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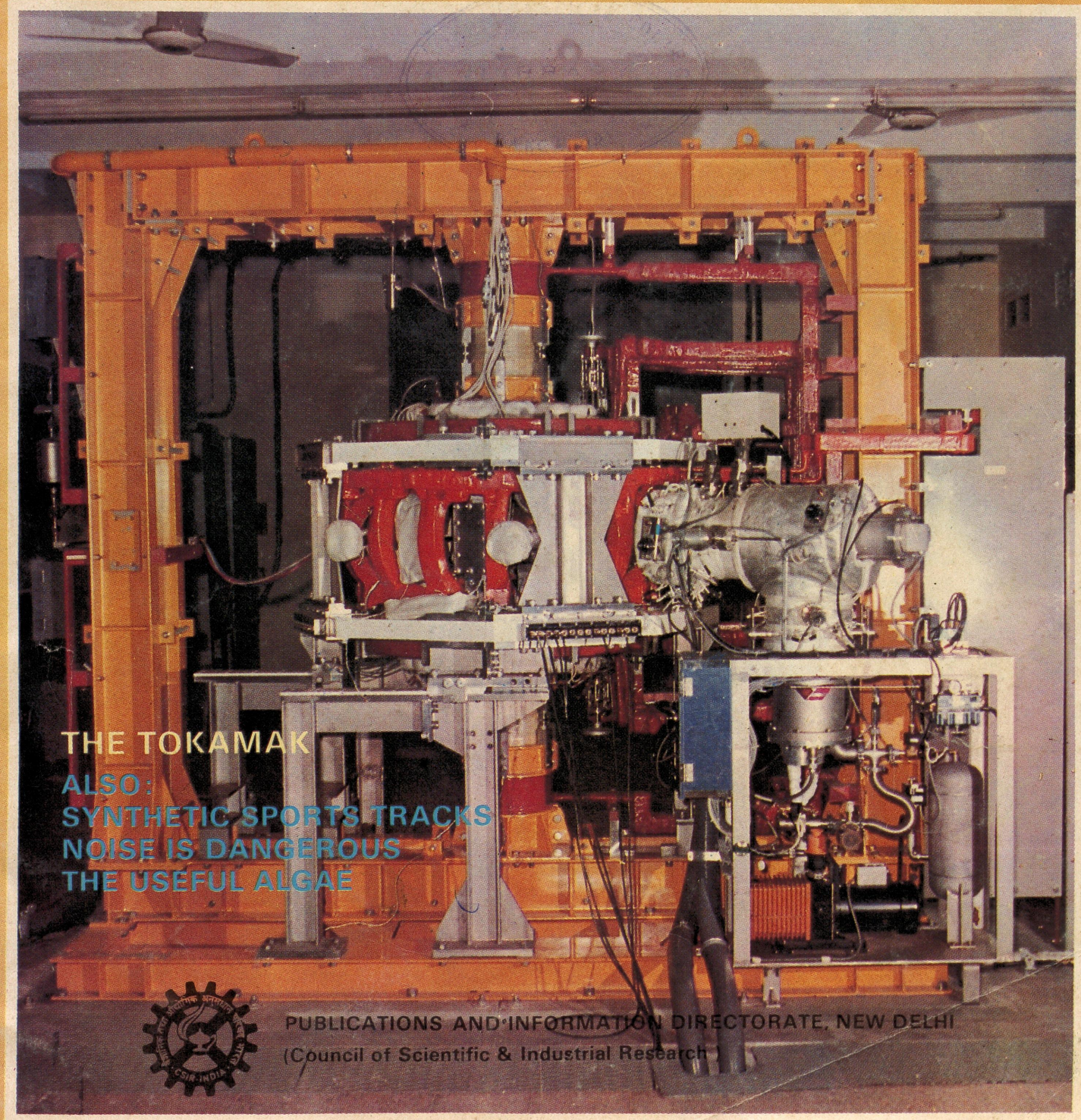

THE TOKAMAK

ALSO :
SYNTHETIC SPORTS TRACKS
NOISE IS DANGEROUS
THE USEFUL ALGAE

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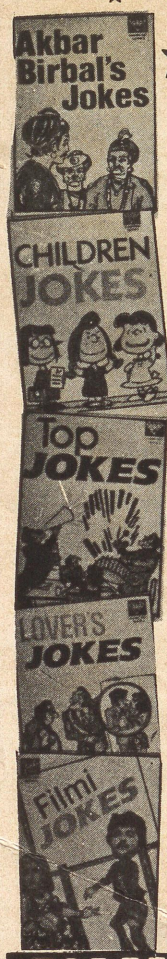

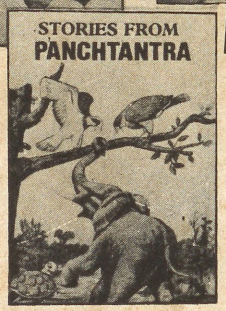

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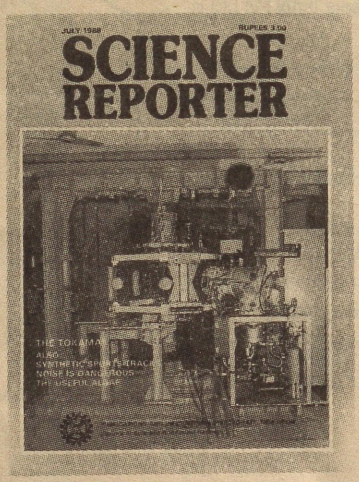

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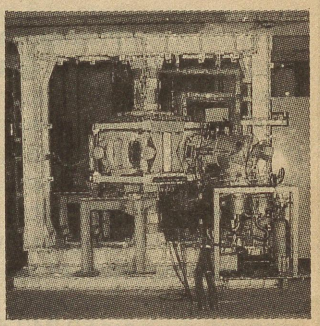

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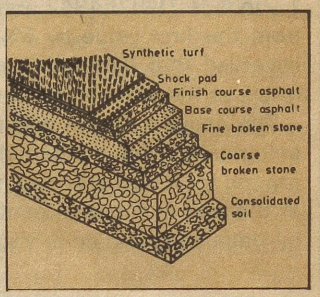

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Gelidiella acerosa

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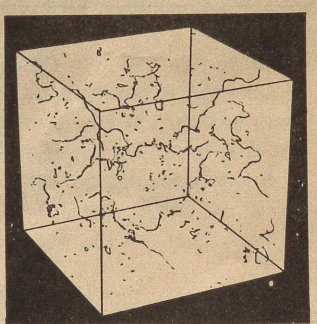

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LETTERS

Primes

Sir, the article **Puzzles from 'Queen of mathematics'** by S. Seetha Rama Raju (*S.R.*, April 1988.), which dealt essentially with prime numbers, was informative. An interesting prime number theorem states that the percentage of primes within an interval from 1 to any large number N is approximately equal to the reciprocal of the natural logarithm of N. For example, there are 50,847,478 primes smaller than 1,000,000,000. Dividing this by 10^9 yields .050847478 and 1 /ln N is .048254942, which differs from the first value by 5%. It is also observed that larger the value of N, lesser is the percentage deviation.

The above theorem was discovered empirically. The mathematical background for it was provided much later, at the end of the nineteenth century, by Hadamard and de la Vatee Pousin.

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Fluoride in tea

Sir, Permit me to supplement the article **The cup that cheers** by A. Subrahmanyam (*S.R.*, April 1988).

The fluoride content of tea is unusually high, being about 150 ppm for black tea and more than twice this level for green tea (Robert L. Wickremasinghe, *Advances in Food Research*, **24**, 229-286, 1978).

A black tea brew provides 1 to 2 ppm of fluoride, indicating that tea drinking could make a significant contribution to the fluoride intake which is required for the prevention of dental caries.

Incidentally, theine and caffeine are identical, this xanthine alkaloid is chemically and pharmacologically related to theophylline (occurring in tea) and theobromine (the principal alkaloid in cocoa, also present in cola nuts and tea). In a way, consumption of caffeine-containing beverages has made caffeine one of the world's most widely used psychotropic drugs and part of our daily diet (C.J. Gallant, T. Macaulay and R.F. Chandler, *The Eastern Pharmacist*, **24**, 31-36, 1981). Although caffeine is implicated in certain disease conditions, its stimulative effect "has worked its way to the marrow of civilized life" (E.A. Starbird, cited *ibid*).

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Psyche behind drinking tea

Sir, **The cup that cheers** by A. Subrahmanyam (*S.R.*, April 1988) was interesting and informative. Let me add a little to the much disputed—useful or harmful—aspect of drinking tea. The amount of tea itself is not harmful but the 'Psyche' behind drinking it is harmful.

Akhilesh Chandra Shah
Botany Department
University of Garhwal
Srinagar, Garhwal
246174

Mimicry and Rothschild

Sir, The article on Miriam Rothschild (*S.R.*, March 1988) by D.M. Salwi was interesting and inspiring. She is an authority on mimicry in insects and has published several papers which are widely referred to. She studied the evolution of mimicry and observed that various pre-adaptations like rarity of a species play an important role in the evolution of Batesian mimics. I hope 'Science for the Young' will frequently feature the lives of eminent personalities in various fields.

Y.G. Prasad
Department of Entomology
Indian Agri. Res. Institute
New Delhi-110012

Famous scientists

Sir, I am a regular reader of *Science Reporter*. It is a very good journal that contains mathematics and science as well as astronomy. The topics published in it are interesting and educative. I hope you will publish articles on famous scientists such as Shanti Swarup Bhatnagar, C.V. Raman, Srinivasa Ramanujan, M.N. Saha, Jagadish Chandra Bose, Isaac Newton, Kepler, Archimedes, Hooke, Boyle, Pasteur, Ronald Ross, Charaka, Mendel, Bhagavantham, Gauss, and many other scientists and physicians.

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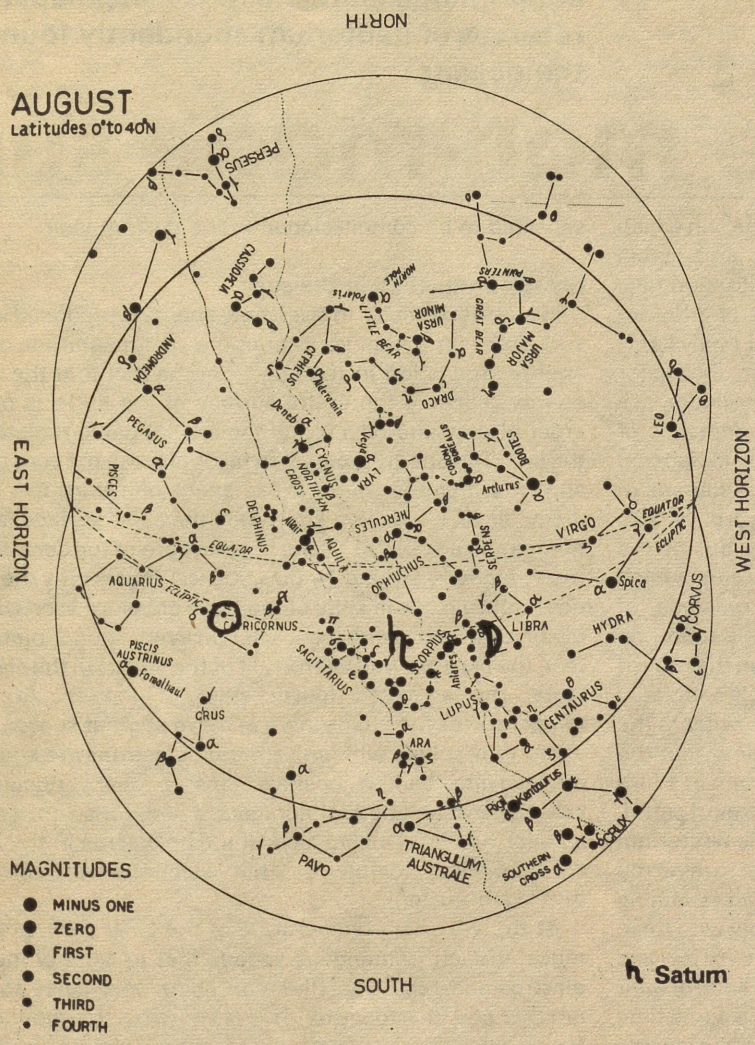

Planetary positions for August 1988

Date	*1st*		*10th*		*20th*	
Planets	*R.A.*	*Decl.*	*R.A.*	*Decl.*	*R.A.*	Decl.
Mercury	8h 37m	20.2N	9h 51m	14.9N	10h 59m	7.6N
Venus	5h 41m	18.8N	6h 11m	19.4N	6h 49m	19.7N
Mars	0h 34m	1.4S	0h 43m	0.7S	0h 49m	0.3S
Jupiter	3h 59m	19.6N	4h 04m	19.8N	4h 09m	20.0N
Saturn	17h 45m	22.3S	17h 44m	22.4S	17h 43m	22.4S

Adopted from figures supplied by Positional Astronomy Centre, Calcutta.

The moon

NEW moon occurs on 12th at 6-01 pm and full moon occurs on 27th at 4-26 pm I.S.T. The moon passes about seven and a half degrees north of Mars on 2nd, six degrees north of Jupiter on 6th, about nine degrees north of Venus on 8th, six degrees south of Saturn in the early hour of 23rd and about eight and a half degrees north of Mars again on 30th. The moon is at apogee or farthest from the earth on 14th and is at perigee or nearest to it on 27th.

The lunar crescent becomes first visible after the new moon day in the evening of 14th.

The planets

Mercury *(Budha),* is too near the sun to be visible during the first half of the month. Thereafter it is visible in the evening sky and sets about an hour after sunset. It is in superior conjunction with the sun on 3rd. It moves from Cancer (*Karkata*) to Virgo (*Kanya*) through Leo (*Simha*). Its visual magnitude varies from —0.7 to —0.2.

Venus (*Sukra*), visible in the morning sky, rises about two hours after local midnight during the month. It is in greatest western elongation of about 46° from the sun on 22nd. It is in Gemini (*Mithuna*). Its visual magnitude is about —4.4.

Mars (*Mangala*), visible in the evening sky, rises about three hours after sunset during the first half of the month and about two and a half hours after it during the second half. It becomes retrograde on 26th. It is in Pisces (*Mina*). Its visual magnitude is about —1.9.

Jupiter (*Brihaspati*), visible in the morning sky, rises at about local midnight during the first half of the month and about an hour before it during the second half being in quadrature with the sun on 28th. It is in Taurus (*Vrisha*). Its visual magnitude is about —2.3.

Saturn (*Sani*), visible in the evening sky, sets about one and a half hours after local midnight during the first half of the month and about half an hour after it during the second half. It becomes direct on 30th. It is in Sagittarius (*Dhanus*). Its visual magnitude is about +0.3.

(*Source*: Positional Astronomy Centre, India Meteorological Department, New Alipore, Calcutta-700053)

TOKAMAK : The man-made sun

The only way out of the impending energy crisis is to build a miniature "sun", which could harness the almost inexhaustible reserves of deuterium abundantly found in the oceans

JAYANTA BASU

LIFE on earth and its evolution owe much to the sun which gives warmth and light to maintain a suitable environment. The advancement of human civilization has, by and large, been made possible by the use of different sources of energy, most of which, in the final analysis, is derived from the energy of the sun. However, the major sources, namely, the fossil fuels coal and petroleum, are fast getting depleted due to ever-increasing demands of human civilization, and they may be practically exhausted in a few decades or so. The potential of other sources of energy, for example, nuclear fission and hydro, is also rather limited. It appears that the only way out of the impending energy crisis is to build a miniature 'sun', which could harness the almost inexhaustible reserves of deuterium (an isotope of hydrogen) abundantly found on earth. Although deuterium is present in water in the ratio of 1 atom to 6,000 atoms of ordinary hydrogen, it is estimated that the total deuterium in the vast quantity of water in the oceans exceeds 10^{14} tonnes. If we keep in view that the energy which can be obtained from the deuterium in 1 litre of water is equal to that obtainable from 350 litres of petrol, the total energy that can be supplied by all the deuterium would be around 10^{18} Megawatt-years, enough to meet the world's energy needs for millions of years, even assuming that the consumption will increase considerably with time.

To build an artificial sun is, however, not an easy job, and scientists have not yet been able to build one in spite of their best efforts since the mid-fifties. It should at the same time be mentioned that there has been considerable progress towards the goal. Various schemes have been put forward and several types of machines have been constructed with a view to finding out if they can be made to work as miniature suns. In this context the tokamak machine seems to be the most promising, and it is almost universally believed that the first successful artificial sun will be a tokamak. There are still several problems in constructing a successful tokamak and also in understanding the basic physical processes occurring inside the machine. Attempts are being made in many countries to solve the problems by utilizing tokamaks of different sizes and having different parameters.

The first tokamak in India has recently been installed at the Saha Institute of Nuclear Physics, Calcutta, for carrying out investigations on some of the basic process involved. It was commissioned in July last year. Another tokamak which is in an advanced stage of construction at the Institute for Plasma Research in Gandhinagar, Gujarat, is expected to be commissioned in the current year.

Energy production in the sun

Let us first discuss, in brief, how energy is produced in the sun. One can get an idea about the vast magnitude of the energy production in the sun from the fact that the solar energy reaching the entire surface of the earth is of the order of only one-billionth of the energy being radiated by the sun. The energy production takes place in the core of the sun, the diameter of which is about one-third the solar diameter of 1.4 million km. While the solar surface is at a temperature of 5,500°C, the temperature of the core is very much higher—around 14,000,000 °C. That is why the core does not collapse in spite of the huge pressure exerted by a billion tonnes of overlying matter on every square meter. In fact, the core (as well as the rest of the sun) is in the plasma state, the so-called fourth state of matter. At high temperatures the atoms in a gas move at great speeds, and when they collide with one another, electrons are knocked off, leaving behind positive ions (or bare nuclei). A conglomeration of equal numbers of electrons and positive ions (or nuclei) is called a plasma. The plasma in the solar core consists mainly of free electrons and protons (hydrogen nuclei).

At the very high temperature of the solar core, protons move at such tremendous speeds that in spite of mutual electrostatic repulsion they can come very close to one another and fuse together. This is known as thermonuclear fusion. Usually four protons fuse together, yielding an alpha particle (helium nucleus). In the sun this fusion takes place by two processes, each process consisting of several steps. In the process known as 'proton-proton cycle' two protons fuse together in the first step, and the intermediate products are deuterons (deuterium nuclei) and helium-3 nuclei. In the other process, known as 'carbon cycle', carbon acts as a catalyst. In either of the above two processes a considerable amount of energy is liberated. This is because the mass of an alpha particle is about 99.3 per cent of the sum total of the masses of four protons; the missing mass is converted into energy in accordance with Albert Einstein's celebrated equation $E=mc^2$, where m is the mass converted, E is the energy produced and c is the velocity of light (3×10^7 m /s). It is evident from the above equation that a large quantity of energy is produced even on the transformation on a small mass. In the sun 657 million tonnes of hydrogen are getting converted to 652.5 million tonnes of helium every second; the missing 4.5 million

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tonnes are transformed into enormous amounts of energy.

Like the natural sun, the man-made sun will be a 'fusion reactor'. However, the basic fuel used in the reactor will be deuterium instead of hydrogen, and deuterons in place of protons will undergo fusion. The reason is as follows. The probability of protons fusing together is very small. But as there are almost innumerable protons in the sun, the number of fusion reactions per second, despite the small probability, is sufficient to keep the sun burning. But the number of protons in an artificial sun will be many orders of magnitude less, and the fusion reactions will not at all be adequate in number.

When deuterium is used as the fuel, the initial reactions are as follows :

$$D+D \longrightarrow T+p+4.03 \text{ MeV},$$
$$D+D \longrightarrow {}^3He+n+3.25 \text{ MeV}.$$

where D is a deuteron, T is a triton (nucleus of tritium another isotope of hydrogen), ^3He is a helium-3 nucleus, p is a proton, n is a neutron and MeV is million electron volt energy, one electron volt being the energy gained by an electron in passing through a potential difference of 1 volt. The above two reactions have an equal probability of occurrence. The tritons and helium-3 nuclei thus produced react with deuterons to yield finally helium-4 nuclei (alpha particles) :

$D+T \longrightarrow {}^4He + n + 17.58$ MeV,

$D+He^3 \longrightarrow {}^4He + p + 18.34$ MeV.

