006. The 540 MWe Unit-3 of the Tarapur Atomic Power Project (TAPP) attained criticality on 21 May 2006 that signified the start of self-sustaining nuclear fission chain reaction in the reactor core. Designed and built by the Nuclear Power Corporation TAPP-3 is the sixteenth nuclear power reactor in the country. With this the aggregate capacity of NPCIL will increase to 3900 MWe.

TAPP - 3 and 4 (the later has achieved criticality on March 6, 2005) comprise two Pressurised Heavy Water Reactor (PHWR) units of 540 MWe each. PHWRs use natural uranium as fuel and heavy water both as moderator and coolant. The experience gained from TAPP – 3 and 4 is to be utilised for up rating the unit size to 700 MWe. Four such units of 700MWe each are proposed to be built, two units each at Rawatbhata in Rajasthan and Kakrapur in Gujarat.

(*Source:* Nuclear India)

Optical Atomic Clock

James C. Bergquist, Physicists at the National Institute of Standards and Technology (NIST), Boulder, Colorado, USA has claimed that his team of researchers has refined an innovative atomic clock, which would be more precise than the best of clocks designed during the last 50 years. The advancement according to researchers may indicate that the reign of cesium atomic clocks is coming to an end.

To track time, a cesium clock exploits the absorption of microwaves by a cloud of cesium atoms. In contrast, the NIST optical clock makes use of interactions between ultraviolet radiation and a single mercury ion. Ultraviolet electromagnetic waves oscillate about 100,000 times as fast as the cesium-cloud microwaves do and so provide a much finer means to measure a second.

The NIST researchers led by Bergquist having made further improvements have designed a clock that's about 10 times as precise as the world's cesium standard. According to NIST figures, the cesium standard would be off by no more than 1 second in 70 million years of continuous operation. The NIST advance could ultimately improve navigation and tele-communications systems, opines Jean-Jacques Zondy of France's National Metrology Institute in La Plaine Saint Denis. Beyond that, the achievement "raises the issue of changing the definition of time", he notes.

However, a redefinition of the second, now based on a specific property of cesium, may be decades away, according to Zondy. Scientists don't yet know whether some other atom will prove better than mercury in optical clocks. The record-low uncertainty of the NIST clock opens the door to ultraprecise tests of foundations of physics, including relativity and the steadiness of the so-called fundamental constants. According to Bergquist at least one such test is already well under way. In recent years, astrophysical data have indicated that the fine-structure constant called *alpha* has increased since the early universe. By comparing the behaviour of the new mercury clock and another NIST optical clock based on aluminum, the NIST team is seeking evidence that *alpha* may be changing today.

(*Source:* Science News online)

Titan's Lakes: Evidence of liquid on Saturn's largest moon

New radar images indicate that Saturn's giant moon Titan contains lakes of liquid hydrocarbons. The finding provides the first compelling evidence for bodies of liquid on the surface of any object besides Earth, say the researchers who analysed the images.

Located in Titan's north polar region, the lakes range in width from just under a kilometre to 32 km and extend up to 90 km. Titan's surface, at a frigid –180°C, is much too cold for liquid water. According to Stephen Wall, Planetary Scientist of NASA's Jet Propulsion Laboratory in Pasadena, Calif, the lakes probably consist of methane, possibly mixed with ethane. The lakes are a source of the methane gas that accounts for 5 per cent of Titan's smoggy atmosphere, assert Wall and his colleagues. Over millions of years, sunlight breaks down atmospheric methane, and scientists have long sought a source that could replenish it. They've suspected that much of the moon might be covered with methane seas.

NASA's Cassini spacecraft, which began touring Saturn in the summer of 2004, dispelled that notion. But radar images taken by the craft on 22 July 2006 show a landscape that resembles lake-strewn Minnesota. If the lakes are indeed composed of methane, the hydrocarbon would cycle between Titan's surface and atmosphere just as water cycles on Earth. Researchers consider the discovery of the equivalent of a hydrological cycle on Titan quite significant as the finding adds yet another reason to study the moon as it may help scientists to unravel the mystery of frozen Earth prior to appearance of life on it.

Although Titan's hydrocarbon haze hides the moon's surface in visible light, radar penetrates the smog. Radar-dark regions, such as the ones just found by Cassini, can denote either a smooth, liquid surface or an accumulation of powder or sand that absorbs light. However, Wall interprets that several signs from Cassini paint a lakelike portrait. Not only are the dark areas shaped like lakes, but they also have channels leading out of them. A smooth, dry powder or sand couldn't sculpt channels. Furthermore, some of the lakelike areas show what appear to be multiple shorelines, as if the body of liquid has been receding. Millions of years ago, when methane was more plentiful, lakes might have covered much more of the moon, suggests Jonathan Lunine of the University of Arizona in Tucson, who collaborated with Wall.

Cassini would not provide radar images of areas near Titan's South Pole until 2008. But this October, the radar system will look at the north polar region of Titan from a different angle. If such observations over several years show changes with season or brightness changes that could be caused by waves, they'll strengthen the evidence that liquid methane currently resides on Titan, says McEwen.

(*Source:* Science News online)

New Technique Can Manipulate Light Beams

It may be surprising to observe a laser beam spreads when it is directed to the moon and returned by one of the mirrors, a few kilometers in diameter, left behind by the Apollo astronauts at the end of their trip. This spread is mostly due to atmospheric distortions, but it nonetheless poses problems to those who wish to keep laser beams from diverging or focusing to a point as light travels through a medium.

Now a team of physicists, mathematicians, and electrical engineers from the California Institute of Technology and the University of Massachusetts at Amherst has come out a trick to keep light pulses from diverging or focusing. Using a multi-layer sandwich of glass plates alternating with air, the scientists have provided the first experimental demonstration of a procedure called "nonlinearity management". This technique wouldn't do anything for light traveling all the way to the moon, but could be useful in future generations of devices involving optical switching and optical information processing, for which precise control of laser pulses will be advantageous.

The researchers have demonstrated that a laser beam passing through multiple layers of glass and air can be made to last much longer than if it had passed through only one type of medium. This procedure exploits a phenomenon known as the "Kerr effect", which causes the refractive index of an individual material to change if the light energy is sufficiently intense. When light is propagated only through glass, one obtains a focused beam so intense that it generates a plasma in the medium by ionizing it. Using a multi-layer "Kerr sandwich" of light and air, however, keeps the plasma from being created because the different refractive indices of the media cause the light beam to diverge and converge several times.

However, the researchers say that the setup they have used is intended to demonstrate that nonlinearity management can be performed, and it is not by any means the final version of a practical apparatus.

(*Source:* Science Daily online)

Apple Juice Benefits Neurotransmitter that Affect Memory

'An apple a day keeps the doctor away' is perhaps one of the most familiar proverbs. Now a research study conducted by scientists at University of Massachusetts Lowell (UML) demonstrates that apple products can help boost brain function similar to medication. Apples and apple juice may be among the best foods that could be added to our diet especially for babies and senior citizens, according to researchers.

Research on animals at the University of Massachusetts Lowell (UML) indicates that apple juice consumption may actually increase the production in the brain of the essential neurotransmitter acetylcholine, resulting in improved memory. Neurotransmitters such as acetylcholine are chemicals released from nerve cells that transmit messages to other nerve cells. Such communication between nerve cells is vital for good health, not just in the brain, but throughout the body.

Thomas Shea, Director, UML Center for Cellular Neurobiology and Neurodegeneration Research anticipates that the day may come when foods like apples, apple juice and other apple products are recommended along with the most popular medicines for Alzheimer's disease. The role of acetylcholine in the brain is not a new area of research. Alzheimer's medication studies start with the premise that increasing the amount of acetylcholine in the brain can help to slow mental decline in people with Alzheimer's disease. Testing a similar hypothesis, the UML research team found that having animals consume antioxidant-rich apple juice had a comparable and beneficial effect.

In this novel animal study at UML, adult (9-12 months) and old (2-2.5 years) mice, some specially bred to develop Alzheimer's-like symptoms, were fed three different diets (a standard diet, a nutrient-deficient diet, and a nutrient-deficient diet supplemented with apple components (in this case, apple juice concentrate was added to their drinking water). Among those fed with the apple juice-supplemented diet, the mice showed an increased production of acetylcholine in their brains. Also, after multiple assessments of memory and learning using traditional Y maze tests, researchers found that the mice who consumed the apple juice-supplemented diets performed significantly better on the maze tests.

The findings also suggest that the apple-supplemented diet was most helpful in the framework of an overall healthy diet. Shea concludes, "The findings of the present study show that consumption of antioxidant-rich foods such as apples and apple juice can help reduce problems associated with memory loss." According to Shea clinical study evaluating consumption of apple products on humans will begin in the near future.