It is worth noting that all the above reactions are exothermic.

Instead of using deuterium solely, a mixture of deuterium and tritium may be employed as the fuel in a fusion reactor and this has several advantages in that the D-T reaction takes place at a lower temperature than necessary for the D-D reaction, the probability of occurrence of the D-T reaction is larger and the overall energy output is higher. But as tritium is not available in nature, it has to be continuously bred in the fusion reactor by surrounding the wall of the reactor chamber with a blanket of lithium which, upon bombardment by neutrons, yields tritium. Since lithium is available in plenty on earth, the requirement of lithium in a reactor with the D-T fuel may be met for many thousands of years.

It may be mentioned in passing that man has already used the D-T reaction to produce thermonuclear energy. This has been done in a hydrogen bomb, the energy of which once released is totally uncontrollable and devastating. The idea of a fusion reactor is to tame a hydrogen bomb, as it were.

Conditions for success

The failure of scientists to build an artificial sun in spite of their efforts for the last thirtyfive years or so is due to the fact that two stringent conditions have to be met for success. We have seen earlier why a very high temperature is required for fusion reactions to occur. But only the occurrence of fusion reactions is not enough; the number of reactions per second must be sufficiently large so that the energy generated exceeds the energy loss due to radiation by an appreciable amount, when the excess energy can be employed for useful work. It has been estimated that the required temperature is 400 million degrees Celsius in the case of a reactor with deuterium as the fuel; it is 40 million degrees Celsius if the fuel is a deuterium-tritium mixture. Furthermore, in practice there are, besides radiation, other factors which contribute to energy loss, and consequently the actual required temperatures would be higher than those mentioned above. The temperature of an effective man-made sun with the D-T fuel will be at least 100 million degrees Celsius. Notice that it is much higher than the temperature of the core of the sun.

To keep a very hot plasma confined within a specified region is a formidable task because of the natural tendency of high-speed plasma particles to spread out in all directions. If the plasma spreads out and comes in contact with the wall of the reactor chamber, it would get cooled in no time. Hence, the plasma must be kept confined away from the wall for at least some reasonable period of time in order that a sufficient number of fusion reactions can take place for producing an appreciable amount of energy. However, the number of reactions depends not only on the time of plasma confinement but also on the number of nuclei in the plasma, which must also be sufficiently large. In fact, it was shown by J.D. Lawson that in order to produce thermonuclear energy in excess of the input energy required for plasma heating together with the usual energy losses, the product $n\tau$ (where n is the number of nuclei per unit volume of the plasma and τ is the confinement time) must be equal to or greater than a minimum value. This is the second condition, known as the Lawson criterion, which must be satisfied for the success of a controlled fusion reactor. The minimum value of $n\tau$ is 10^{22} $m^{-3}s$ if the fuel is deuterium; it is $10^{20}m^{-3}s$ in the case of D-T fuel.

Tokamak —the first choice

The fulfilment of the aforesaid stringent conditions demands a lot of theoretical and experimental ingenuity, tremendous perseverance and mustering of various technical resources. There are two basic schemes for building an artificial sun in which the above conditions are fulfilled.

(i) Magnetically Confined Fusion (MCF). The hot restless plasma is kept confined inside an invisible magnetic cage made up of magnetic fields, the confinement occurring due to the restoring effect of the magnetic fields on the moving charged particles. Here the expected value of n for the D-T plasma is of the order of $10^{20} = 10^{21} m^{-3}$ and that of τ is 0.1 = 1 sec. The Lawson criterion may therefore be satisfied. Various devices belonging to this category are named as tokamaks, stellarators, magnetic mirrors, spheromaks, etc.

(ii) Inertially Confined Fusion (ICF). In this case a hot, dense plasma of small dimensions generated by an intense laser beam, relativistic electron beam, or ion beam incident on a D-T pellet is confined only due to inertia, the confinement lasting for about a nanosecond (10^{-9} s). The Lawson criterion may still be satisfied because of the very high density of the plasma.

The results obtained so far have led to the belief that, out of all the devices proposed, developed and tested, the tokamak has the greatest chance of success as a man-made

sun, and it has been accepted as the first choice all over the world.

'Tokamak' is an abbreviated Russian name, the full name signifying 'toroidal (i.e., doughnut-shaped) magnetic chamber'. Invented in the USSR, the tokamak was nurtured and put ahead of the other devices in the fusion race by Lev Andreevich Artsimovich, who is known as the father of tokamak research. It was he who first obtained optimistic results on a T-3 tokamak in the late sixties and made other scientists aware of the potentialities of the tokamak machine.

How it works

In a tokamak, the plasma is created in a toroidal metallic vessel which is initially evacuated to a very low base pressure and then filled with the desired gas to be maintained at a working pressure of about 10^{-4} torr. The toroidal vessel has an advantange over the usual cylindrical vessel in that the plasma cannot escape through the ends because a toroid does not have any 'end'. Some of the terms relevant to a torus are introduced in Fig. 1. The vertical line AOB which passes through the centre O of the torus is called the major axis while the circular line CDE which is the central line inside the torus is known as the minor axis. The radius OP of the minor axis, i.e., its distance from the centre O is termed the major radius while the radius PQ of a vertical cross-section is called the minor radius.

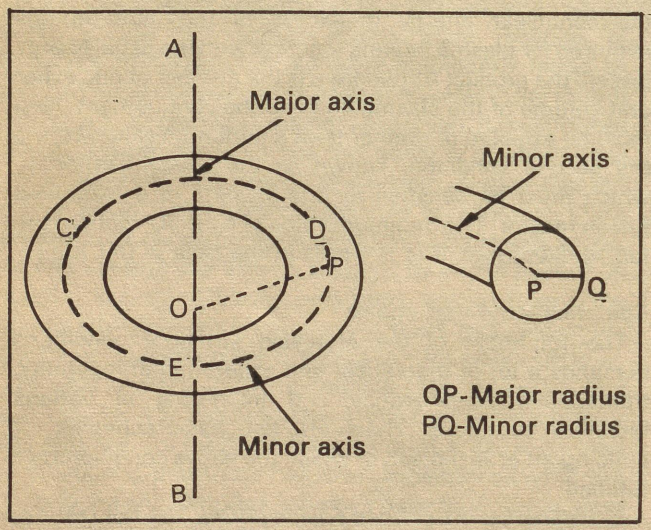

Fig. 1. Toroidal vessel of a tokamak and its vertical cross-section

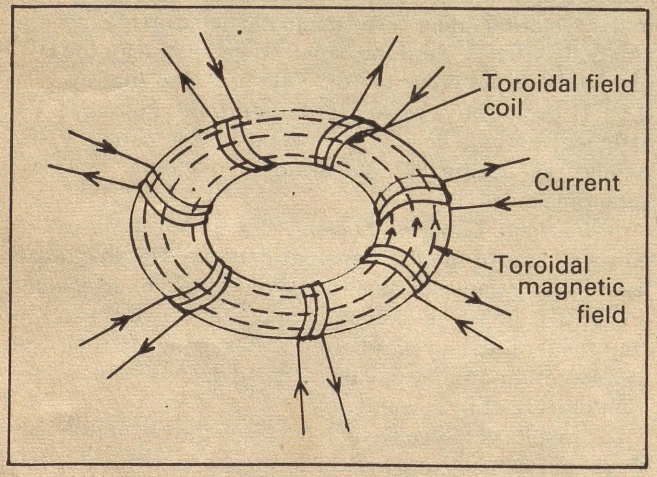

Fig. 2. Production of the toroidal magnetic field in a tokamak

The speciality of a tokamak is its strong magnetic cage for confining very hot plasma. As shown in Fig. 2, an intense toroidal magnetic field is created by passing electric current through a number of coils (known as toroidal field coils) surrounding the toroidal vessel. It is well-known that a magnetic field restrains the motion of charged particles in directions perpendicular to the field, as a result of which the particles spiral about the field line and essentially move along the field (Fig. 3). It therefore appears at first that

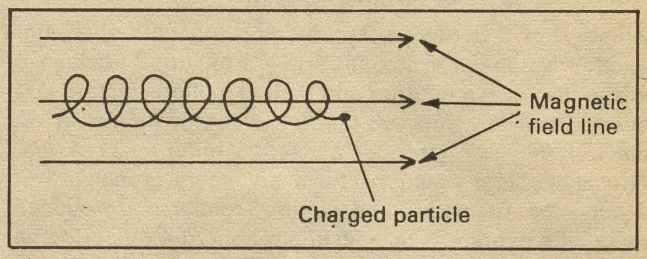

Fig. 3. Motion of a charged particle in a magnetic field

plasma particles will be confined away from the wall of the vessel by the toroidal magnetic field. But it turns out that the field alone is not enough for plasma confinement. Because of the gradient of this field (the field on the inside of the torus being higher than that on the outside) and also its curvature, the positively and negatively charged particles move in opposite directions, leading to charge separation (Fig. 4). This results in the production of an electric field

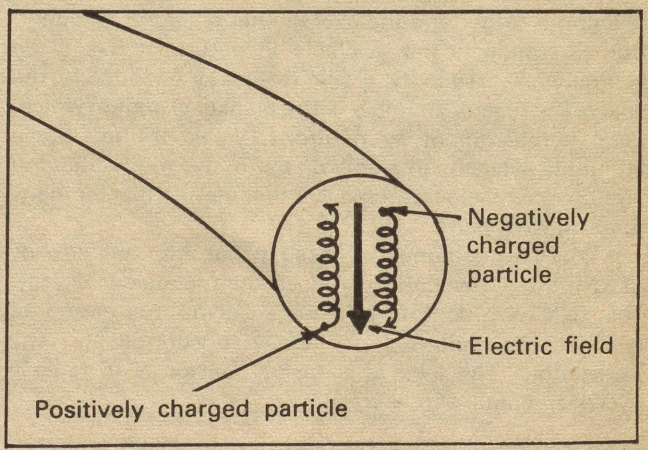

Fig. 4. Additional motion of charged particles due to the gradient of the toroidal magnetic field and its curvature

which, in combination with the magnetic field, drives the plasma outwards.

The above effect is circumvented by generating a poloidal magnetic field, which, in the case of a tokamak, is produced by an electric current flowing in the toroidal direction (Fig. 5). An important feature of the tokamak is that the ratio of the toroidal field to the poloidal field at any point inside the torus is above a critical value, depending on the torus dimensions; this ensures suppression of gross plasma

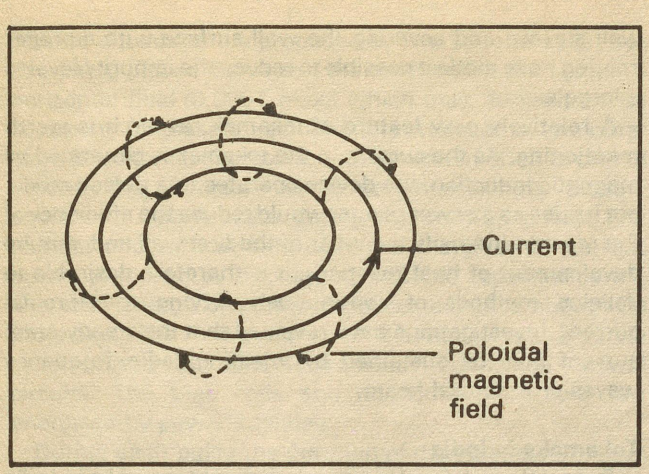

Fig. 5. Production of the poloidal magnetic field in a tokamak

transformer action, that is, by operating the torus as the secondary of a transformer (Fig. 6). When a large varying current is passed through the primary of the transformer from some external source, an appreciable voltage is produced in the torus due to electromagnetic induction. The voltage gives rise to a current which not only produces the desired poloidal magnetic field but also creates the plasma and heats it up considerably. A plasma has a finite resistance, and we know that when current passes through a resistance, electrical energy is converted into heat. This method of heating is known as Joule heating (after J.P. Joule). That is why the primary coil of a tokamak transformer is called the Joule heating coil. The use of an iron-core transformer, as shown in Fig. 6, has the advantage that the desired plasma current can be generated by a relatively small current in the Joule heating coil. However, it also has a few limitations and so an air-

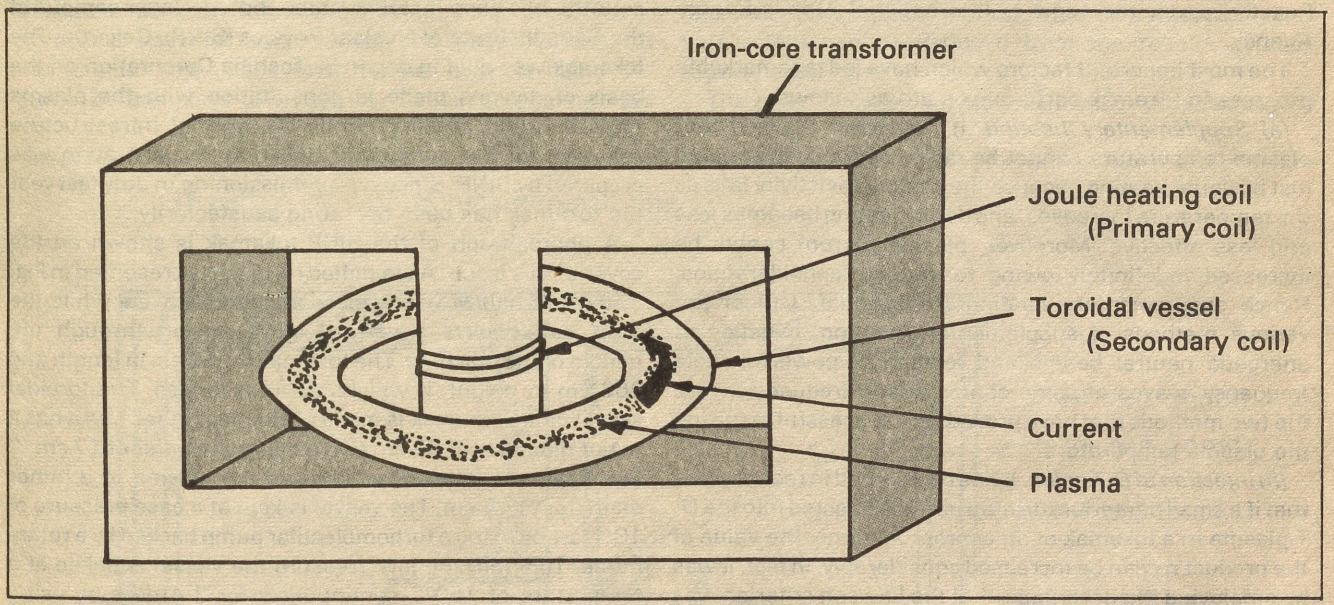

Fig. 6. Generation of the toroidal current in a tokamak

instabilities. The resultants of the toroidal and poloidal field lines are helical field lines, each of which winds endlessly on a surface, covering it densely; such surfaces are termed magnetic surfaces. The magnetic cage of a tokamak consists of a bunch of nested magnetic surfaces like the peels of an onion. Charged particles constrained to move along the helical field lines are glued to the magnetic surfaces, as it were. It can be shown that in this case charged particles maintain, on the average, a fixed distance from the minor axis; hence there is no charge separation, and the deleterious effect mentioned above does not exist.

As the poloidal magnetic field produced by the toroidal plasma current is not uniform, being stronger on the inner side of the torus than on the outer side, a vertical magnetic field produced by external field coils is added to compensate for the difference in the magnetic pressure on the two sides of the plasma column. There may be also other magnetic fields produced externally for maintaining plasma equilibrium.

The toroidal current in the vessel is generated by

core transformer is employed in some tokamaks, particularly in those with large dimensions.

Progress in tokamak research

The tokamak came into limelight in 1968 when Artsimovich convinced the world that the plasma temperature in the Soviet T-3 tokamak had reached a million degrees Celsius and that it had been possible to keep the high-temperature plasma confined for 10 milliseconds. Since then a number of tokamaks have been built in many countries to carry out research and development on various aspects of the device, the ultimate aim being, of course, the construction of a tokamak as a viable man-made sun.

The tokamaks which are most noteworthy at present are the following: TFTR, Alcator and D-III in USA; T-10 and T-15 in USSR; JT-60 in Japan; and JET (Joint European Torus) in England. In order that one can get an idea about a big tokamak we mention below some of the parameters of the TFTR (Tokamak Fusion Test Reactor): major radius=285 cm,

minor radius=85 cm, toroidal magnetic field=5.2 Tesla (i.e., 52,000 gauss) and maximum plasma current=2.5 MA (i.e., 2.5 million ampere). A record temperature of 200 million degrees Celsius in TFTR at Princeton was reported a few months ago, but the value of the product $n\tau$ was considerably off the mark. On the other hand, the Lawson criterion is reported to have been satisfied in the Alcator tokamak at MIT, but the plasma temperature was relatively low.

There is so much optimism about the scientific feasibility of a tokamak that steps are under way to build the next generation of tokamaks designed to attain ignition (i.e., self-sustainment of fusion) and also prove the technological feasibility. These tokamaks are the NET (Next European Torus), FER (Fusion Experimental Reactor) in Japan, OTR (Opytnyj Termoyadernyj Reaktor: Thermonuclear Test Reactor) in the USSR, and INTOR (International Tokamak Reactor) under the aegis of International Atomic Energy Agency.

The most important factors which have led to remarkable progress in tokamak performance are as follows:

(a) Supplementary heating. It has been realised that plasma temperature cannot be raised to the desired value just by Joule heating because the plasma resistivity falls as the temperature increases, and Joule heating becomes less and less effective. Moreover, plasma current cannot be increased indefinitely owing to stability considerations. Hence supplementary heating is essential. Out of the various methods of supplementary heating, injection of energetic neutral beams and feeding of powerful radio frequency waves at some characteristic frequencies are the two methods that have proved very successful in raising the plasma temperature.

(b) Injection of D-T pellet. It has been noted in recent years that if a small deuterium-tritium pellet is injected into the D-T plasma in a tokamak at an appropriate time, the value of the product $n\tau$ can be increased considerably. In fact, it was by employing this technique that the Lawson criterion was first satisfied in the Alcator tokamak in USA.

(c) Non-circular cross-section of plasma column. A few tokamaks employ such arrangements that the shape of a vertical cross-section of the plasma column, instead of being circular, is like that of the letter D or like that of a bean. This has the advantage that a plasma of higher pressure (and hence of higher density if the temperature is the same) can be kept confined by using magnetic fields of the same intensity. However, this has also a disadvantage in that plasma instabilities tend to increase.

(d) Use of superconducting magnets. The employment of superconducting magnets has yielded very high magnetic fields, which are essential for pushing up the plasma parameters in a tokamak.

(e) Impurity control. Just as pollution is injurious to human health, so are impurities detrimental to the health of tokamak plasma. In particular, the presence of impurities of high atomic number results in substantial radiation loss from the plasma and consequent cooling. The use of limiters (surfaces of proper material and cross-section introduced into the toroidal vessel to limit the plasma away from the walls), meticulous discharge cleaning of the inside wall surface and covering the wall surface with a proper coating have made it possible to reduce the impurity level to a large extent.

A relatively new feature of tokamak research is worth mentioning. As the current in the tokamak is generated by magnetic induction, the device operates in a pulsed mode, but its use as a power reactor would reduce the efficiency of the reactor, intensify the wear of the first wall and require development of heat reservoir. It is therefore desirable to develop methods of continuously driving the toroidal current. Investigations have revealed that the steady-state current may be sustained by injecting radio frequency waves or a neutral beam.

Tokamaks in India

Research and developmental work on tokamaks in India started only recently. A tokamak, the first of its kind in the country, has been installed at the Bidhan Nagar campus of the Saha Institute of Nuclear Physics (SINP), Calcutta. The tokamak was built in Japan by Toshiba Corporation on the basis of designs made in consultation with the plasma physics group of SINP, while the special infrastructure required for the machine installation and operation was prepared by SINP. Since its commissioning in July last year the tokamak has been operating satisfactorily.