(*Source:* Science Daily online)

Anti-obesity Vaccine Tested

In what may be the first published breakthrough of its kind in the global battle against obesity, scientists at The Scripps Research Institute have developed an anti-obesity vaccine that significantly slowed weight gain and reduced body fat in animal models.

In the new study, mature male rats immunized with specific types of the active vaccine ate normally yet gained less weight and had less body fat, indicating that the vaccine directly affects the body's metabolism and energy use. This finding may be especially important to stop what is commonly known as "yo-yo dieting", the cycle of repeated loss and regain of weight experienced by many dieters. The new vaccine, which is directed against the hormone ghrelin (pronounced "grell-in"), a naturally occurring hormone that helps regulate energy balance in the body, has shown the potential, in animal models at least, to put an end to that risky and often futile struggle.

Ghrelin, a gastric endocrine hormone produced primarily in the stomach, plays a physiological role in energy homeostasis, although the full extent of that role remains unknown. It was first identified in 1999 as a naturally occurring ligand—a molecule that binds to another to form a larger molecular complex—for a growth hormone secretagogue receptor. What is known is that ghrelin promotes weight gain and fat storage through its metabolic actions, decreasing the breakdown of stored fat for energy as well as curbing energy expenditure itself. During periods of weight loss, such as dieting, the body produces high levels of ghrelin to slow down fat metabolism, encourage eating, and promote fat retention, changes which normally make it difficult to lose weight and keep it off. There is broad speculation that ghrelin evolved as a response to the feast or famine conditions of early humans. Those who were genetically predisposed to eat heartily and store fat efficiently during periods of plenty were more likely to survive the next round of scarcity and passed this trait onto the next generation. In recent years, however, that powerful genetic legacy has come in direct conflict with the dangerous phenomenon of overeating in the developed world

The findings of the research team may mark a turning point in the treatment of obesity by confirming the effectiveness of immunopharmacotherapy to combat this serious and growing global problem. Immunopharmacotherapy engages the immune system, specifically antibodies, to bind to selected targets, directing the body's own immune response against them. This approach is being tested in a number of other areas including drug addiction, especially addiction to cocaine and nicotine.

According to Kim Janda, Jr. Professor of Chemistry at Scripps Research, the study shows that the vaccine developed by the research team slows weight gain and decreases stored fat in rats. The research showed that even though food intake was unchanged in all testing groups, those who were given the most effective vaccines gained the least amount of weight. To have an impact on appetite and weight gain, the hormone, ghrelin, first has to move from the bloodstream into the brain – where, over long periods, it stimulates the retention of a level of stored energy as fat. The researchers claim that their study is the first of its kind to provide evidence proving that preventing ghrelin from reaching the central nervous system can produce a desired reduction in weight gain.

However, researchers caution that their study does not answer all the questions pertaining to obesity treatment once and for all. What the study confirms is that this looks like a serious workable solution to the problem. And while much more research is needed to understand the full therapeutic potential of immunopharmacotherapy in combating obesity, these initial results are extremely positive. Right now it appears that active vaccination against ghrelin is one avenue that can slow weight gain and fat build-up in the body.

A vaccine against ghrelin also is particularly compelling in terms of the well-documented problems of human dieting. When you diet, the body responds as if it was starving and produces ghrelin to slow down fat metabolism and stimulate eating, changes meant to help retain and regain body fat. As a result, many people end up regaining the weight they lost and more once they go off their diets. This vaccine may have the real potential to prevent or seriously reduce yo-yo dieting; the repetitive cycle of weight loss and gain, because it interferes with ghrelin's ability to promote weight gain and fat accumulation.

(*Source:* Science Daily online)

X-rays Reveal Archimedes' Hidden Writings

Previously hidden writings of the ancient Greek mathematician Archimedes are being uncovered with powerful X-ray beams nearly 800 years after a Christian monk scrubbed off the text and wrote over it with prayers.

Researchers at Stanford University's Linear Accelerator Center in Menlo Park have been using X-rays to decipher a fragile 10th century manuscript that contains the only copies of some of Archimedes' most important works. The X-rays generated by a particle accelerator cause tiny amounts of iron left by the original ink to glow without harming the delicate goatskin parchment. According to William Noel, curator of manuscripts at Baltimore's Walters Art Museum, the investigation is providing new insights into one of the founding fathers of western science. It is perhaps the most difficult imaging challenge on any medieval document because the book is in such terrible condition. It takes about 12 hours to scan one page using an X-ray beam about the size of a human hair, and researchers expect to decipher up to 15 pages that resisted modern imaging techniques. After each new page is decoded, it is posted online for the public to see.

Archimedes, born in the 3rd century B.C., is considered as one of ancient Greece's greatest mathematicians, perhaps best known for discovering the principle of buoyancy while taking a bath. The 174-page manuscript, known as the Archimedes Palimpsest, contains the only copies of treatises on flotation, gravity and mathematics. Scholars believe a scribe copied them onto the goatskin parchment from the original Greek scrolls. Three centuries later, a monk scrubbed off the Archimedes text and used the parchment to write prayers at a time when the Greek mathematician's work was less appreciated. In the early 20th century, forgers tried to boost the manuscript's value by painting religious imagery on some of the pages.

Over the past eight years, researchers have used ultraviolet and infrared filters, as well as digital cameras and processing techniques, to reveal most of the buried text, but some pages were still unreadable. However, scientists are not optimistic to never recover all of it.

(*Source:* SciCentral)

Hydrogen Power System Unveiled

A system that produces hydrogen energy to provide backup lighting and warmth has been demonstrated at the Chewonki Foundation's environmental education center. The nonprofit foundation teamed up with the Portland-based Hydrogen Energy Center to develop the system that was touted as an example of the kind of cutting-edge technology that can reduce dependence on fossil fuels and help ease global warming.

It is well known that hydrogen represents a huge growth industry, and the researchers around the world are trying to develop reliable hydrogen based energy systems. The system unveiled at

Chewonki uses renewable power — from solar panels atop the center and purchases of "green" electricity — to produce hydrogen from water through a process known as electrolysis. New technology that produces the gas at high pressure eliminates the need for a costly compressor. Developers of the system claim that it is the first publicly accessible direct high-pressure hydrogen energy system as well as the first complete hydrogen energy system.

Because hydrogen is flammable, the electrolyzer and eight cylinders of the gas are stored in a wood and concrete shed. The gas is then taken by a pipe, where three fuel cells convert it into one kilowatt of electricity. That power will be available in the event of an outage to supply four days' worth of lighting, operation of the building's water pump and warmth for animals that include a turtle, an iguana and an alligator.

The project, which took more than two years to complete, was designed to demonstrate how hydrogen can be generated, stored and used to provide energy. While the hydrogen generator is educational in nature, researchers are confident that commercial applications for the technology are beginning to emerge.

(*Source:* Sciencenews online)

Dark Matter Spotted After Cosmic Crash

An intergalactic collision is providing astronomers with a giant payoff: the first direct evidence of the invisible material that theorists say holds galaxies together and accounts for most of the universe's mass. For nearly 70 years, cosmologists have agreed that theories of gravity account for observations in Earth's solar system but fail on a larger scale. For example, if those theories held throughout the universe, objects on the outskirts of the Milky Way would rotate more slowly than those toward the centre. But observations have revealed that it is not so.

Scientists have offered two competing explanations of this discrepancy. The first is that an invisible substance called dark matter accounts for 90 percent of the universe's mass and gravity. Although scientists don't know what dark matter consists of, they propose that it keeps each galaxy intact. However, there is another view that doesn't accept existence of dark matter and that traditional models of gravity simply need modification.

To search for dark matter, Douglas Clowe of the University of Arizona in Tucson and his colleagues used several telescopes and observatories to image an unusually energetic collision between two galaxies that occurred 100 million years ago. Normally, as galaxies travel through the universe, gravity keeps dark and ordinary matter close together, so the invisible substance can't be distinguished. During a galactic merger, however, hot gases from one galaxy bump into hot gases in the other and both galaxies are slowed by a force similar to wind resistance. But dark matter from one galaxy, in theory, passes right through another galaxy's dark matter. According to Clowe dark matter particles don't experience the same type of drag that slows down gas clouds. His team used a technique called gravitational lensing to locate the main mass in the aftermath of the collision. If dark matter didn't exist, all the mass would have been lumped together with the gases. Instead, the researchers found most of the mass in clumps that appeared to have whizzed past the hot gases.

The method called gravitational lensing essentially involves observation and measurement of change in direction of light as it passes close to a massive objects in space. The gravity of a massive object, whether visible or invisible, changes the direction in which light travels. By observing and measuring this light, researchers can figure out the location and even size of the object, whether a star, galaxy, or cloud of gas, responsible for the bending. The researchers focused on a galaxy cluster called 1E0657-56 found that the gravity of something invisible and extremely massive had bent light coming from more-distant galaxies visible in the background. In fact, they detected two large, separate clumps. One of the clumps, the researchers say, is made of ordinary matter, consisting of hot gases. The other clump is made of dark matter. Normally, ordinary and dark matter would be together in the same clump.