A photoghraph of the SINP tokamak is shown on the cover of this issue. A simplified diagram is presented in Fig. 7, the left half of which gives an external view while the right half depicts a vertical cross-section through the middle of the machine. The tokamak is 269 cm in length and 262 cm in height; it weighs about 8 tonnes. The toroidal vessel of the tokamak is made of stainless steel, and it has a major diameter of 60 cm and a minor diameter of 17 cm. A few limiters in the vessel confine the plasma to a minor diameter of 15 cm. The vessel is kept at a base pressure of 10^{-8} torr by using a turbomolecular pump backed by a rotary pump. To attain the low pressure the vessel is baked at a temperture of 150°C continuously for 3-4 days by using heating coils wound around the vessel. (The baking operation is re quired for driving out the impurities from the wall.)

The tokamak, as usual, operates in pulses. At the beginning of each pulse hydrogen or deuterium gas is injected into the vessel by a controllable gas puffing system in such a way that the working pressure in the vessel is 10^{-4} torr. The gas is pre-ionized by an electron beam, and then the discharge current pulse (75 kA max.) is produced by transformer action in which the toroidal vessel acts as the secondary of an iron-core current transformer. The current in the Joule heating coils (primary coils) is generated by the discharge of a capacitor bank in which electrical energy is initially stored by a charging circuit. As the iron-core transformer tends to saturate at a given value of the magnetic flux, its range of operation is extended by the use of a pair of bias coils which produce magnetic flux in a direction opposite to that of the flux produced by the Joule heating coils.

The toroidal magnetic field (2T max.) necessary for plasma confinement is provided by 16 coils surrounding the toroidal vessel. The vertical field (0.75T max.) required for

plasma equilibrium is produced by two pairs of coils, one pair being placed above and the other below the vessel. A horizontal field (0.005T max.) which may, in addition, be necessary for plasma equilibrium is produced by two other pairs of coils. Furthermore, an aluminium shell is placed around the toroidal vessel for maintaining plasma equilibrium, particularly during the start-up phase. The toroidal and vertical field coils are energised by current pulses produced by discharging suitable capacitor banks. The total energy of all the capacitor banks is about 400 kilojoules. The firing times of the banks are properly synchronised by opto-electronically connected control circuits. The bias coils and horizontal field coils are energised by power supplies.

During each pulse the duration of the plasma formed in the toroidal vessel is 3-5 ms. The expected plasma density is $2\text{-}5\times10^{19}m^{-3}$, electron temperature is 3-4 million degrees Celsius, and ion temperature is 2-3 million degrees Celsius.

There are several radial, vertical and tangential ports on the toroidal vessel, the total number of ports being 44. Some of the ports are used for vacuum pumping, gas injection, etc., but most of them are to be employed for diagnosis of plasma parameters and various other experimentations. There are a few instruments mounted on the toroidal vessel for measuring the plasma current, magnetic fields at different locations inside the vessel, position of the plasma column, etc.

It needs many discharge cleaning shots at relatively low voltages across the capacitor banks before the plasma current reaches the expected maximum value. The plasma current attained to-date is 68.5 kA, i.e., a little more than 90% of the maximum design value. A number of preliminary experiments have been carried out on the tokamak. Several systems are being set up for measuring the plasma parameters in the toroidal vessel. In two of the diagnostic systems the visible, ultraviolet and soft X-ray radiation emitted by the plasma will be detected and analysed. In another system the effect of the plasma on a microwave beam passing through it will be studied. Plasma parameters can be deduced from the results of such experiments.

The fields of investigation which will be pursued at SINP

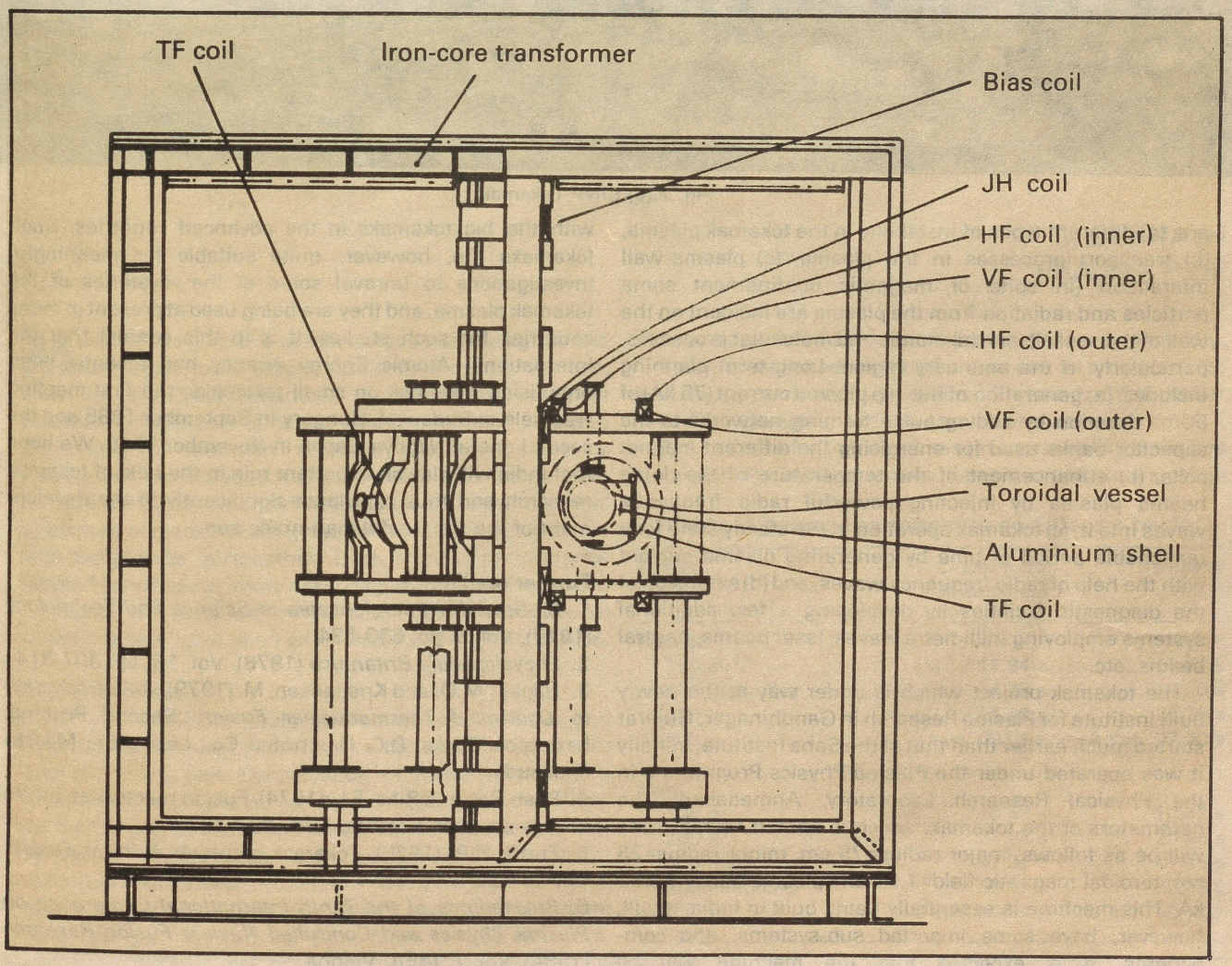

Fig. 7. (a) A simplified diagram of SINP Tokamak.JH coil : Joule heating coil, TF coil : Toroidal field coil, VF coil: Vertical field coil, HF coil : Horizontal field coil [See photo Fig. 7 (b)]

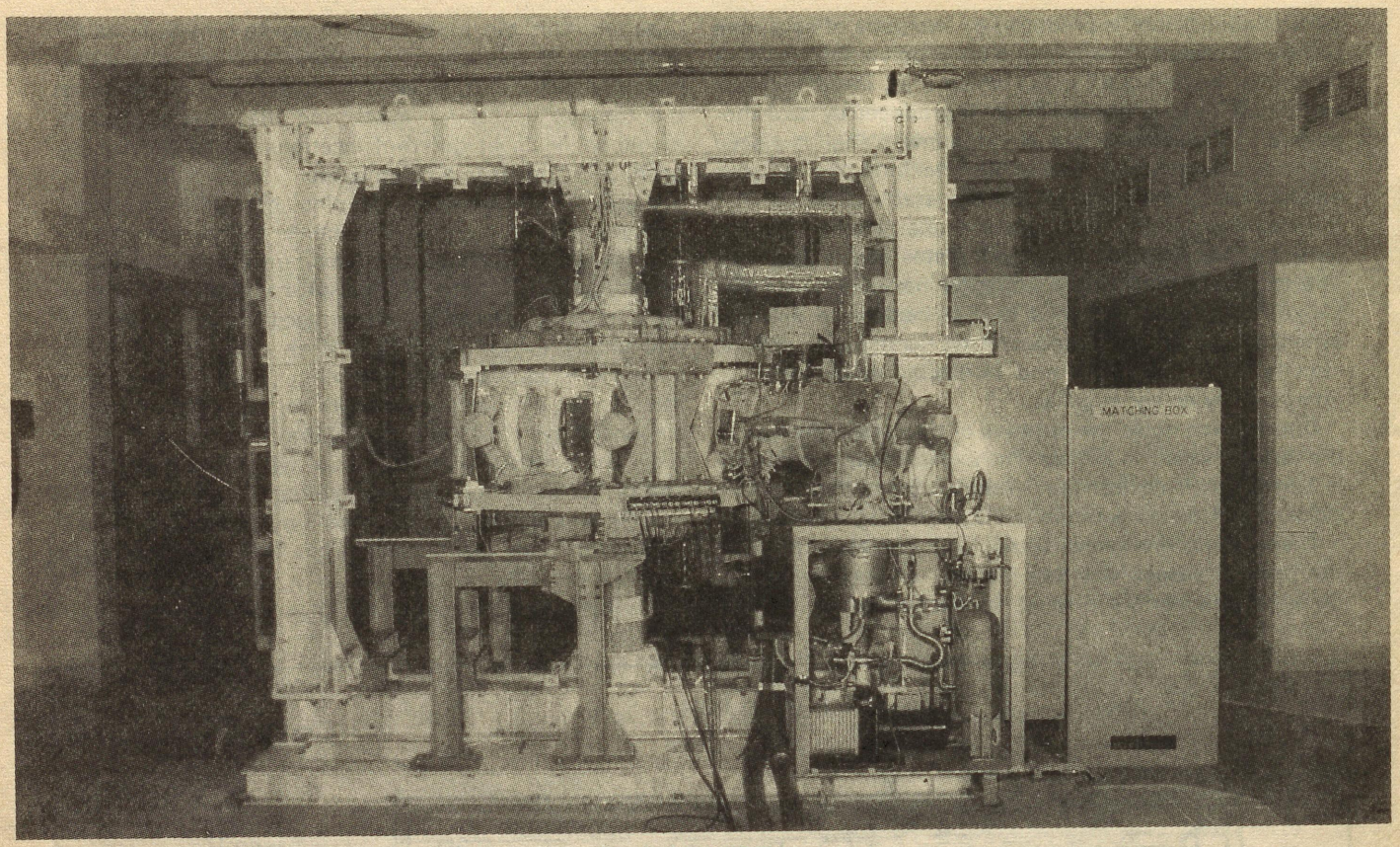

Fig. 7.(b) SINP Tokamak

are: (a) different types of instability in the tokamak plasma, (b) transport processes in the plasma, (c) plasma-wall interaction (in spite of magnetic confinement some particles and radiation from the plasma are incident on the wall of the vessel), and (d) atomic and molecular processes, particularly in the boundary region. Long-term planning includes: (a) generation of flat-top plasma current (75 kA) of 50ms duration by adding pulse forming networks to the capacitor banks used for energising the different magnet coils, (b) enhancement of the temperature of the Joule heated plasma by injecting powerful radio frequency waves into it, (c) tokamak operation in the steady state for a reasonable period of time by generating plasma current with the help of radio frequency waves, and (d) extension of the diagnostic facilities by developing a few additional systems employing millimetre waves, laser beams, neutral beams, etc.

The tokamak project which is under way at the newly built Institute for Plasma Research in Gandhinagar, Gujarat started much earlier than that at the Saha Institute. Initially it was operated under the Plasma Physics Programme in the Physical Research Laboratory, Ahmedabad. The parameters of the tokamak, which is named *Aditya* (Sun), will be as follows: major radius=75 cm, minor radius=25 cm, toroidal magnetic field=1.5T and plasma current=250 kA. This machine is essentially being built in India; it will, however, have some imported sub-systems, and components. It is expected that the machine will be commissioned this year.

Both the tokamaks in India are of modest size compared with the big tokamaks in the advanced countries. Such tokamaks are, however, quite suitable for meaningful investigations to unravel some of the mysteries of the tokamak plasma, and they are being used at present in many countries for such studies. It is in this context that the International Atomic Energy Agency has recently been organising meetings on small tokamaks; the first meeting was held at Budapest, Hungary in September 1985 and the second one at Nagoya, Japan in November 1986. We hope that India will play an important role in the field of tokamak research and thus contribute significantly to the development of the successful man-made sun.

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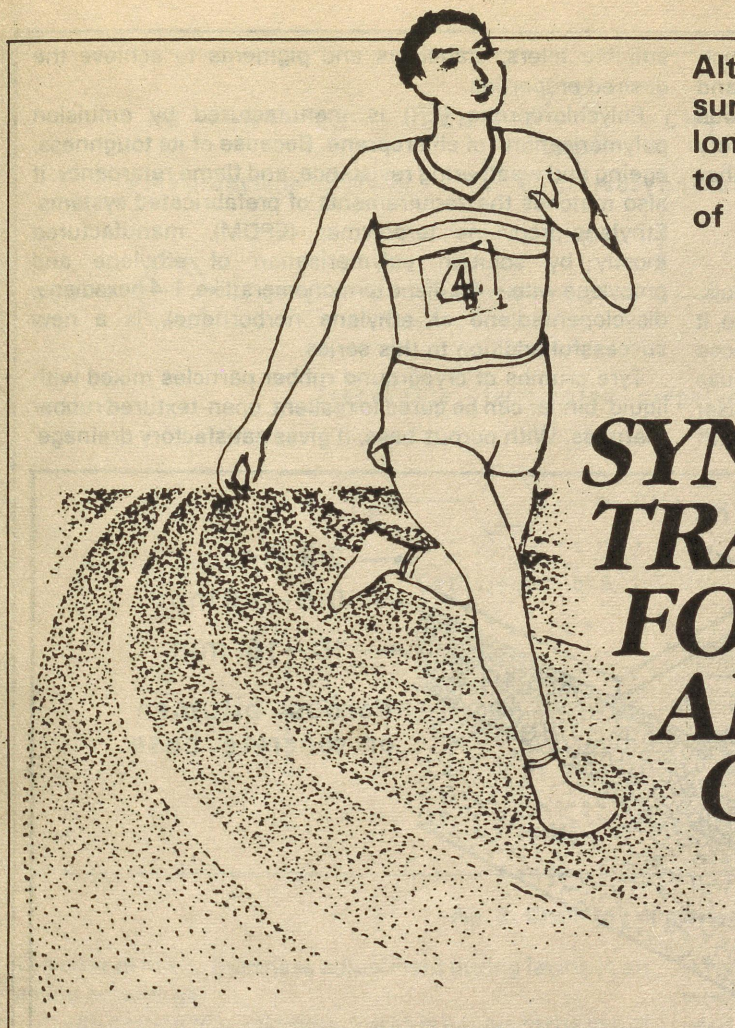

Although the initial cost of laying synthetic surfaces is high, they are cheaper in the long run than conventional grass and lead to all-round improvement in performance of athletes and players

SYNTHETIC TRACKS FOR SPORTS AND GAMES

S. DEBNATH
PRAJNA P.DE

MOST of the games and sports have been designed and developed to be played outdoors on grass surface. However, the busy schedules round the year of most stadium complexes around the world have made it next to impossible to maintain them in playable conditions throughout the seasons. Consequently, artificial polymer surface (APS)has emerged not only as an ideal technical substitute of conventional grass surface (CGS) but also one that can provide "all weather" track, improve performance (Table 1) and reduce injury risks. Beginning with the Mexico Olympics in 1968 all other subsequent international athletic meets have been extensively making use of APS.

Types of surface

Ball games require a balance of hardness, resilience and dynamic mechanical properties of the surface for proper bounce of the ball. Optimisation of these properties is obtained through the preparation of consolidated artificial surface, cross-sectional features of two of which are shown in Fig. 1. The figures are self explanatory. Civil works of substructures are also important and any negligence in this area may give poor playing conditions and may necessitate redesigning if not abandonment of the whole structure. However, we will confine our discussions to polymers only.

Three established methods are in use to produce APS, namely, (I) pre-fabricated sheets, (II) resin-bonded rubber shreds or granules, and (III) cast *in situ* elastomers.

For surfaces for indoor games (in sports halls), type I has no match. For outdoor games, types II and III have an edge

Table 1. Average performance on different tracks

Events	*Cinder track (conventional)*	*Synthetic track*
Women		
100 m	11.84 s	11.74 s
100 m hurdles	14.38 s	14.20 s
200 m	24.68 s	24.26 s
800 m	2 min. 09.05 s	2 min. 07.30 s
Men		
100 m	10.58 s	10.47 s
200 m	21.23 s	20.96 s
400 m	47.91 s	47.45 s
400 m hurdles	50.97 s	50.33 s
1500 m	3 min. 50.82 s	3 min. 50.62 s

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over type I, because of the flexibility of *in situ* work which enables minor thickness adjustment during casting and helps in drainage. Resin-bonded rubber shreds with porous sub-structure offer better drainage, but unsatisfactory spike-resistance restricts its use only to less tougher environments as in children's playground.

Polymers

Polyvinyl chloride (PVC) is manufactured by bulk, suspension, or emulsion polymerisation of vinyl chloride. It is plasticised with di-isooctyl phthalate for general purpose or di-iso-octyl sebacate, edipate or azelate for outdoor use to impart low-temperature flexibility. Phosphate plasticiser adds to flame retardancy. These are compounded with suitable fillers, stabilisers and pigments to achieve the desired properties.

Polychloroprene (CR) is manufactured by emulsion polymerisation of chloroprene. Because of its toughness, ageing and weathering resistance, and flame retardancy, it also matches the requirements of prefabricated systems. Ethylene-propylene terpolymer (EPDM), manufactured mostly by solution polymerisation of ethylene and propylene with ~4% diene termonomers (like, 1-4 hexadiene, dicyclopentadiene or ethylene norbornene), is a new successful addition to this series.

Tyre crumbs of cryoground rubber particles mixed with liquid binder can be cured to resilent, open-textured rubber mattress. With porous base, it gives satisfactory drainage.

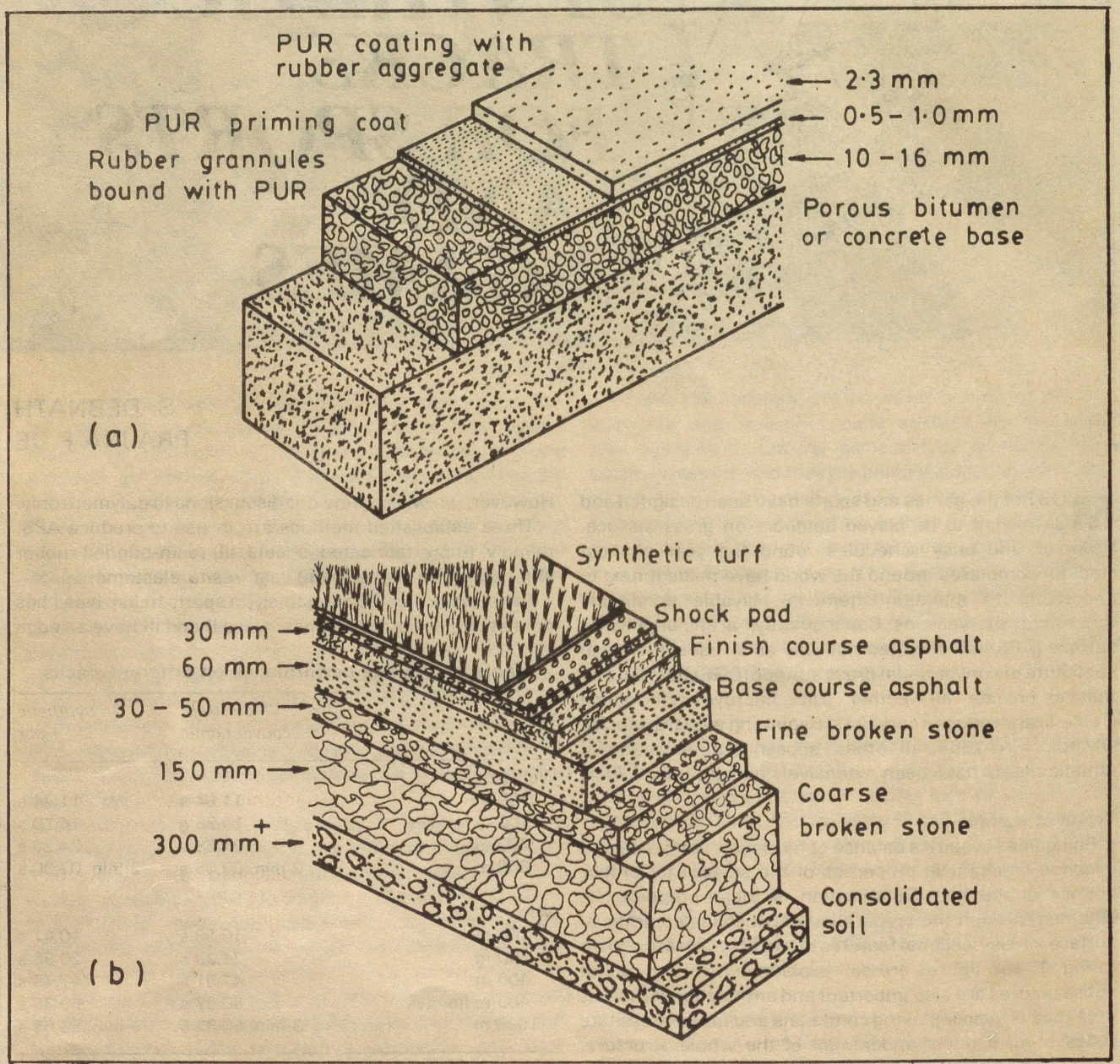


Fig. 1. Diagram showing sections of an (a) porous outdoor games surface, and (b) impermeable synthetic turf system

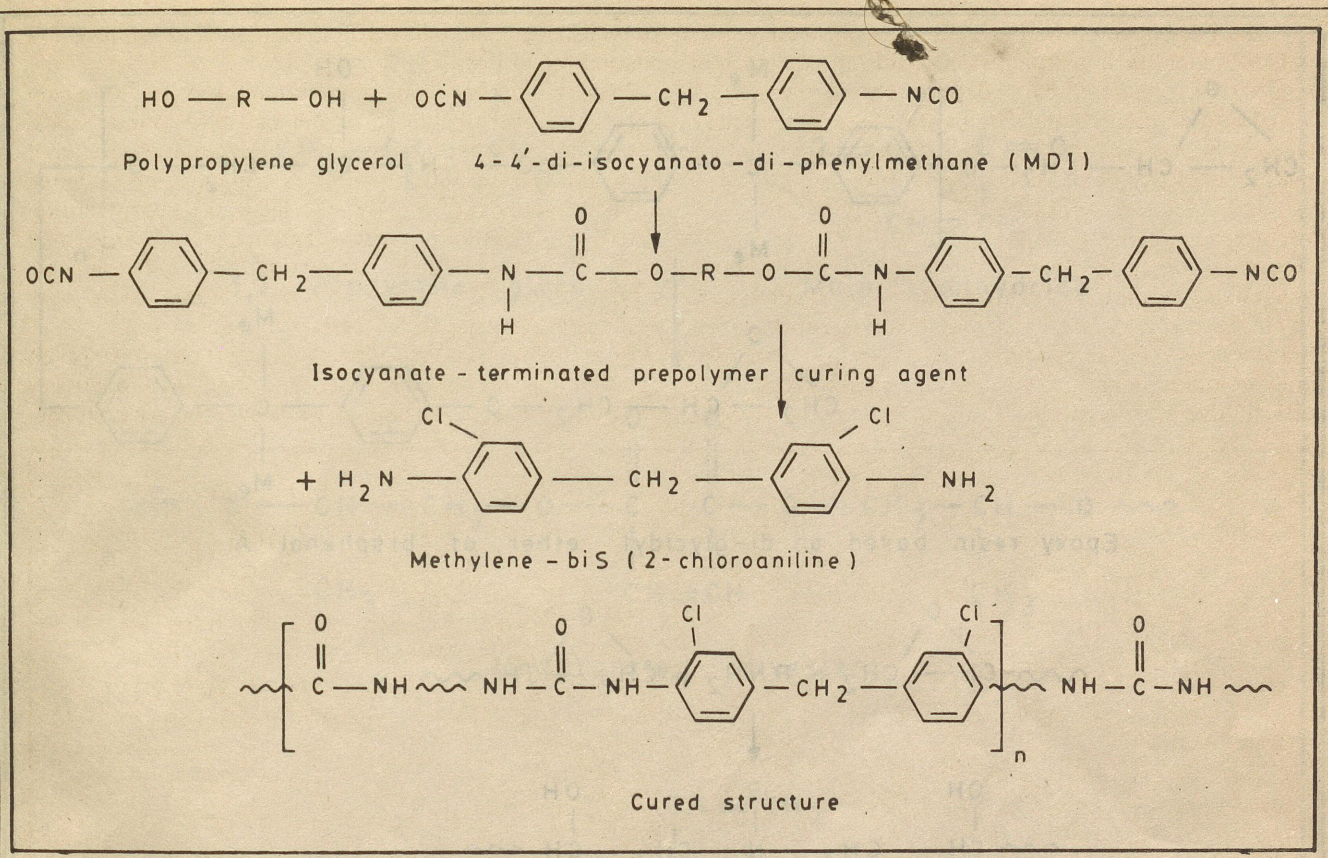


Fig. 2. Chemistry of polyurethane system

The ease of minor thickness adjustment during laying is an added advantage.

In situ casting of elastomeric tracks is unique in the use of APS. Polyurethane (PUR) has the advantage that it can be cured at ambient temperature (Fig. 2). Polyurethane prepolymer, formed by the reaction between polyhydric alcohol and isocyanate, reacts with weakly basic amines (curing agent) to give cured structure. The ratio of glycol to isocyanate, the amount and nature of curing agent can be varied widely to optimise the property requirements.

In latex-based system, compounded latex (natural rubber, styrene-butadiene rubber, CR) having good flowability is spread and gelled with a delayed action coacervate. Zinc oxide assists in uniform gellation and improves mechanical properties by forming zinc soap. When latex is coagulated, coacervated water comes out of the coagulated rubber matrix. This water must be removed from the system. It is sweeped out by portland cement (dispersed in a hydrophobic solvent to avoid permature coagulation) which also improves the compression set of APS.

Synthetic turf

To simulate the grass surface, synthetic turf is created on the top PUR layer to modify the bounce, grip, traction, friction, abrasion, etc. It is generally prepared by bonding injection molded polypropylene (PP), Nylon 66 / Nylon 6, or polyester fibres to the PUR layer with adhesive.

Needle punched carpets are popular in tennis-courts whereas injection molded oriented filaments of PVC are used in 'dry' ski slopes.

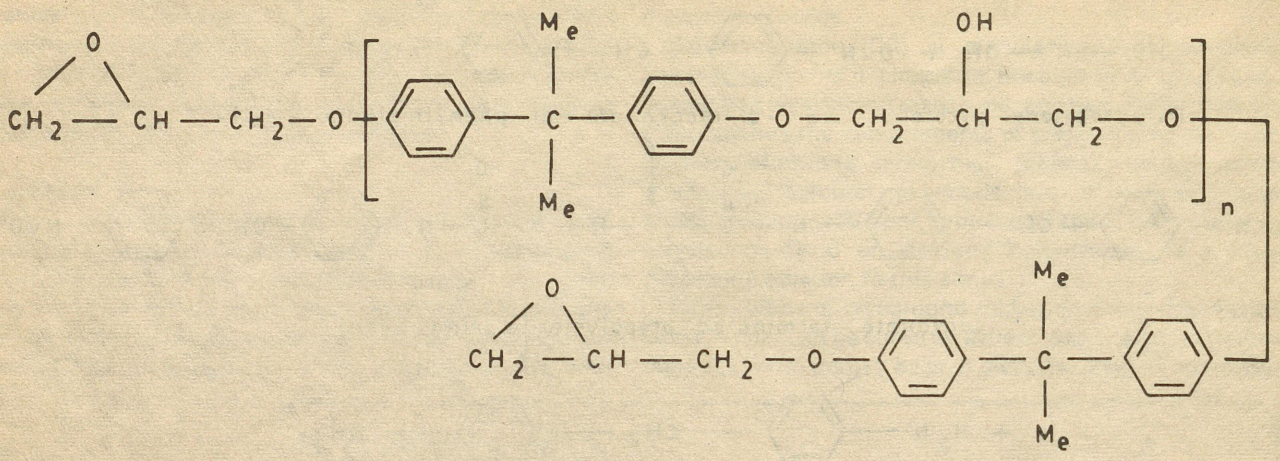
Other surfaces

Artificial roller skating surface uses epoxy floors, based on diglycidyl ether of bis-phenol A, cured either by amines or acids as in Fig. 3. In alkyd system, a pre-polymer (based on polyhydric alcohols and di-basic acids / anhydrides, like propylene glycol, glycerol, adipic acid, maleic anhydride, phthalic anhydride, etc.), having low molecular weight (~2000), is mixed with a reactive diluent such as styrene or methyl methacrylate, and an initiator such as cobalt naphthenate or octoate or methyl-ethyl ketone-peroxide, for crosslinking as shown in Fig. 4. Low coefficient of friction, and high abrasion and impact resistance of polycarbonate have been exploited in roller and ice skating surfaces.

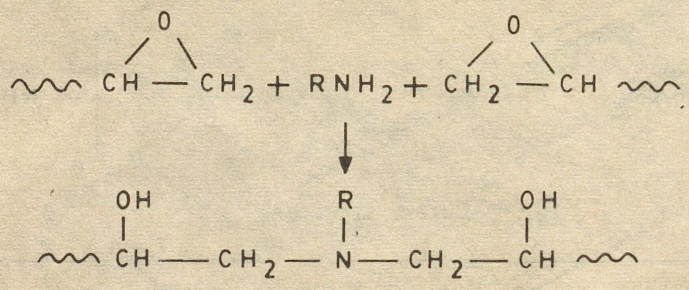
Ski slopes have been designed from low-density polyethylene (LDPE) or a blend of LDPE / polyvinyl acetate (PVAC) containing poly-tetrafluoroethylene (PTFE) as lubricant.

Property requirements

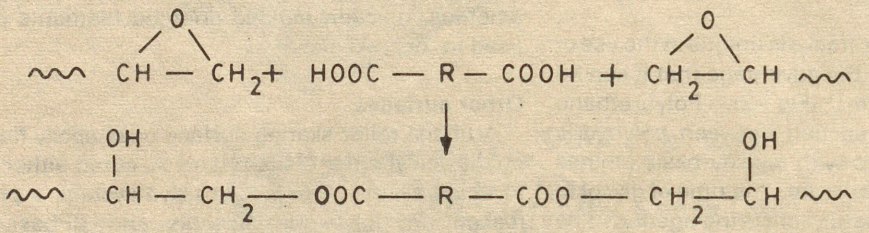
A large number of contradictory properties have to be optimised for the proper functioning of an APS. In general, any APS should possess excellent abrasion and spike-resistance, age and weather resistance, tolerance to



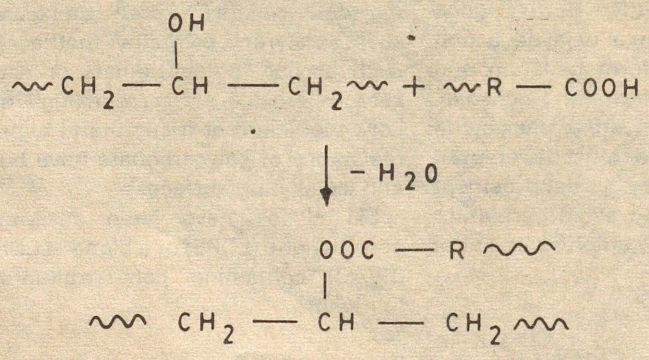
Epoxy resin based on di-glycidyl ether of bisphenol A



Amine cured



Acid with epoxy ring



Acid with hydroxyl group

Fig. 3. Chemistry of epoxy system

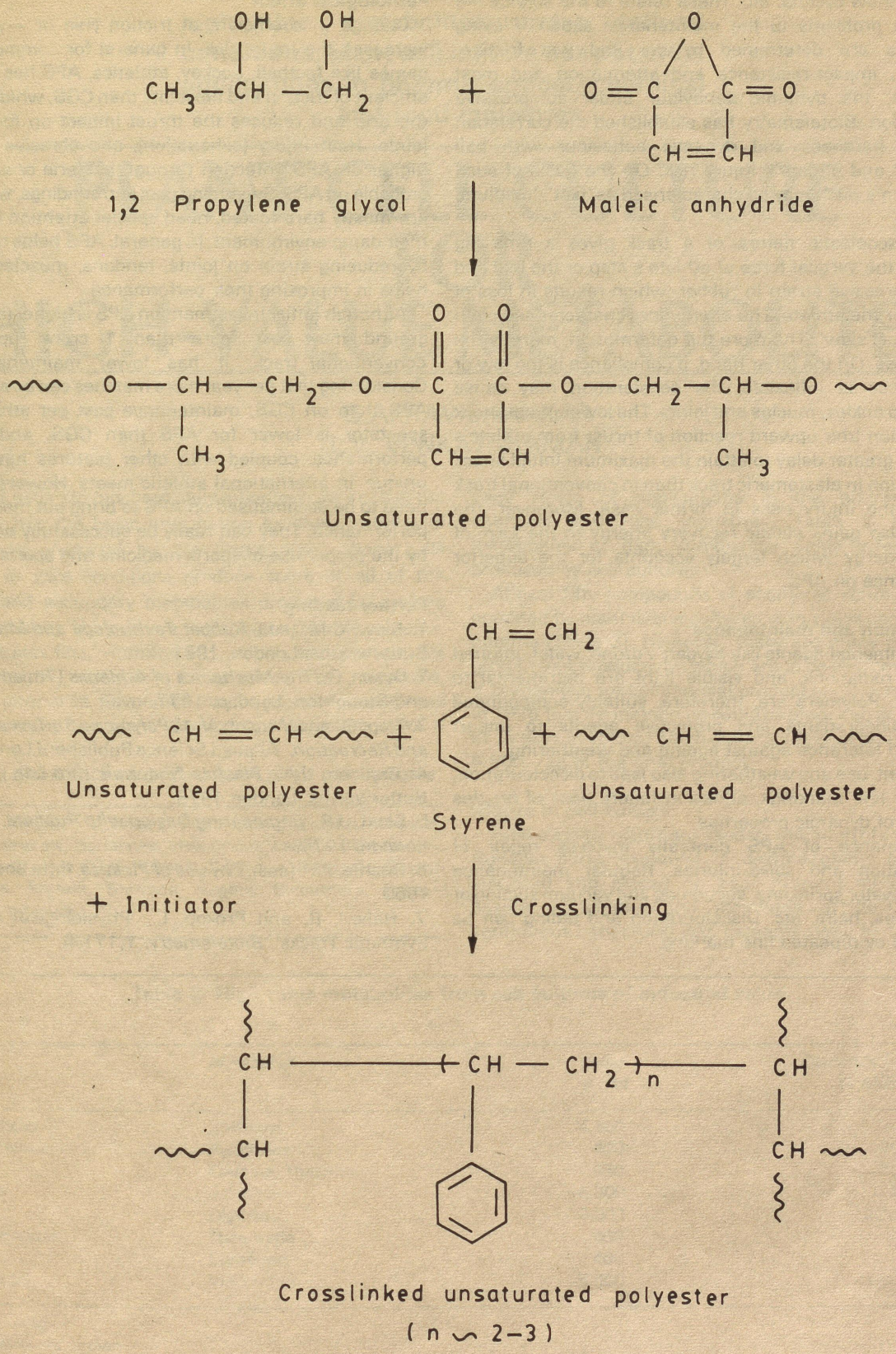


Fig. 4. Chemistry of alkyd system

freeze / thaw cycling, etc. These relate to the service life and pose problems to the maintenance squad. Playing conditions are determined by dry and wet friction, hardness, impact-resistance and attenuation and most important, the dynamic behaviour under compressive deformation. Biotelemetry has established the correlation between hardness and dynamic behaviour with ball dynamics and athlete's injury risk. On the basis of such correlation a pitch may be characterised as 'fast', 'medium' or 'slow'.

The viscoelastic nature of a track gives a time lag between the vertical force of athlete's step or the ball and the compressive strain in rubber, which results in loss of energy for the athlete. The energy loss characterised pitch as 'fast' or 'slow'. The more the deformation, more is the energy loss. On the other hand, if compliance is too low or the surface is inflexible, the deceleration may cause injuries to ankles, mucles and joints. The lower initial shock acceleration (the upward reaction of thrust from athlete's feet) and greater delay to attain the maximum initial shock acceleration in elastomeric track than in conventional track reduces the injury risks in former case. Moreover, the athlete also gains elastic recovery energy in the form of kinetic energy which largely accounts for the superior performance on APS.

Degradation and maintenance

Environmental agents like oxygen /ozone, water, infrared and UV radiations, and visible light are detrimental to polymers. Polymers are, therefore, suitably compounded with antidegradants and protective agents to impart enhanced tolerance against ageing and weathering.

Frequent use and weathering also lead to discolouration, fading of line markings, adhesion failure, loss of bristles and loss of dynamic properties.

Maintenance of APS generally involves repair of delamination and spike-injuries. Regular maintenance includes water sprinkling, suctioning and vacuum suction of dirt, leaves, hairs, etc. Discolouration and fading can be managed by repeated line marking.

Pathological effect

Change in coefficient of friction (+ve or —ve) of APS increases the injury risk. In general for common outdoor games like football, hockey, athletics, APS has higher coefficient of friction and flexibility than CGS, which improves the grip and reduces the thrust impact on muscles and joints. Heat injury (exhaustion), and abrasive injury are higher on APS. Infection through bacteria or virus is less probable on APS. Swimming pool surroundings, where users are mostly bare footed, need special attention because of their damp environment. In general, APS helps the athletes by reducing strain on joints, tendons, muscles and thus helps in improving their performance.

Although initial investment on APS is higher (one football ground may cost more than 1 crore rupees) than conventional track, it has lower maintenance cost. Considering that per year more matches can be arranged on APS than on CGS, maintenance cost per athlete or per spectator is lower for APS than CGS, and improved performance, coupled with other features have made it unique in international athletic meets. However, athletes need to be acclimatised on APS to bring out their all-round performance. They can really be successfully acclimatised by the proper use of sports medicine and sports dynamics.

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Endowed with the capacity of producing high-value metabolites under defined conditions, plant cell culture has potential applications in pharmaceutical, chemical and food industries

PLANT CELL CULTURE FOR HIGH-VALUE METABOLITES

G.A. RAVISHANKAR
L.V. VENKATARAMAN

PLANT cells are biochemically totipotent. Any cell of the plant has the basic information for the synthesis of compounds produced by the intact plant. Plant cells cultured *in vitro* conditions produce some or all of the primary and secondary metabolites produced by mature plants (Table 1). The primary metabolites include proteins, carbohydrates,fats, vitamins etc., which are essential for growth, while secondary metabolites like, alkaloids, steroids, phenolics, flavonoids may be produced as defense mechanisms by the plant. Secondary metabolites have a wide range of applications in the pharmaceuticals, chemical and food industries. Table 2 lists some metabolites of high commercial value which can be produced by cell cultures.