But why would dark matter separate from ordinary matter? During the impact, the hot gases of one galactic cluster slowed down the hot gases of the other. In contrast, because dark matter from one galaxy passes right through another galaxy's dark matter, the dark matter wasn't slowed by the impact. So, they could detect the two types of matter as separate clouds.

Clowe's team argues that only a theory of gravity that includes dark matter can explain the separation. According to Maxim Markevitch of the Harvard-Smithsonian Center for Astrophysics in Cambridge, and a member of the research team their finding proves in a simple and direct way that dark matter exists. It puts to rest the remaining doubt that cosmologists have had until now. The matter separation caused by the collision is "mind-boggling," says cosmologist Michael Turner of the University of Chicago. However, he adds that the researchers can't rule out alternative theories, in part because the models from them are so inconsistent.

(*Source:* Science News online)

Extending Life of Lithium Batteries

Modern rechargeable batteries for electronic gadgets generally use lithium compounds as the positive electrode and have revolutionised the electronics industry. They can be made very compact but can still deliver the required voltage to run everything from cell phones to digital cameras and notebook computers. And, not forgetting those ubiquitous MP3 players. However, everyone using a laptop, digital camera or a MP3 player experiences the frustration due to battery discharge every now and then. As gadgetry becomes sophisticated so consumer demands on battery life have risen. Moreover, more powerful lithium batteries are beginning to be used in power tools and may soon be seen in electric vehicles, applications that are much more draining than those for which conventional lithium batteries are used.

A solid solution to the problem could come from chemists in the UK. They have devised a new and efficient way to improve battery power as well as make that precious charge last longer. According to Kuthanapillil Shaju and Peter Bruce of the University, St Andrews, Scotland, lithium batteries use so-called intercalation materials as their anode. These materials are composed of a solid network of lithium atoms together with other metals, such as cobalt, nickel, or manganese, meshed together with oxygen atoms. When one charges a lithium battery, the charging current pulls the positive lithium ions out of this network. When this battery is used, it discharges as these lithium ions migrate back into the electrode, pulling electrons as they go, and so generating a current.

The challenge is to make new electrode materials that deliver high power (fast discharge) and high energy storage. Shaju and Bruce hope that they could solve these problems by developing a new way of synthesizing a particular lithium intercalation compound ($Li(Co_{1/3} Ni_{1/3} Mn_{1/3})O_2$). As a bonus, they hope to be able to simplify the complicated manufacturing process.

The St Andrews team has devised a new synthetic approach to the compound that involves simply mixing the necessary precursor compounds - organic salts of the individual metals - with a solvent in a single step. This is in sharp contrast to the conventional multi-step process used for making the compound. Using this technique, they have been able to make highly uniform lithium oxide intercalation materials in which nickel, cobalt, and manganese ions are embedded at regular intervals in the solid, which also contains pores for the electrolyte. The highly porous nature of the new material is crucial to its electrical properties. The pores allow the electrolyte to make intimate contact with the electrode surface resulting in high rates of discharge and high energy storage. The St Andrews team has tested their new lithium electrode material by incorporating it into a prototype battery and found that it gives the battery far superior power and charge retention. Increasing the rate by 1000%, so that the battery can be discharged in just six minutes, reduces the discharge capacity by only 12%. The test results suggest that this approach to rechargeable batteries could be used to make even higher power batteries for vehicles and power tools. There is an added bonus in that replacing a proportion of the cobalt used in the traditional lithium-cobalt-oxide electrodes with manganese improves safety by reducing the risk of overheating.

Flying on Hydrogen

Georgia Institute of Technology researchers have conducted successful test flights of a hydrogen-powered unmanned aircraft believed to be the largest to fly on a proton exchange membrane (PEM) fuel cell using compressed hydrogen. The fuel-cell system that powered the 22-foot (6.6 metre) wingspan aircraft generates only 500 watts. According to Adam Broughton, a research engineer who is working on the project in Georgia Tech's Aerospace Systems Design Laboratory (ASDL) five hundred watts is sufficient to light a bulb, but not for the propulsion system of an aircraft this size. In fact, 500 watts represents about 1/100th the power required by a hybrid car. The project jointly undertaken by ASDL and the Georgia Tech Research Institute (GTRI) has been led by David Parekh, Deputy Director, GTRI and the founder of Georgia Tech's Center for Innovative Fuel Cell and Battery Technologies.