Table 1. Substances reported from plant cell cultures

Alkaloids, Enzyme inhibitors, Flavonoids, Flavones, Flavours, Furanocoumarins, Hormones, Insecticides, Latex, Lipids, Nucleic acid, Oils, Organic acids, Phenols, Perfumes, Pigments, Growth regulators, Protein, Steroids, Sugars, Sweetners, Tannins, Terpenes, Vitamins

Atleast fifty compounds of economic value have been obtained by plant tissue cultures with yields comparable to parents (Table 3). However, there are many problems of growth and productivity which are to be overcome to make it economical for commercial production. It was estimated in 1978 that if a metabolite could be produced at 1g/l yield in 15 days in 100 m^3 batch culture, the cost would be about $ 500 /kg of the final product.

Stages in cell culture

High yielding plants are used for initiation of cell cultures. Suitable parts (explants) of desired plants are surface sterilized and placed on agar nutrient medium under aseptic conditions and incubated at 25°C± 2°C in continuous light (3000 lux). Explants swell and give rise to

Table 2. High value metabolites from cell cultures of industrial value

Plant	*Metabolite*	*Value $ /kg*	*Demands in US ($ Million)*
Lithospermum	Shikonin	4,500	—
Chrysanthemum	Pyrethrins	400	20
Papaver	Codeine, Thebaine	650	50
Jasminum	Jasmine	5,000	0.5*
Digitalis	Digoxin	3,000	20–25
Thaumatococcus	Thaumatin	400	—
Coptis	Berberine	400	—
Catharanthus	Vincristine	5,000	18–20

*World demand
—Information not known

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Table 3. High yielding cell lines for secondary metabolites from few selected plants

Product	*Species*	*Yield (% d.wt.)*
Ajmalicine	*Catharanthus roseus*	1.0
Anthraquinones	*Morinda citrifolia*	18.00
Caffeine	*Coffea arabica*	1.6
Carotene	*Daucus carota*	0.07
Diosgenin	*Dioscorea deltoidea*	3.00
Ecdysterone	*Trianthema portulacastrum*	0.08
Ginsengoside	*Pnax ginseng*	27.00
Hyoscyamine	*Hyoscyamus niger*	0.02
Morphinane alkaloids	*Papaver somniferum*	5.6
Nicotine	*Nicotiana rustica*	3.4
Rosmarinic acid	*Coleus blumei*	15.0
Serpentine	*Catharanthus roseus*	1.0
Shikonin	*Lithospermum erythrorhizon*	2.0
Visnagin	*Ammi visnaga*	0.31
Vitamin B_6	*Cytisus scoparius*	1.38

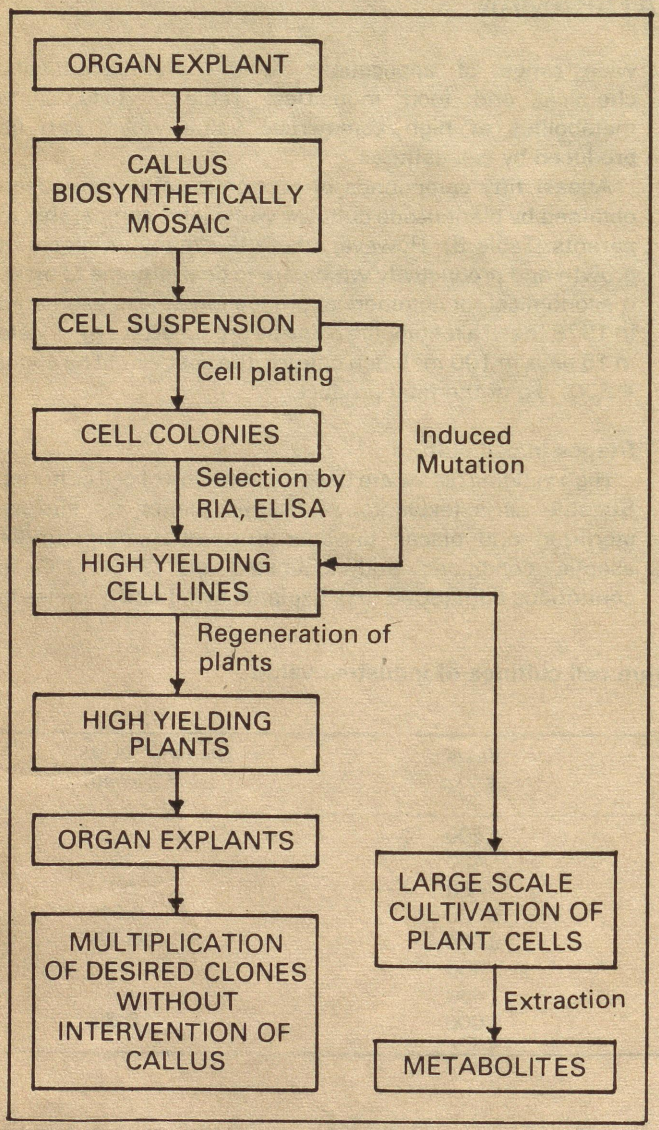


Fig. 1. Utilization of plant cell culture for obtaining metabolites of interest

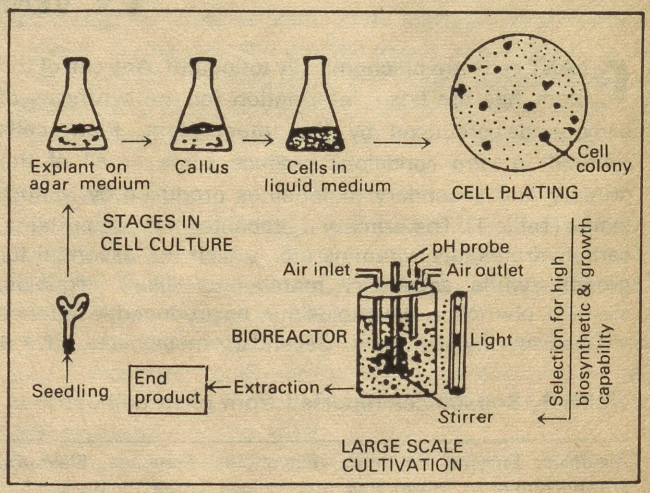


Fig. 2. Stages in plant cell culture

an undifferentiated mass of cells-'callus' (Figs. 1&2). The callus tissues are tested for the production of the desired substance. Once the production capability is ascertained, the most promising cell lines can be selected from the callus tissues and transferred to a liquid nutrient medium and agitated on rotary shaker at 100 rpm to get a cell suspension culture. The media used for growth of cells and production of metabolites have to be carefully developed for maximal yields. The yield potential of cell culture can be enhanced by further selection of cell line by plating techniques. Established cell lines are grown in bioreactors for large scale operations.

Selection of cell lines

The stability of cell line is tested over a period of time with regular transfers on fresh medium. Only stable cultures are put on to production level. The selection of cell lines can be done visually if the product is pigmented, otherwise, Radio Immuno Assay (RIA), Enzyme Linked Immuno Sorbent Assay (ELISA), High Performance Liquid Chromatography (HPLC), Cytophotometry or any sensitive method can be used. Cell lines can be cryopreserved in liquid nitrogen to

obviate repeated selection.

A simple method has been devised for selection of high nicotine yielding cell lines. In this, the clones are pressed on a filter paper and sprayed with Dragendorf's reagent to develop colour. Clones producing highly intense colour are isolated for production. In another case, selection of high diosgenin (a steroidal precursor for oral contraceptive) yielding cell lines has been identified by antimony penta chloride solution which imparts red colour to diosgenin yielding cells.

Improvement of secondary product formation by induced mutations is also possible. Three-fold increase in β-carotene and lycopene content has been observed in mutated carrot cells obtained by treatment with mutagen, N-methyl-N-nitrosoguanadine. An increase in serpentine and ajmalicine (2% dry weight) production has been obtained by irradiating the *Catharanthus* cell cultures with gamma rays.

Culture parameters

A typical plant tissue /cell culture medium consists of nitrate, sucrose and other vitamins and hormones, minor and major elements. Nutrients supply is a crucial factor for culturing cells at a high density. Higher nutrient concentrations may inhibit secondary metabolite production. For example, Shikonin (antibacterial compounds) production in *Lithospermum* is adversely affected by the NH_4-concentration. Similary, production of metabolites like capsaicin, ajmalicine, serpentine, etc., are affected by the high concentration of nitrogen and phosphates in the medium.

Plant growth regulators exert profound influence on secondary product formation cell growth. Tobacco cells are sensitive to 2,4-dichlorophenoxy acetic acid (2,4-D) whereas indole-3-acetic acid (IAA) promotes nicotine formation and growth of tobacco cells. Changes in hormonal concentration increase the ecdysterone (insect moulting hormone) yield several folds in *Trianthema portulacastrum* cell cultures. Changing from naphthalene acetic acid (NAA) to 2,4-D increases anthraquinone content by thirty fold in *Morinda citrifolia* cells. Gibberellins (GA) increase berberin production in *Coptis japonica* while they inhibit shikonin in *Lithospermum erythrorhizon*.

Feeding of precursors often results in increased productivity of secondary metabolities. Cell suspensions of *Coleus blumei* are reported to produce 100% more rosmarinic acid as compared to control when supplied with 500 mg L-phenylalanine per litre of Gamborg's B5 medium. Similarly, phenylalanine boosts production of shikonin. O-succinyl benzoic acid increases anthraquinone in cell cultures of *Gallium mollugo*.

To obtain high yields of metabolites, two-stage culture systems are employed wherein two bioreactors are serially arranged for growth and for the production of the desired compounds, respectively. It is economical to use a growth medium for maximal biomass and a production medium for secondary compound synthesis which yields maximal products.

Eliciting secondary metabolism

Microbial invasion of whole plants leads to the synthesis of antimicrobial secondary metabolites. This can be mediated by viral, bacterial or fungal contact. The microbe-derived molecules found in culture media which stimulate secondary metabolism are called 'elicitors'. Table 4 lists a few secondary metabolites which act as elicitors.

Table 4. Phytochemicals elicited in plant cell cultures

Product	*Plant cell culture*	*Elicitor*
Codeine, morphine	*Papaver somniferum*	Fungal spores
Sangninarine	Do.	Do.
Phaseollin	*Phaseolus vulgaris*	Fungal glycoprotein
Diosgenin	*Dioscorea deltoidea*	Fungal mycelia

The mechanism of elicitation of secondary metabolism is not clearly known. However, possible role of adenosine 3', 5' cyclic monophosphate (cAMP) and Ca^{2+} calmodulin regulatory system is being studied. The elicitation of antibiotic secondary metabolites show rapid kinetics with maximum levels within 48-72 h after exposure. Increase in production may be 20-30 folds. This phenomenon is currently employed to cut down the time and cost of product formation in fermentation, wherever applicable.

Scaling up of submerged cultures

The cultures of established cell lines are allowed to grow in conical flasks till they are viscous and used as inoculum for bioreactors. Optimal conditions are standardized in small bioreactors (upto 15 l) before going in for production on a large scale.

The bioreactor may be of turbidostat or chemostat or batch type, either open or closed. In open type, the medium constantly flows in and an equal volume of it leaves the culture vessel. The main feature of this is the possibility of maintenance of steady state of growth and cell division. In turbidostat culture system, medium is monitored by means of a photocell to maintain constant turbidity.In closed type, as exemplified by batch culture, there is no inflow and outflow of medium and cells may start dying after the growth period if not removed immediately.

Plant cells in culture are 10 to 100 times bigger than bacterial and fungal cells and cannot withstand the mechanical stirring, hence airlift agitation is best suited. Plant cells are dense and have a tendency to form clumps. Formation of clumps may be due to non-separation of cells after division or aggregation due to sticky properties. Thus bioengineers had to build fermentors to avoid settling of clumps and take into consideration the slow growth (doubling time 25-110 h) and low respiratory rate in the region of 1μ mo l $/O_2 / h^{-1}$ at 10^6 cells^{-1}.

In mass culture of plant cells, which are sensitive to shear stress, the most important factor is the supply of oxygen without affecting the metabolite producing cells. Airlift-cum-agitation type jar with a modified paddle impellar gives highest oxygen transfer coefficient. Some others have used airlift fermentors which show best production of plant metabolites. Rotary drum type tank has been used by

Japanese workers which causes least cell injury due to gentle revolutionary movements. Thus the selection of culture tank design appears to be dependent on the individual preferences based on the nature of plant cell cultures.

20,000 l fermentors for the culture of tobacco cells with 1500 l inoculum and 14,000 l of medium and transient doubling time of 15 h., have been used by the Japanese, wherein final yield has been reported to be 15 g dry wt /day. This is often considered as a model study for fermentation of plant cells.

For photoautotrophic cultures, which synthesise carbohydrates in light, the air flow should be at a slow rate and supplemented with about 2% carbon dioxide. Light intensity of 2000 lux is sufficient for normal cultures whereas photoautotrophic cells require upto 8000 lux. In

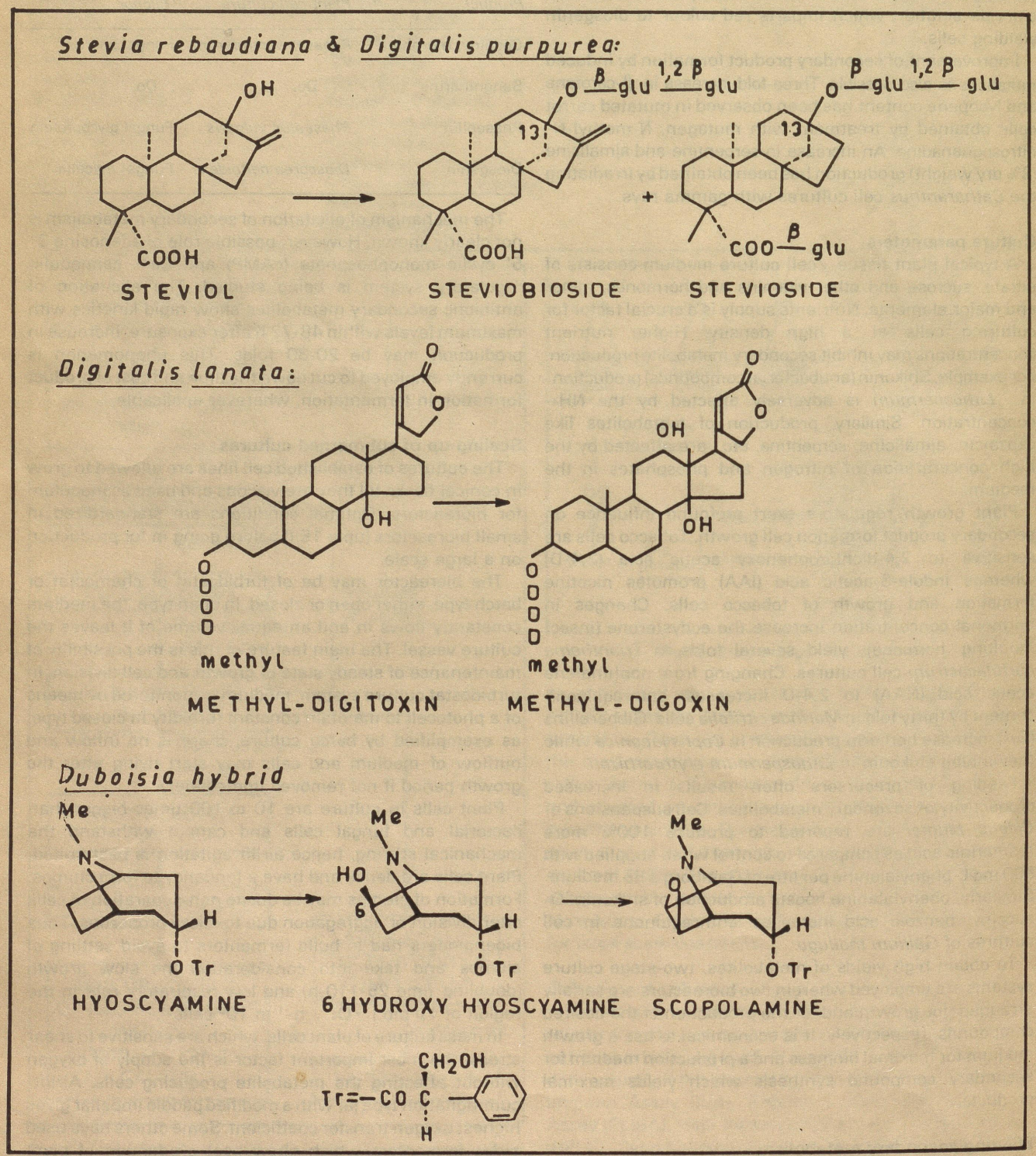


Fig. 3. Few selected biotransformation reactions in plant cell cultures

future it may be possible to use photoautotrophic cell culture for metabolite production specially by leaves of intact plants.

Although the release of metabolites is considered a difficult task, resulting in disturbance within the cells themselves, there are few examples demonstrating the excretion of active substances out of the cell. Release of *Capsaicin* (pungent principle) from immobilised cells of *Capsicum frutescens* and digoxin from cultured cells of *Digitalis purpurea* are some of the model systems presently used. It seems advantageous to get maximal production of metabolites in cells and then its excretion into the medium.

Biotransformation

Conversion of organic compounds by highly specialised plant cell cultures is an exciting area of research, particularly when this cannot be performed by microbes. The projected potentials of the biotransformation lie in conversion of less expensive and bulk product to value added high cost and low volume products. The biotransformation of digitoxin or methyldigitoxin to digoxin or methyldigoxin by *Digitalis lanata* cell cultures has been shown. The cell cultures can carry out biotransformation at 15% conversion in 24 h and 70% in 7 days. Digoxin finds its use in cardiac treatment.

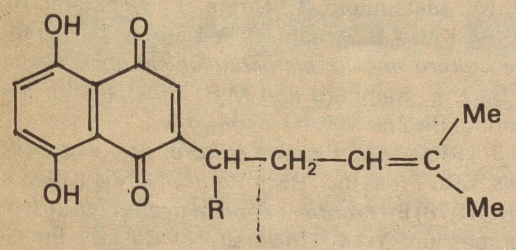
The diterpenoid stevioside is widely used as natural sweetner (hundred times sweeter than cane sugar) but not its aglycone steviol. The cell cultures of *Stevia rebaudiana* and *Digitalis purpurea* can biotransform the steviol to steviolbioside and stevioside. Some of the biotransformations are shown in Fig. 3.

Immobilization of cells

Since 1979, there are a number of reports of entrapment of cells of many important plants such as *Catharanthus roseus, Capsicum frutescens, Digitalis lanata, Morinda citrifolia, Papaver somniferum,* etc. Cell can be entrapped in gel such as calcium alginate, agarose, agar, polyacrylamide or reticulate polyurethane hollow fibres, etc. The advantages of physical entrapment are: (i) cell to cell contact to facilitate better chemical communication; (ii) reduced cell division which results in shift in primary metabolism to secondary pathway thereby increasing production capability; (iii) excreted product (as in capsaicin) facilitating yield of metabolite without destruction of the biomass; and (iv) if the precursor compound is permeable

Table 5. Suggested products of commercial importance that can be produced by plant cell cultures

Product	*Plant*	*Source*
Chemical industry		
Diosgenin	*Dioscorea deltoidea*	Tubers
Essential oils	*Mentha Sps*	Leaves
Nicotine, Scopoletin	*Ruta graveolens*	Leaves
	Nicotiana tabacum	
Food & agriculture industry		
Colourants		
Anthocyanin, carotenoids	*Daucus carota*	Roots
Betanine	*Beta vulgris*	Roots
Flavour		
Angelica	*Angelica Sylvestris*	Flower
Capsicum	*Capsicum annuum*	Fruit
Celery	*Apium graveolens*	Leaves
Garlic	*Alium sativum*	Bulbs
Ginger oil	*Zingber officinale*	Roots
Hops	*Humulus lupulus*	Flowers
Onion	*Alium cepa*	Bulbs
Insecticide		
Pyrethrins	*Chrysanthemum cinerariaefolium*	Flowers
Non-nutritive sweetners		
Thaumatin	*Thamatococcus daniellii*	Fruit
Stevioside	*Stevia rebaudiana*	—
Pharmaceutical industry		
Ajmalicine, Serpentine, vincristine, vinblastine	*Catharanthus roseus*	Root
Atropine, hyoscyamine	*Atropa belladonna*	
Codeine, Morphine,	*Papaver somniferum*	Capsule &
thebaine,	*Papaver bracteatum*	seedlings
Berberine	*Coptis japonica*	Rhizome
Anthraquinones	*Cassia tora*	Fruit
	Morinda citrifolia	
Digitoxin—Digoxin	*Digitalis purpurea*	Leaves
Reserpine	*Digitalis lanata*	Leaves
Visnagin	*Rauwolfia serpentina*	Roots
	Ammi visnaga	Roots



R : OH — shikonin
H — deoxyshikonin
OCOMe — acetylshikonin
$OCOCHMe_2$ — Isobutylshikonin
$OCOCH=CMe_2$ — β-β-dimethylacrylshikonin
$OCOCH_2CHMe_2$ — isovalerylshikonin
$OCOCH_2CMe_2$ (OH) — β-hydroxyisovalerylshikonin

Fig. 4. Shikonin and its derivatives

Table 6. Institutions in India engaged in plant cell cultures for metabolite production*

Institution	*Metabolites*
Pharmaceutical	
Bhabha Atomic Research Centre, Bombay	Fermentative production of Ajmalicine, Vinblastine, Vincristine.
Central Institute of Medicinal & Aromatic Plants, Lucknow	Artemesin, Essential oils.
Regional Research Laboratory, Jammu-Tawi	Diosgenin, Indole alkaloids, Morphinane alkaloids, Scopoletin and Visnagin.
M.S. University of Baroda, Baroda	Synthesis of Atropine, Nicotine, Phenolics, Phytoecdysones, Solasodine.
University of Rajasthan, Jaipur	Atropine, Berberine, Diosgenin, Hyoscyamine, Opium alkaloids, precursor biotransformation.
University of Jodhpur, Jodhpur	Ephedrine, Indole alkaloids
Food	
Central Food Technological Research Institute, Mysore	Capsaicin (Pungent spice), Pyrethrines (Bioinsecticide for grain storage), Saffron (Flavour and colour), Garlic (flavour), Carum (spice)

*The list is only representative.

across the cell-wall, it can facilitate bioconversion of added precursor to end products as exemplified by *Digitalis* system. By virtue of its merits, cell immobilisation has future prospects as an integrated part of a large scale production process.

Commercial products

Despite the problems in cell culture research there are already few products commercially produced by Japanese and W. German scientists. Mitsui Petrochemical Industries of Japan have started producing shikonin, a red pigment from *Lithospermum erythrorhizon*. Shikonin is an antibacterial and antiinflammatory compound used widely in Japanese pharmacopea (Fig. 4). Since it is also a safe red dye, it is presently marketed as 'bio-lipstics' pending clearance by drug authorities for pharmaceutical use. A West German firm is setting up a plant for the manufacture of digoxin from digitoxin by biotransformation. Phosphodiesterase from tobacco cells is being marketed by Bethesda Research Lab., Maryland (USA), berberin (used against stomach distress) production by *Coptis japonica* is likely to be industrialised. The production of two or more products from one culture is being explored. For example, tobacco cells cultured in 20,000 l fermentors are being used for producing ubiquinone (used against heart ailments), biotin, and low tar tobacco for cigarettes. Suggested plant products with industrial potentials obtainable from plant cell culture have been listed in Table 5.

Industrial production of high cost secondary metabolites by plant cell cultures is receiving greater attention now than before. This is evident from the large number of commercial companies evincing keen interest to exploit the potential. Till recently, only a few groups in W. Germany, Japan and Canada were actively involved in production of metabolites from cell culture, but now many countries have actively entered this area of biotechnology, which offers great promise for immediate future.

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Xenobiotics in the body

B. GANESH BHAT

MAN'S environment has always contained small amounts of a very large variety of non-nutrient substances such as food additives, drugs, pesticides, industrial chemicals, etc., normally regarded as foreign to the body. Modern man is becoming increasingly dependent upon the use of these synthetic chemicals or foreign compounds of natural origin. These substances are collectively called 'xenobiotics' which are utilised neither for the production of energy nor for the elaboration of tissue components. Thus it is important to know what happens to them when they enter the body. The study of the metabolic fate of xenobiotics is termed as xenobiochemistry. We now know that the body possesses a biochemical defence mechanism which can protect us against the harmful effects of these substances, but it is interesting to know how this defence system works and what are its limitations.

An animal is unable to separate nutrients from the contaminating foreign compounds during the process of ingestion but it has the means of accelerating the elimination of xenobiotics and also of neutralising any physiological or pharmacological activity they may possess. This vital function of chemical defence is known as detoxication and is effected principally by the liver (hepatic metabolism), but other organs and tissues such as the gastrointestinal (GI) tract, kidney, lung, gut flora, etc., also contribute to the metabolism of a xenobiotic (extrahepatic metabolism).

Metabolic transformation may produce an increase or decrease in toxicity. In this way drugs or foreign compounds may be deactivated (detoxication) or activated (intoxication). Inactive xenobiotics or prodrugs may be converted into therapeutically active compounds or proximate carcinogens. For example, inactive prodrug, prontosil, becomes active sulphanilamide after reductive scission and inactive insecticide, parathion, becomes active paraoxon after desulfuration. Thus knowledge about detoxification permits us to predict what compounds are safe to use and to avoid those which produce adverse effects.

Absorption, tissue distribution and excretion of xenobiotics

Foreign compounds enter the body mostly by absorption from the GI tract or from mouth, the lungs and the skin by simple diffusion. The absorbed xenobiotics are taken via the portal vein to the liver where they are detoxicated. The secondary sites of detoxication are located in other tissues such as lungs, GI tract, kidney and the skin. Consequently, the foreign compounds or their metabolites may appear in expired air, saliva and sweat or get distributed in different tissues. Foreign compounds of high lipid-solubility tend to become localised in the adipose tissue by simple partitioning of the non-ionised molecules between the intracellular lipids and body water.

The detoxication products from liver are principally excreted in the bile to be passed out in the feces or taken to the kidneys via blood to be excreted in the urine as highly polar conjugates or metabolites. They may also be excreted in expired air, sweat and saliva. Of these, the excretion of foreign compounds and their metabolites in bile is a process of greater importance which follows certain principles depending upon the chemical nature, molecular weight of the compounds, biological factors and the species of the animal studied.

What happens to non-nutrient substances such as drugs, food additives, etc., when they enter the human body and how the body's defence system deals with them is discussed here

Biliary excretion. The blood containing foreign compounds absorbed from GI tract enters the liver by the portal vein, passes through the hepatic sinusoids of the liver lobules and returns into the systemic circulation by the hepatic (central) vein. Xenobiotics are absorbed from the blood of the hepatic sinusoids into the hepatic parenchymal cells and are then transferred, as metabolites or conjugates, into the bile or are returned into the blood of the sinusoids to be ultimately excreted by the kidneys.

Enterohepatic circulation. Foreign compounds excreted in the bile mostly as conjugates may be hydrolysed by hydrolytic enzymes (1 /3-glucuronidases, sulphatases, etc.) of liver, intestine or flora. Some of these conjugates are reabsorbed, transported to the liver, reconjugated and

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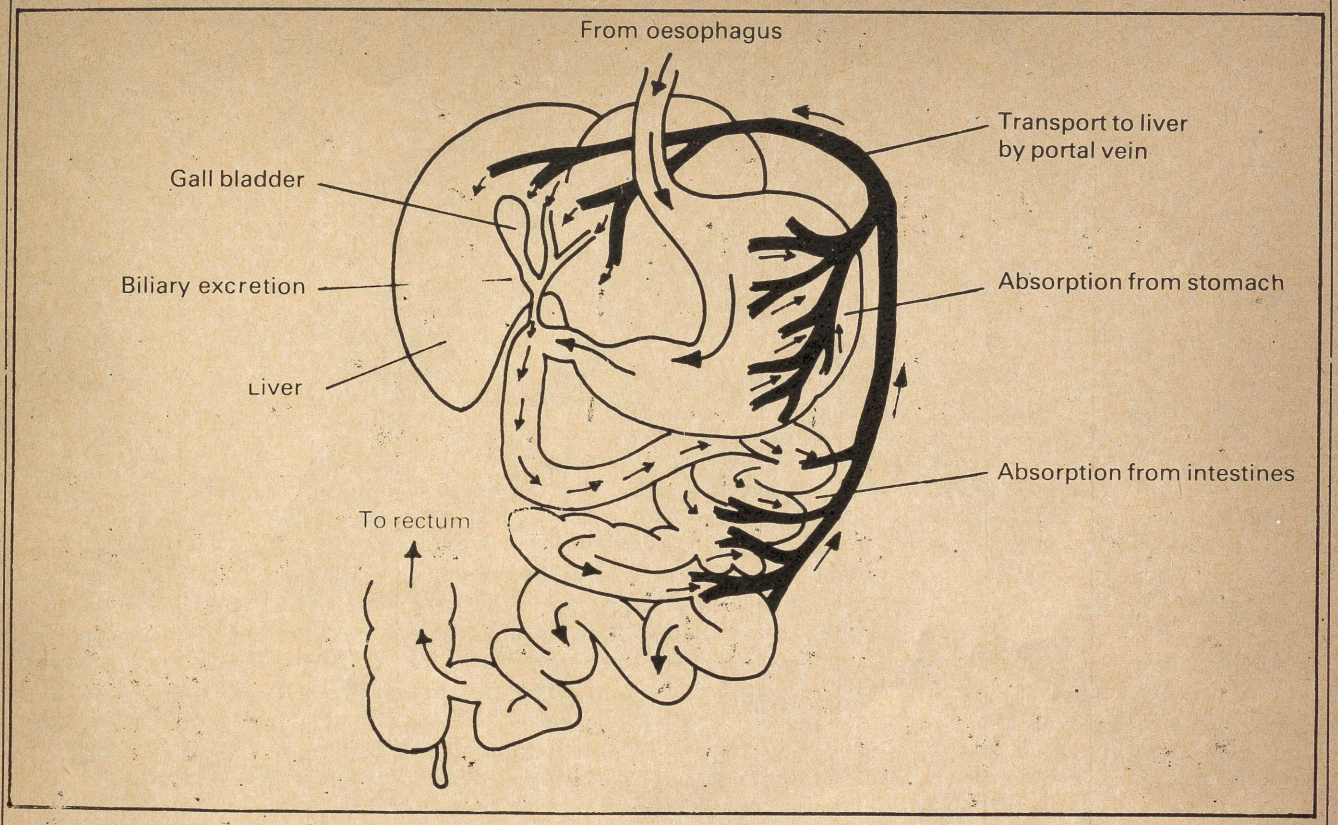

Fig. 1. Enterohepatic circulation

excreted again in the bile. Such a cycle of biliary excretion, intestinal reabsorption and excretion is known as enterophepatic circulation (Fig. 1) and occurs in case of long acting drugs.

Factors influencing biliary excretion

Physico-chemical factors. Many fat-soluble substances of relatively high molecular weight (300-400) are eliminated predominantly via the bile rather than in the urine. The presence or introduction after metabolic conversion of a strongly polar group such as glucuronide, carboxyl, sulfate, etc., in a molecule appears to be a requirement for extensive biliary excretion to occur.

Biological factors. Biliary excretion of foreign compounds varies with species, sex, genetic factors and extent of protein (of hepatic cell and plasma) binding.

Metabolic reactions. After entering the body, xenobiotics are metabolised usually by two phases of reactions.

Phase I is the metabolic transformation where the compound undergoes an oxidative, reductive or hydrolytic reaction or a combination of these reactions giving rise to metabolites with increased polarity. The oxidative reactions include aromatic hydroxylation, oxidation of alkyl chains and cycloalkyl groups, oxidative dealkylation, N-oxidations, sulfoxidations and epoxidations. Reductions are of nitro, azo or ketone groups of the compounds. Hydrolysis may be of compounds containing ester or amide groups.

The enzymes of phase I reactions are mainly located in the endoplasmic reticulum of the hepatic cells, and probably other tissues and are called microsomal enzymes. The endoplasmic reticulum consists of an ordered lipoprotein structure with lipid molecules arranged in a bilayer within which drug metabolising enzymes of lipid-soluble substrate specificity are ogranised.

Microsomal oxidation reactions are catalysed by certain enzymes known as 'mixed function oxidases' that are concerned in the metabolism of xenobiotics, steroids and lipids and require reduced form of NADP as cofactor and oxygen. This oxidising system contains atleast 2 catalysts—NADPH-cytochrome C reductase and cytochrome P_{450}—which catalyse the consumption of one molecule of oxygen per molecule of substrate with one atom of oxygen appearing in the product, and the other undergoing reduction to give water as shown in Fig. 2.

Role of cytochrome P_{450} in oxidations. Cytochrome P_{450} plays a very important role in xenobiotic oxidations. A large number of compounds possessing different structures undergo oxidative transformations with cytochrome P_{450} containing monooxygenase systems in the microsomes. Almost all compounds which act as substrates for the cytochrome P_{450} system are lipophilic. The active site of cytochrome P_{450} is embedded in the lipid phase of microsomal membrane such that only lipophilic substrates can penetrate the site and the catalytic site is exposed to aqueous phase. The multiplicity of cytochrome P_{450} in several sources, especially in liver microsomes, enables the cytochrome P_{450} system to handle a wide range of substrates.

One important feature of cytochrome P_{450} dependent

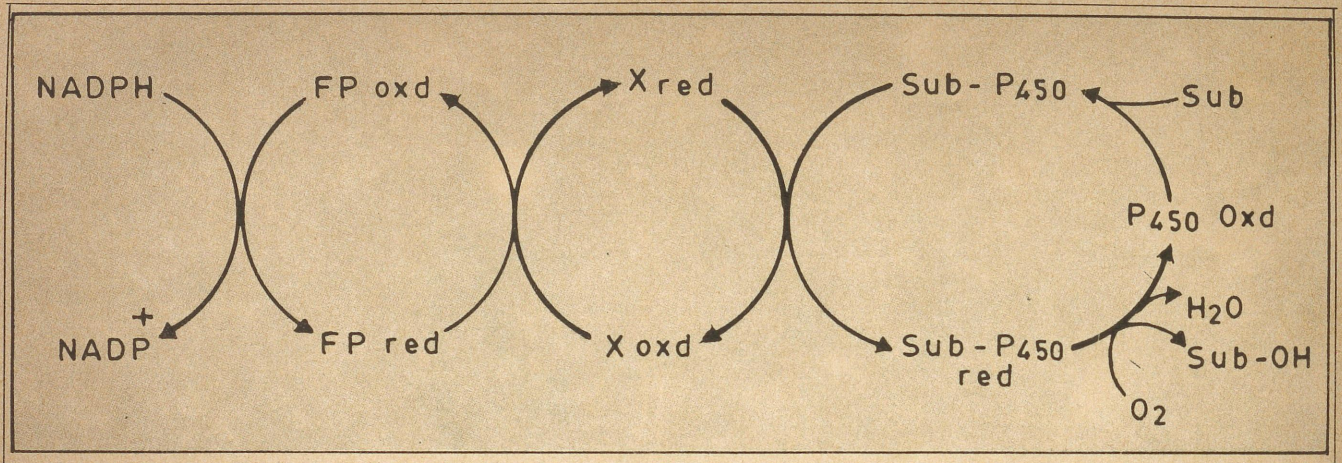

Fig. 2. Mechanism postulated for the hydroxylation of organic substrates by the liver microsomal P_{450} system. FP-Flavoprotein (NADPH-cytochrome C reductase), X-unidentified carrier

metabolic pathways is that most of the sequences are not fundamental to the maintenance of life, but they are related to differentiated functions and are distributed only in cells having specialised functions. In this connection it is of interest to note that no cytochrome P_{450} has been detected in foetal liver, an undifferentiated tissue, and several hepatomas, the dedifferentiated tissues.

Phase II is the conjugation or synthetic reaction of phase I products giving rise to conjugates which are then excreted in urine, bile or expired air. But some compounds may be metabolised predominantly by reactions of one phase only.

Xenobiotics and their metabolites (Phase I products) containing suitable groups as -OH, $-NH_2$ and -COOH can undergo synthetic or conjugation reactions in the body in which the compound is combined through one of these groups to an endogenous substance (conjugating agents) derived from the body's carbohydrate and protein resources. The process is referred to as detoxication mechanism. Some common conjugation mechanisms are given in Table 1. All these reactions require activated nucleotides as intermediates in the process of conjugation, and ATP as a source of energy. The activated neucleotide intermediate may contain either the conjugating agent or the foreign compounds. One of the typical examples of conjugation mechanism is glucuronidation—catalysed by glucuronyl transferase, which transfers glucuronic acid moiety from its activated conjugating agent, UDP-glucuronic acid, to the xenobiotic or its metabolite to form its glucuronide conjugate. The group on the xenobiotic or its metabolite at which glucuronidation can occur can be a -OH, -COOH, $-NH_2$ or a -SH group. Glucuronides are strong acids, highly ionised and very water soluble at physiological pH. They make a non-polar compound more polar and increase its molecular weight by 176 units.

Table 1. The common conjugation mechanisms

Mechanism	*Conjugating agent*	*Conjugates excreted in*
Glucuronide synthesis	Glucuronic acid	Urine and bile
Ethereal Sulphate synthesis	Sulphate	Urine
Hippuric acid synthesis	Glycine	Urine
Glutathion Conjugation (Mercapturic acid synthesis)	Glutathione	Bile
Methylation	Methyl group	Urine
Acetylation	Acetyl group	Urine

Factors affecting metabolism of xenobiotics

The rate at which xenobioltic metabolism reactions proceed and their relative importance may be affected by a variety of factors resulting in changes in the pattern of metabolism and differences in toxicity, pharmacology and physiogical effects of xenobiotics. These factors may be genetic, physiological or environmental in origin. Differences in response to xenobiotics are often due to genetically determined enzyme defects, which result in variations in the patterns of metabolism of the drugs. Further, genetic factors also include species differences and strain differences within the same species.

The physiological factors that affect metabolism include age and development of enzyme systems, sex differences, hormones, the nutritional state of the animal, pregnancy and disease.

Adverse environmental conditions result in an increase of the NADPH dependent, microsomal oxidations. Exposure to ionising radiation produces a typical stress response which may result in impairment of the hepatic microsomal oxidations. Simultaneous administration of two drugs may result in activation or inhibition of the metabolism of one of the xenobiotics administered at molecular level.

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Algal cultures represent one way to meet the worldwide food and protein shortage. In countries such as West Indies, China and Japan, marine algae are used as an alternative source of human food

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SUNITA JOSHI

Algae and their utility

WITH the rapidly increasing population of the earth, there is growing understanding of the necessity to draw on all resources to meet the demands for increasing food production. Plants are our primary food producers. By means of their pigments, particularly chlorophyll-a, they are capable of binding and transforming energy from the sun to a form suitable for organic life on our planet. Sea plants have also been used in different coastal regions of the world, but with the advance of food technology they have to a large extent been replaced by food products from other sources. In the densely populated countries of South East-Asia, however, seaweeds are playing an increasingly important role as a food reserve. The natural production of some types of seaweeds no longer keeps pace with the demand and efforts are being made to develop methods to increase the standing crop. Mariculture is growing in importance alongside of agriculture.

In countries which have not felt population pressures to the same extent as the eastern countries, interest in seaweeds arises from the recognition of their economic importance for chemical industry. When the supplies of some important products like agar and alginates were cut short during the war, it was found that they could be replaced partly by products from local seaweeds.

As food source

Algal cultures represent one way to meet the worldwide food and protein shortage. In several countries, viz., West Indies, China and Japan, marine algae are used as an alternative source of human food. Besides, they are also used as feed for fowls, domestic and marine animals. Higher values of protein are found in Chlorophyceae (*Chlorella pyrenoidosa*, 40%-50%, *Ulva* 20%-30%) and Rhodophyceae than in Phaeophyceae. The blue-green alga *Spirulina maxima* is very rich in protein (63%-68%) and vitamins. It possesses carbohydrates between 18%-20% and 2%-3% lipids. From nutritional point of view, vitamin content of some algal cultures is very high which makes them even more valuable as food. On the basis of protein content, algae have a three-fold advantage over leguminous plants. Their caloric yields per unit of environmental area under natural large-scale culture is equal to that of the best terrestrial crop plants at their season of peak production. Continuous cropping of algae can yield a 3-9-fold higher caloric conversion per year if cultures are maintained at peak efficiency.