Parekh wanted to develop a vehicle that would both advance fuel cell technology and galvanise industry interest. While the automotive industry has made strides with fuel cells, apart from spacecraft, little has been done to leverage fuel cell technology for aerospace applications. According to him a fuel cell aircraft is more compelling than just a lab demonstration or even a fuel cell system powering a house. It is also more demanding. With an airplane, you really push the limits for durability, robustness, power density and efficiency.

Fuel cells, which create an electrical current when they convert hydrogen and oxygen into water, are attractive as energy sources because of their high energy density. Higher energy density translates into longer endurance. Though fuel cells don't produce enough power for the propulsion systems of commercial passenger aircraft, they could power smaller, slower vehicles like unmanned aerial vehicles (UAVs) and provide a low cost alternative to satellites. Such UAVs could also track hurricanes, patrol borders and conduct general reconnaissance. Fuel cell powered UAVs would have several advantages over conventional UAVs, according to researchers. To begin with, fuel cells emit no pollution and unlike conventional UAVs, don't require separate generators to produce electricity for operating electronic components. Another plus, because fuel cells operate at near ambient temperatures, UAVs emit less of a heat signature and would be stealthier than conventionally powered UAVs.

Comet Swan

There's a new comet in the night sky, Comet Swan. It's a trifle too dim for naked-eye viewing, but it is an easy target for binoculars and small telescopes. Observers report a "spectacular" emerald-colored head and a long sinuous tail. All those interested in tracking the comet may visit http://spaceweather.com for sky maps and more information.

(Compiled and edited by R. Joshi)

Book Review

Learning Science (Parts 1 to 4)
By Indumati Rao and C.N.R. Rao
Published by Jawaharlal Nehru Centre for Advance Scientific Research, Jakkur P.O., Bangalore 560 064. Pp.84, 148, 167, 119.

SCIENCE HAS become an integral part of our lives. Applications of science have provided us many benefits and ensured a better quality of life. The world today uses a language which has a lot of science in it. Even unknowingly we use many words and phrases derived from science. It is, therefore, important to learn the language of science. Not only children but also adults have to know the rudiments of science so that they may be able to apply the lessons learnt from science in daily life. The book under review has been written keeping this very objective in mind.

The book is in four parts. Each part has a different title and an independent cover. Part 1 entitled 'Universe, Solar system, Earth' explores our universe, the solar system and earth. Various aspects have been covered and concepts introduced in a simple and interest-arousing manner. However, on page 55, about gravitational force, the authors write: "The strength of the force depends upon the weight of the object – the heavier the object, the stronger is the force." There is a clear-cut lacunae in this statement which should be taken care of in the future edition.

Part 2 is entitled 'The world of physics and energy: Learning physical principles'. Indeed, physics has a very important role to play in our daily lives. Our day begins with physics. We use heat, hear sounds and use energy. We switch on the fan, see TV and preserve food in a fridge, use a computer or travel to work. Our day ends with physics when we turn off the TV, shut down the computer, switch off the light and go to bed. This part includes various aspects, from levers to solar and fuel cells. Even information about pacemaker and electrocardiograph has been included. However, in the chapter on light, some elementary information about lasers should have been included.

Part 3 is entitled 'The world of chemistry: of molecules and materials, Air around us, All about water.' This part comprises thirteen chapters in all. The titles of some of the chapters are 'Why chemistry?'; 'Water: the cradle of life on earth'; 'Carbon: the black rock that burns'; 'Man and metals'; 'Man-made materials'; 'Air around us'; and 'All about water'. In the chapter on Air, one also finds information about weather and weather forecasting. One only wonders whether the two chapters on Water could have been combined into a single one.

Part 4 is entitled 'Biology and Life' and comprises eight chapters in all. The chapters are entitled 'What is Biology?', 'Evolution of life on earth', 'The amazing plant kingdom', 'Origin of the animal kingdom', 'Biology and life processes', 'Same life processes but different methods', 'Energy sensors', and 'The invisible world of microbes'.

All the four parts of the book have been nicely produced on glossy paper with lots of coloured, interesting and eye-catching plates and illustrations. Certainly, the book will be useful to school children as supplementary reading material. It will also be useful to adults who want to learn science and partake in the excitement of this experience.

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