In addition to protein and carbohydrates, some marine algae are rich in vitamins (B_1, B_2, B_{12}, C, D, E and K) and essential growth substances including minerals. Examples are *Laminaria, Undaria, Eisemia, Hijika, Manostrama, Enteromorpha, Ulva, Porphyra, Meristotheca, Gelidium*, etc. These algae also contain several amino acids with the exception, however, of cystine, methionine and tryptophan.

Two algae of Chinese origin, viz., *Isochriysis galbana* parke and *Pailora lulheri* have exhibited good feeding efficiency in rearing of *Mytilus edulis* larva. Fermented laminaria blades have likewise been used as feed for raising marine animals as they are claimed to be rich in yeast protein, amino acids and alginic acid. In Belgium, microalgae have been used as a source of food for commercially important fishes, molluscs and crustaceans.

Polymers

Extensive investigations have been carried out in the past two decades on algae. Mucilage extracted from marine algae contains a high content of polysaccharides. The algal polysaccharides of the greatest industrial importance are obtained from brown algae (alginic acid, fucoidans, laminarans) and red algae (sulphated galactans, agar and carrageenin). The other polymers such as xylans, mannans, xylomannans, cellulose, hemicellulose, chitin, pectins, etc., are of academic interest only at the moment. Algal starches have been known as storage products in many genera. Many structurally similar polysaccharides isolated from separate genera differ only slightly from known polymers. Their structural composition is still being studied

Alginates are the reserve product of cellular metabolism. These polymers find a number of useful applications. For example, in the field of medicine, sodium alginate is employed in the preparation of gelcose sponge gauze, which is reported to have a haemostatic action and is slowly absorbed in the human system. Alginates are also useful in making accurate dental impressions. Besides, alginates have been used in pharmaceutical emulsions and in coating of pills, surface film and paper, in placing of glaze in ceramics, in various emulsion paints as well as polishing agents. Sodium alginate is considered to be superior to all other colloids as a stabilizer and creaming agent for ice-creams, because of its non-toxicity and colloidal properties. Its thickening properties make it useful in the preparation of foods such as soups and creams of various kinds, and as a gel in freezing of fishes.

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Agar has a variety of uses in commerce and is very important in microbiological laboratory studies. A 1%-2% solution gives a satisfactory gel, which in the presence of different nutrients remains undigested and refractile to microbial attack. It is non-toxic and has gained wide use in food industry for canning meat and fish. It has another popular use as an emulsifier in laxatives. It has also been used in cosmetics, leather and textile industry.

Algae serve as a source of halogens (bromine, iodine), and mineral constituents like, Ca, Mg, K, Cu, Fe, Zn, Co, V, Mo, Mn, B, Al and Cr. The first three elements are present in relatively larger amounts, while the remaining elements are found in trace quantities only. The presence of these minerals in algae forms the basis of their use in supplementing basic fodders and fertilizers.

Medicinal uses

Some algae have been found to possess medicinal properties and antibiotic activity. Many algal products have exhibited bacteriostatic or bactericidal action against various pathogenic species.

Antimicrobial activity. Antibacterial, antifungal and anti-protozoal properties are associated with several seaweeds. The antimicrobial activities are due to the presence of bromophenols /alkylated resorcinols and phloroglucinols. Test organisms used for determination of antimicrobial effect include *Bacillus subtilis, Escherichia coli, Vibrio* sp., and *Saccharomyces cerevisiae*. The brown algae, genus *Cytophora*, is described to be a potential source of new antibiotics.

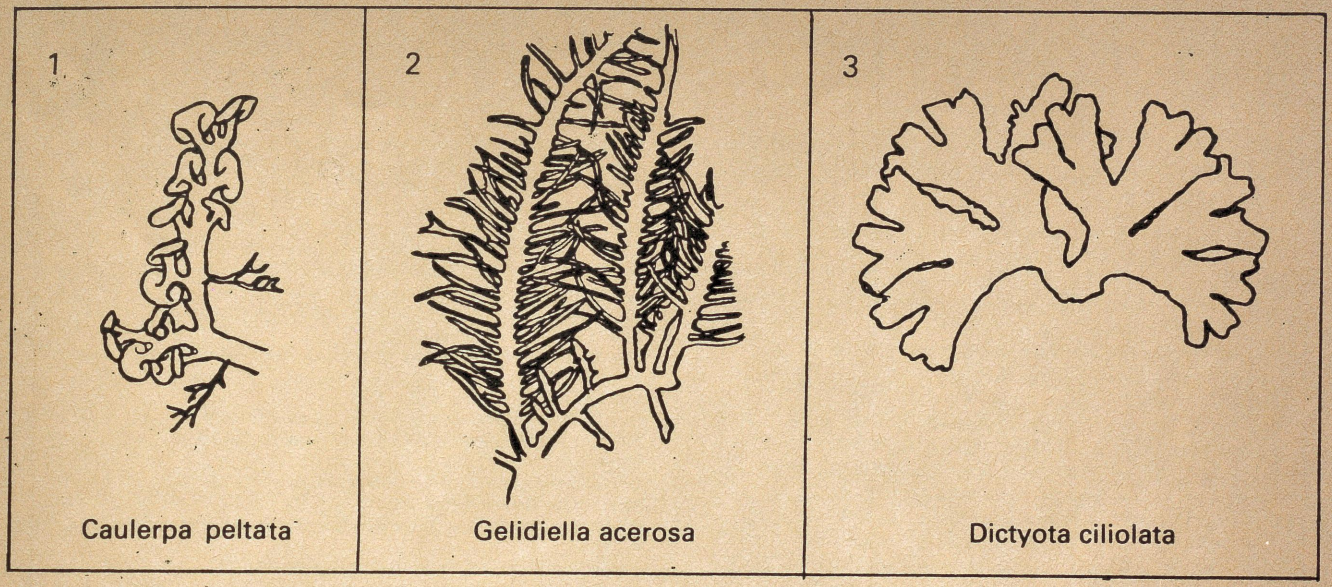
Anthelmintic activity. Three red seaweeds, viz., *Digenea simplex, Caloglossa lepricurii* and *Ishige okamurai*, have been reported to contain kainic acidtype compounds which exhibit anthelmintic action.

Antitumor activity. Antitumor activity in mice of crude extracts from some edible marine algae, against L-1210 leukemia, p-388 lymphocytic leukemia and Ehrlich ascites have been claimed. Sulphated polysaccharides are described to be the antitumor component of the edible brown algae. Many marine and fresh-water algae are components of Chinese herbals, which have been used for treatment of tumors and cancers since historical times.

Hypocholesterolemic activity. Alginates (7%) are reported to prevent absorption of fats and cholesterol by alimentary tract. They are claimed to be superior to wheat bran for their hypocholesterolemic (cholesterol-reducing) effect. β-Homotaine has been identified as the chemical component responsible for the aforementioned biological action.

Table 1. Constituents of algae

Paraffinic Hydrocarbons	C_{15}—C_{19}& C_{27}—C_{30} hydrocarbons
Carbohydrates	Arabinose, Glucose, Sucrose, Trehalose, Dulcitol, Mannitol, Sorbitol, Ascorbic acid, Agar, Chitin, Hemicellulose, Pectin, Starch, Algin, Alginic acid, Carrageenan, Fucosan, Glycogen liminarin
Fatty acids	Linoleic, Myristic, Oleic, Palmitic, Stearic acids, etc.
Amino acids	Usual amino acids including L-Baikainin, Taurine (and its derivatives), Gongrine and Gigartinine
Proteins	Octapeptides of glutamic acid and polypeptides
Enzymes / co-enzymes	Catalse, Cytochrome-C, Dehydrogenase, Dextrinase, Diastase, Hematochrome, Lipase, Oxidase, Peroxidase
	Quercitin and Rutin
Pigments	Anthocyanins, Carotenes, Chlorophylls, Crocin, Crocetin, Crocetin dimethyl ether (*cis* & *trans*) Fuscochlorin, Fuscorhodin, Gloeocapsin, Phycobilins, Phycocyanin, Phycoerythrin, Phycoporphyrin, Volutin and Xanthophylls
Sterols	C_{26}—C_{29} sterols, viz., 22 *trans*-24-nor-cholesta-5, 22—diene—3—Ol, Cholesterol, 22—(and 24—) dehydrocholesterols, Chalinasterol, β-Sitosterol, Stigmasterol, Brassicasterol, Chondrillasterol, Fucosterol, Sargasterol, etc.
Vitamins	Vitamins (B_1, B_2, B_{12}, C, D, E and K).
Antibiotics	Alkylated resorcinols, Bromophenols, Kainic acid type Compounds, Phloroglucinols and Sulphated polysaccharides
Miscellaneous	Glycerol, Indole acetic acid, Picrocin, Protocrocin, Safranal
Inorganics	Na, K, Cu, Ca, Mg, Zn, B, Al, V, Cr, Mn, Fe, Co, Mo, Br, I



Figs. 1-3. Green, Red and Brown Algae respectively

Miscellaneous activities

Several seaweeds, particulary those of Chinese origin, have useful therapeutic action such as antifebrile, antioedema, diuretic, expectorant, hypotensive, antidiabetic, anticoagulant and hemostatic action. Stypoldione, the brown algal natural product, is reported to produce an immediate inhibition of sperm motility and irreversible inhibition of cell division. The sulphated polysaccharide obtainable from brown algae finds applications as stabilizer for 'PS type' barium sulphate preparation used in contrast to X-ray examination of gastric ulcers.

From the marine red algae, some water-soluble neuroactive proteins (molecular wt.: 5×10^4-1×10^5) have been isolated, which induce behavioural and developmental metamorphosis of *Haliotic* larvae.

Commercially imporant seaweeds

Porphyra. In-depth studies of the economically important Porphyra Spp. have been made in China, Japan and the U.S.A. These include formation, liberation and collection of spores.

Laminaria. Seaweed research in China got an impetus after 1950. Previously China used to import seaweeds and seaweed products from Japan. The significant contributions to our understanding of the optimal conditions—particularly the temperature for the transplanation of summer sporlings, development of hybrid varieties of *Laminaria* (which are better in terms of yield of seaweed than the parent stock) and better cultivation techniques are largely due to Chinese scientists. *Laminaria saccharina* has been successfully adapted in Norway as the best suited seaweed for cultivation for a 9-month period (October-June). In Europe *Laminaria* are considered an alternative renewable energy source, as this seaweed is readily susceptible to fermentation by methane producing bacteria.

Gracilaria In different parts of the world, ***Gracilaria*** farming is done on a commercial basis for obtaining agar in different states of purity. Low grade agar is produced in Thailand, and agar for biomedical purposes is made in U.S.A. In West Indies (Caribbean islands), *Gracilaria* (sea-moss) is used for human consumption.

Considerable work has been done by Chinese scientists on improvement of *Gracilaria* cultivation (viz., adoption of fixed raft method) on a large scale, adopting the best yielding varieties of seaweeds (viz., *Gracilaria verrucosa, Gracilaria sjoestedtii*) under optimal temperature conditions (April) and employment of the best techniques for acidifying and bleaching of agars.

Seaweeds of economic importance

Dunaliella bardawil and *Dunaliella salina* are used in the isolation of B-carotene, glycerol and protein. *Eucheuma gelatinca* and *Eucheuma okamurai* have been employed as human food and have proved useful as a raw material for isolation of carrageenan. *Scenedesmus chlorella* finds application as a feed for pigs. The marine biomass obtained from three algae, viz., *Macrocystis angustifolia, Macrocystis pyrifer* and *Ulva reticulata*, is used as an energy resource. The nitrogen fixing blue-green alga, namely, *Anabaena*, is used as a biofertilizer. It increases the average yield of rice by 10%-20%.

Further Reading

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And now cosmic strings

WHEN black holes—extremely massive bodies that do not allow even light to escape—were predicted in the 30s, nobody was ready to believe that such things could exist in the universe. It could only catch the fancy of science fiction writers and was interestingly employed in some tales of mystery and imagination. But, today, black holes are part of astrophysics texts and have captured the heart of the public. They are treated and discussed as though they are real objects whose discovery would be announced any time in the near future. In fact, scientists have already attributed the occurrence of several as yet ill understood heavenly phenomena to their presence and are hell bent in bringing them to book. In recent years, however, the glamour and aura surrounding black holes has been fading as yet another heavenly entity with far wider implications in astrophysics and cosmology is gaining prominence. Today, this entity is again looked upon with scepticism and puzzlement as a black hole once was. It is called "Cosmic string" and is believed to be the stuff of which all the heavenly bodies are made. Each string is extremely thin, thinner than an atom, but weighs as much as several mountains, planets, or even several galaxies. Though invisible in all respects scientists claim that its effects produced in the neighbouring space and matter could nonetheless be detected. Along with the exotic black holes, this would be another set of objects astronomers would keenly be looking for in the sky in the days to come.

The concept of cosmic string was first forwarded in 1976 by T.W.B. Kibble of Imperial College of Science and Technology, London, U.K. He was then investigating the aftermath of the Big Bang,the explosive event that triggered off about 15 billion years ago the birth of the present universe which has been expanding ever since. At the time of the birth of the universe all the four forces of nature, namely, gravitational, electromagnetic, weak and strong nuclear, were one. Particles such as electrons and photons were also indistinguishable from one another. But just 10^{-35} second after the Big Bang, when temperature fell considerably, this unitary nature of the universe came to an end. The four forces of nature came into being and particles with different characteristics materialised. However, during these phase transitions, some defects appeared. These defects are not unlike those produced when, for instance, water is turned into ice. Defects appear in an ice crystal; say some lattices are not correctly aligned. What kind of defects could be produced in the case of a cooling and expanding universe?

Scientists have different theories. Kibble claims that the best possible defects could be cosmic strings. Cosmic strings would preserve the early unified conditions of the universe before the aforementioned transitions took place. They would be extremely energetic. From the Einstein's energy-mass conversion relation, such strings would be extremely massive and would move at the speed of light, about 2.3×10^8 meter per second. Hardly 10^{-30} centimeters in thickness, they would either form loops or extend to infinity. Due to the tension inherent in strings, they would be oscillating and thus dissipating energy. The shorter the size of a string, the faster would it dissipate energy and die. A one centimeter length of such a string would weigh as much as a mountain range! A 1000 lightyear long string (one lightyear=9.46×10^{12}km) would die in 10 to 100 million years.

Imagine, then, the universe built as though of a web of cosmic strings. A million years after the Big Bang, they would lump together and form clusters of galaxies. Each string would at least be about 100 lightyears in length. Computer simulation of those events has confirmed that cosmic strings tend to lump together and being gravitationally massive continue to attract the neighbouring strings to form clusters of galaxies. As a result of this

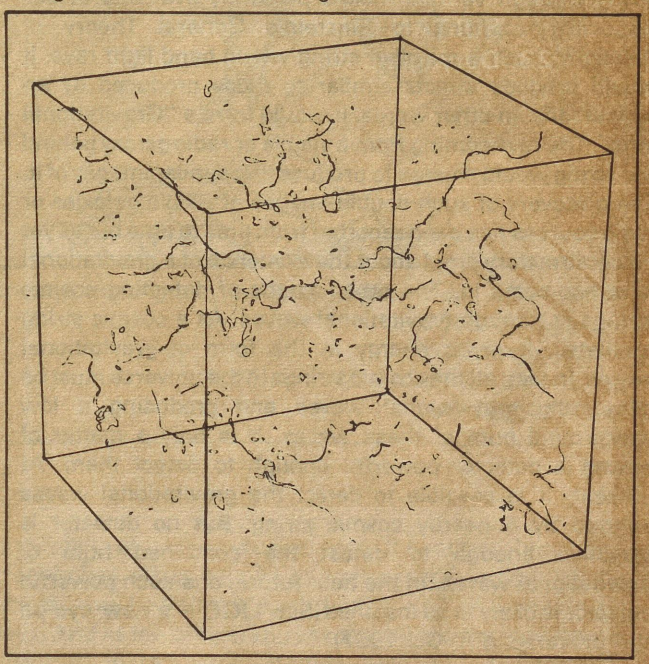


Fig.1. The conditions that led to the formation of clusters of galaxies from cosmic strings were simulated in a computer

clustering effect, immense voids are produced in space. This picture conforms to the visual observations of the sky. Abell clusters—the richest galaxy groups of their kind—are classic example of this clustering effect. However, there is another theory which explains the visual observations of the sky still more minutely, but it claims that the clustering had occurred due to exactly opposite reasons. This theory is based on the "Superconducting" property of cosmic strings. Electrons—mass-less and moving at the speed of light—zooming through the strings would emit electro-magnetic waves just as any current-carrying conductor does. The interstellar gas and particles surrounding the

strings would be pushed out, producing expanding bubbles. Two such expanding bubbles would collide and produce clusters of galaxies at their interface. Immense voids inside the bubbles would separate the galactic clusters. Visual observations of the sky have confirmed the existence of such sheet-like structure of galactic clusters separated by immense voids. However, further investigations are needed to confirm the chain of events that led to the clustering effect. For instance, a superconducting string would leave behind a weak magnetism in the galaxies and the hot boundaries of the bubbles would generate characteristic radio waves.

It is estimated that the cosmic string closest to earth should not be more than 300 million lightyears away. There is however a dim possibility that such a string would pass by or through earth. In any case, consequences of such a possibility would be extremely unpleasent both for the earth and its inhabitants. Be that as it may, the most exciting possibility is of detecting the presence of a cosmic string through various means presently available at our disposal. According to Einstein's General Theory of Relativity, such a massive string would bend light rays. It would produce effects similar to those produced by an optical lens. In other words, it would form a "Gravitational lens". The rays coming from a visible or radio galaxy behind the string would diverge to produce two similar images of it. The discovery of such double images of visible galaxies or radio sources has been reported from time to time but as yet no confirmatory proof about the existence of a gravitational lens has come in. The other means of detecting cosmic strings is through gravitational waves. As a cosmic string oscillates, it emits energy in the form of gravitational waves. In fact, all the cosmic strings in the universe must be generating gravitational waves and producing a low background hum of these waves. It is only a matter of having a detector powerful enough to detect them. At present, it is possible to detect the gravitational waves emitted by a nearby cosmic string. But no detector is sensitive enough to detect the combined hum of gravitational waves. In the near future, one such powerful detector is likely to be installed (See **LIGO —a new eye on the universe,** *S.R.* Oct 1987).

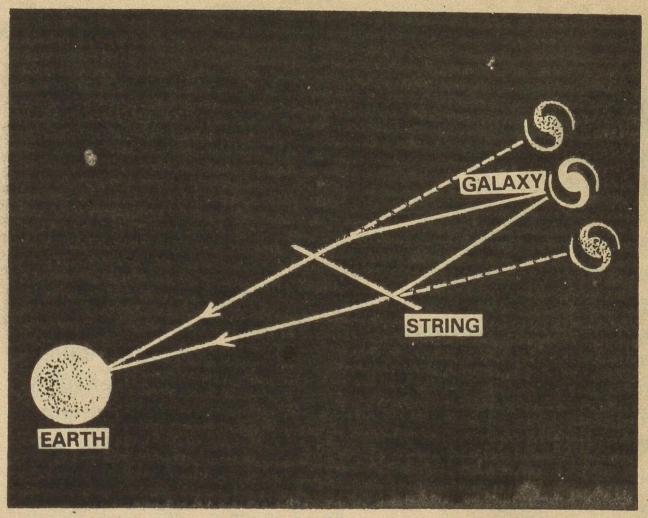


Fig.2. A cosmic string bends light or radio waves in such a way as to produce a "Gravitational lens"

Yet another means of detecting the presence of a cosmic string is by the measurement of microwave radiation background. The remnant of the elt would be difficult, if not impossible, to detect such a change in the microwave radiation background. Besides, it is also claimed that cosmic strings could in some way be responsibile for the origin of cosmic rays, the powerful gamma rays bursts and the highly luminous and most distant quasars. Studies of these objects or phenomena could throw much light on cosmic strings or their existence. Some years ago, a string-like radio source was detected at the center of our galaxy, the Milky Way. Could a light, low energy string be present there?

Cosmic strings are likely to become the darlings of physicists as they are an exotic subject with immense possibilities. They would open new windows on the elementary nature of matter as well as on the birth of the universe.

Dilip M. Salwi

Extreme heat led to dinosaurs' extinction

THE mass extinction of dinosaurs about 65 million years ago has confounded the scientists for a long time now. The exact cause, however, still remains shrouded in mystery. Innumerable theories have been expounded to explain the extraordinary occurrence. The most recent in line is the one suggesting that extreme heat rather than cold might have wiped out the dinosaurs and many other species at the end of the Cretaceous period, 65 million years ago.

Theories of the past had hinted at a drastic cooling down of the earth, as the probable cause for the mass extinctions. Later, the notion, that the extinctions were caused when a meteorite or comet crashed on to the earth, seemed to gain ground. Supporters of this theory, however, had very different ideas about what exactly the impact did to cause such massive extinctions.

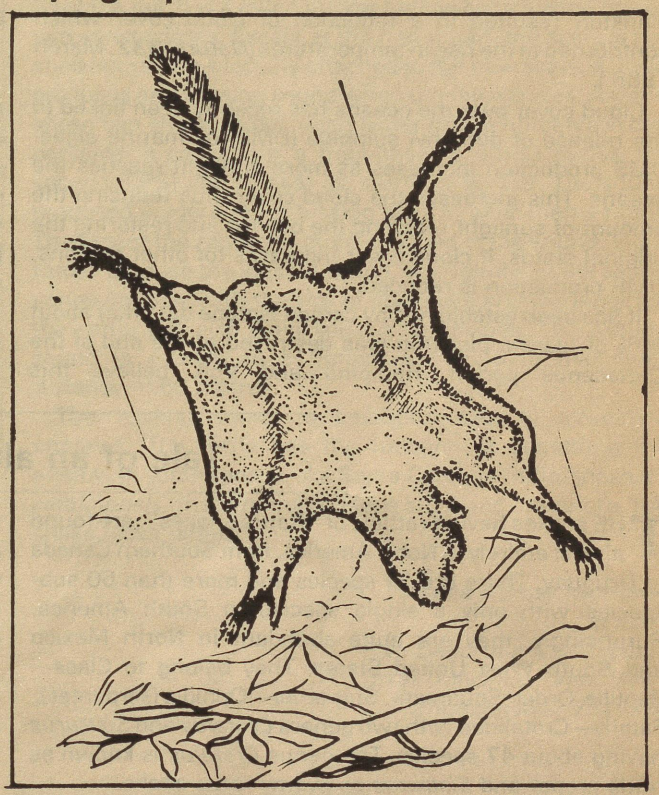
Luis and Walter Alvarez of the University of California originally believed that dust raised by the impact would have blocked the sunlight and cooled the earth. While Ronald Prim of Massachusetts Institute of Technology

Travancore flying squirrel

A flying squirrel known as Travancore flying squirrel (*Petinomys fuscocapillus*), thought to have been extinct or on the verge of becoming so, has been spotted in Kerala in June, 1987. It was caught in Vennikulam, about 10 km from Thiruvalla in Central Travancore by G.U. Kurup of the Zoological Survey of India. Although described earlier in 1847 by a British geologist, Blyth, the animal had been caught only once before by a famous botanist of those times, Bourdillon in Kerala. Only one mutilated specimen of this species as flat skin exists in the British Museum of Natural History, London.

The Travancore flying squirrel, which resembles the one shown in the illustration, belongs to class Mammalia, order Rodentia and Family Sciuridae. A medium-sized flying squirrel, it has an elastic expanse of skin on either sides of the body connecting both the fore and the hindlimbs. It glides in the air by its flying membrane and hence the name flying squirrel.

It possesses a thick fur and broad, long feather-shaped tail. Like tree-squirrels, it has four fingers on the fore limbs the fourth finger being the longest. The foot has five toes, the hallux being the shortest and the sole is quite naked .It has a strand of black long hairs beside the ears. It is reddish brown above with the sides darker than the middle of the back and dark underfur. A central line of the blackish hair runs through most of the length of the tail. The undersurface is white in the typical race.



Travancore flying squirrel, restricted to Kerala, is the only representative of the group of small flying squirrel, all other species existing only in North-Eastern India and beyond.

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argued that the impact of a large comet might produce acid rain as strong as battery acid.

Two recent theories, however, suggest that the impact of the meteorite or comet somehow heated the earth, eventually leading to the mass extinctions. One theory hints at the release of huge quantities of carbon-dioxide in the atmosphere as the cause for the heating. The second theory argues that heating was caused by a reduction in cloud cover.

As is well known, like a one-way filter carbon-dioxide lets energy from the sun pass through it but absorbs the longer wavelength radiations emitted from the earth's surface. The resulting greenhouse effect heats up the earth. John D. O'Keefe and Thomas J. Ahrens of the California Institute of Technology combined this fact with the premise that the floors of the extensive shallow seas of the Cretaceous were probably covered with carbonate sediments.

Ahrens and Keefe suggest that a meteorite or comet would have hit the limestone deposits releasing huge quantities of carbon-dioxide into the atmosphere. The greenhouse effect caused by that excess carbon-dioxide would have heated the earth by 5°C to 20°C in about 10 days. And as the temperatures rose the oceans would have released more carbon-dioxide into the atmosphere, because with rising temperature carbon-dioxide becomes less soluble in water.

To test their hypothesis, Ahrens and O'Keefe modelled several types of impacts by firing high-speed projectiles at samples of limestone. On measuring the amount of carbon-dioxide released they found large variations. An asteroid 20 km across, hitting a layer of limestone 1 km deep would have released 10 tonnes of carbon-dioxide raising the temperature by a few degrees around the world. If the asteroid were 10 km across, amount of carbon-dioxide in atmosphere would have increased by a factor of 20, increasing the average temperature by about 20°C.

According to the second theory by Michael Rampino and Tyler Volk of New York University, the mass extinctions

were the result of a catastrophic decline of plankton in the ocean at the end of the Cretaceous period. The decline of plankton resulted in a reduction of cloud cover which contributed to the rise in temperatures (*Nature*, **332**, March 1988.).

Cloud cover over the oceans has recently been linked to the release of dimethyl sulphide (DMS) by marine algae. DMS production increases as more sunlight reaches the oceans. This increases the cloud cover thus reducing the amount of sunlight reaching the oceans and restoring the original status. If cloud cover increases for other reasons, DMS production is reduced.

It has been established by carbon isotope data that about 90% of marine plankton was destroyed at the end of the Cretaceous period. Rampino and Volk believe this extinction was caused by the impact of a meteorite. The massive extinction would have meant a severe decrease in DMS production, leading to a drastic reduction in CCN and hence marine cloud cover.

Rampino and Volk calculated that extinction of 80% of plankton would reduce cloud cover sufficiently to warm the world by 6°C, while a decline of 90% in plankton would correspond to a warming of nearly 10°C. Decreased marine cloud cover and the resulting high sea surface temperatures could have been a factor in the maintenance of low productivity in the 'Strangelove Ocean' period following the extinctions at the end of the Cretaceous period.

Hasan Jawaid Khan

Tale of an alarming tail

THE snakes having rattles, or "Rattle snakes", are found almost entirely in North America, from Southern Canada to Uruguay. There are 29 species and more than 60 sub-species with only a single species in South America. Surprisingly, they are quite abundant in North Mexico and South West United States. They belong to Class—Reptilia, Order-Squamata, Sub-order—Ophidia (serpentes), Family—Crotalidae with two genera *Crotalus* and *Sistrurus* having about 47 species. The genus *Crotalus* is known as rattle proper and *Sistrurus* as pygmy rattle snake.

A rattle snake is 2-3 metres in length (Fig. 1). The body is

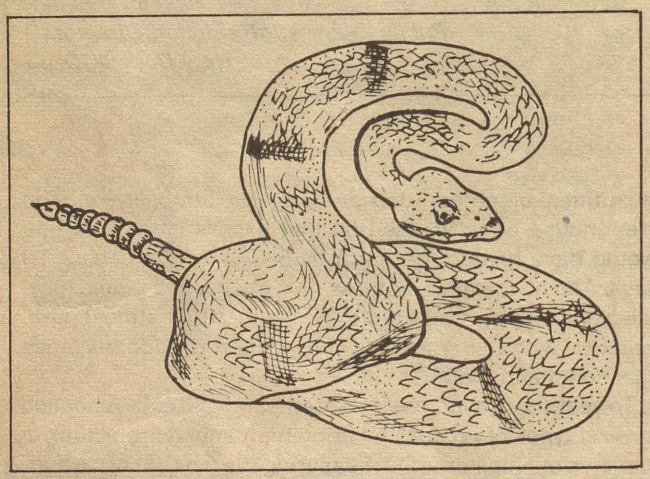

Fig. 1. Morphology of a rattle snake

greyish brown in colour with dark bands and beautiful coloured patterns. The arrangement of bands varies from species to species. The body is clearly divided into head, trunk and tail on the basis of coloured patterns. The head is triangular in shape with small nostrils and ventral mouth. The tongue is bifid and protrusive. The eyes are yellow and small with vertical pupils and protruding eyebrow scales without eyelids. The rattle snake looks sinister because of its peculiar eyes. The body scales are keeled and ventral scales cross the belly. The tail consists of loosely interlocking segments, called "rattle", and hence the common name.

In a new born rattle snake, the tail ends in a spherical scale. All other species of snakes cast off this terminal scale at every moult. Rattle snakes however do so only at their first moult, which occurs 7 to 10 days after birth. The last scale hardens into piston-like hollow structure before the onset of second moulting; it has ring-like constriction. During subsequent moults, this last scale loosens like all the scales of body, but it is not cast off. In the meantime, a new terminal scale develops from its inside. The new one has a greater diameter and holds the first one. Another terminal scale develops at the next moult and likewise it goes on adding more and more cup-like rattles to the chain (Fig. 3). Each of the hollow pod-like scale in the chain was at one time closest to the body of the snake.

The moulting takes place thrice annually. One rattle snake kept in a captive condition had supposedly 29 undamaged rattles at one time. The highest number of rattles recorded is 23, although the average is 8 to 14. However, at each moult a new rattle is added but it does not

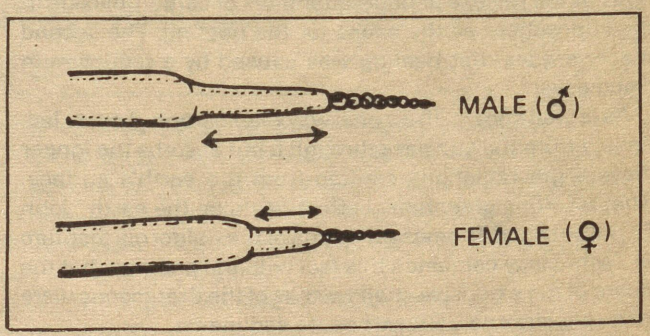

Fig. 2. The structure of tail indicates the difference between male and female rattle snakes.

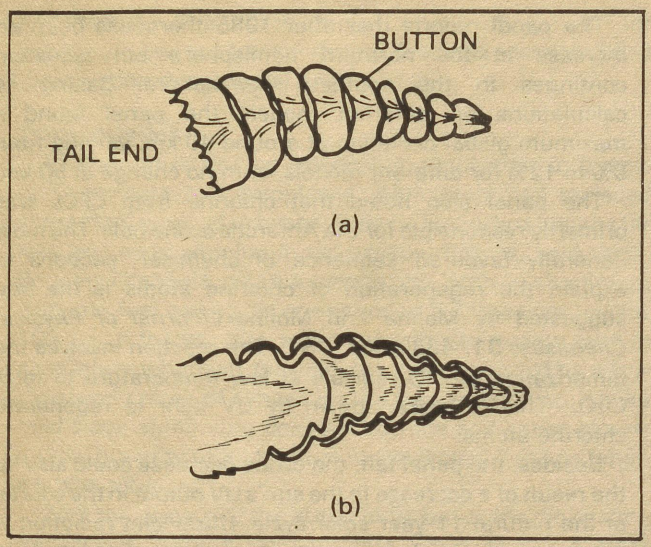

Fig. 3. (a) Dry cornified rattle in external view; (b) Sagital section of rattle to show their attachment

grow in length indefinitely. Since the end scale tends to wear out, the number of rattles differs from individual to individual of the same age. The rattles seldom exceed 14 segments in wild rattle snakes, no matter how old they are. But snakes in zoos may have as many as 29 rattles.

A rattle is made up of a number of loosely interlocked shells, each of which was the scale originally covering the tip of the tail. It is a much thicker hollow cone having one or two constrictions. Except at the first moult, the scale is not shed but remains loosely attached to the new scale. A rattle produces an alarming sound when the tail vibrates. A rattle snake can shake its tail much faster than a human eye can perceive. It can attain a frequency of 40-60 cycles per second (CPS) and in heat as much as 98 cps. The sound produced is more like a hissing buzz or whir than a rattle. The longer the rattle the more subdued is the sound. Eight rattles produce the loudest sound. The volume of the sound varies not only with the size of the snake and the length of the rattle but also from species to species. The rattling sound is audible to a human ear up to a maximum distance of 60 metres.

The rattling sound is basically used to intimidate enemies. The rattle has the function of unsettling the enemy. In some species like Santa Cataline rattle-snake, *C. catalinensis,* the terminal scale is shed and, therefore, the snake lacks rattles.

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The ozone layer is thinning out

THE controversy over the depletion of the ozone layer has been finally resolved. The outcome however is by no means compatible with human interests. The international panel of scientists set up to settle the controversy has confirmed earlier fears that the ozone level in the earth's atmosphere is indeed being depleted globally (*Scientific American*, May 1988). Analysis of the available data showed a global decline of 2.6% from November 1978 to October 1985. The panel also found increasing levels of inorganic chlorine in the atmosphere to be primarily responsible for the damage to the ozone layer.

Ozone in the lower atmosphere forms irritating urban smog and also causes acid deposition on plants, eventually killing them. But in the upper atmosphere the same ozone functions as an efficient greenhouse gas, second only to carbon-dioxide in importance. It absorbs ultraviolet radiation from the sun. A thinning of the ozone layer would enable the UV radiations to reach the earth which would cause more skin cancers, damage crops and fisheries, and destroy materials such as plastics and paints.

Inorganic chlorine atoms, so far held responsible for inflicting the greatest damage to the ozone layer, are released into the atmosphere as a result of Chlorofluoro-carbon (CFC) emissions. Once aloft, CFCs migrate to the upper atmosphere where the sun's intense rays break them down releasing atoms of chlorine. This chlorine in turn drives a series of reactions that destroy ozone. Production of CFCs has grown steadily as demand grew to use them as aerosol propellants, as foam-blowing agents, and as coolants for refrigerators and airconditioners. As a result of worldwide increase in CFC emissions, Stratospheric concentrations of chlorine are now more than twice the natural levels.

The present worldwide concern is, therefore, hardly surprising. Discovery of the Antarctic ozone hole had already confounded the scientists some time back. And now studies by K.P. Bowman (*Science,* **239**, 48-50, 1987) and Donald Heath (*Nature,* **332**, 219-227, 1988) suggest that the depletion could extend to other parts of the globe as well. Heath reported large decreases in global ozone concentrations since 1978, measured using the Solar Backscatter Ultraviolet (SBUV) instrument on the atmospheric research satellite *Nimbus* 7.

Heath found that before 1985, large rates of decrease were confined to high latitudes, but subsequently regions

of large rates of ozone depletion appeared at mid-latitudes as well. Trends indicated that total ozone was increasing at high altitudes and decreasing at mid-and tropic latitudes in southern hemisphere from 1970-76. The rate of decrease was larger with increasing latitude in northern hemisphere. He also observed enhanced rates of ozone decrease during the months of winter and early spring.

Heath's data even hinted at the development of an Arctic ozone hole similar to but less pronounced than the Antarctic ozone hole. Bowman also found trends of similar magnitudes using archived data from the Total Ozone Mapping Spectrometer (TOMS) on *Nimbus* 7. Still, doubts persisted as to the accuracy of measurements due to the fact that calibration of satellite instruments tends to drift. Subsequently the Ozone Trends Panel was constituted to settle the controversy.

The panel reanalysed and renormalised the SBUV and TOMS data. The renormalised data showed a global decrease of 2.6% from November 1978 to October 1985. Based on several ground measurements the OTP further concluded that between 1969 and 1986, in much of the northern hemisphere ozone level decreased by an average of 3% over the year. Winter levels fell the most over the region between 53—64 degrees north latitude declining by as much as 6.2%.

The panel reports that after 1985 there has been an increase in the northern hemisphere but depletion continues in the southern hemisphere. Basing its calculations on different models the panel found a maximum global depletion at around 40 km, varying from 5% to 12% for different models, with no change at 50 km.

The panel also noted that chlorine from CFCs was primarily responsible for the Antarctic ozone hole. The most generally favoured sequence of chemical reactions to explain the regeneration of chlorine atoms is the one suggested by Molina and Molina (*Journal of Physical Chemistry,* **91,** 433-436; 1987). The reaction involves the dimerization of ClO radicals at low temperature to form Cl_2O_2. This is broken down by UV light to regenerate chlorine atoms.

Besides, the panel felt, the ozone decrease could also be the result of a decrease in the sun's UV output in the course of the natural 11-year solar cycle. Ultraviolet radiation is not only shielded by ozone but also stimulates its production. So, for the period up to the next solar maximum as the sun brightens the increased UV radiation would lead to an increase in ozone. But after the solar maximum the decrease in ozone level is expected to continue with renewed vigour.

Hasan Jawaid Khan

Aluminium— the poorman's silver

ALUMINIUM was once considered the most precious of all the precious metals including gold and platinum. An aluminium vase was in fact presented as a precious gift to no less eminent a chemist than Mendeleev, the father of the periodic table in recognition of his great contribution. Everything in this world is relative. If a material is scarce, the demand is high and hence it becomes precious. Aluminium was precious before the present electrolytic method of its production was discovered.

There is also another interesting reference of an aluminium plate that was shown by a goldsmith to Emperor Tiberius in Rome. The plate was very light and almost as bright as silver and was said to be made out of plain clay. The Emperor instead of giving the goldsmith the expected reward, ordered him to be beheaded for fear that his treasure of gold and silver would lose its value if people started to produce this bright metal of clay.

Whether this story was true or not, it is a fact that it took almost 2000 years before method of producing aluminium in an inexpensive way was discovered. It was in 1886 that the American Charles Martin Hall and the French Paul Toussaint Heroult simultaneously brought out the commercial breakthrough in aluminium production.

That aluminium is the most abundant of the earth's crust (7%) is a fact. The production of aluminium has also witnessed a phenomenal growth starting from a mere 13 metric tonnes about a 100 years ago to the world production of 16 million tonnes in 1985. The consumption of aluminium has kept pace with such a huge production. There are about 3000 known applications of aluminium. However, in India the consumption of aluminium is far lower. Compared to the developed countries where the per capita consumption is about 22 kg, the per capita consumption of aluminium in India is about 0.4 kg. The scope for use of aluminium in a variety of applications is quite large and with the availability of large quantities of aluminium in India in the coming years, the use of aluminium is also expected to grow substantially.

The applications of aluminium are numerous. Utensils are one of the first known uses. In the Roman empire, royal guests were served with aluminium cutlery and plates while the common folks were served with silver plates. Today the applications are in widely varying fields like electronics, defence, food packaging, transportation and

architecture. The three major areas of growth for aluminium use are transportation, food and packaging and construction and general engineering.

Transportation

Aluminium is finding increasing application in buses, cars, scooters and aeroplanes. Aluminium has replaced sheet steel or wood in buses. Today a luxury bus weighs far less and uses aluminium for window frames, seat rests, flooring, channels, pipes, supports, etc. With an aluminium body the fuel saving is enormous at 2.7 litres per bus for 100 km. If trucks, cars and other vehicles switch over to aluminium wherever feasible, the savings would be a few thousand crores of rupees on the fuel. In addition, unlike mild steel; aluminium does not corrode and hence almost all the quantity of aluminium is available for resale when a bus is scrapped.

With the growth of the automobile sector the die casting industry is coming up very fast. Most of the scooter components like handle bars, crank case cover, magneto flange, etc., are all pressure die cast using aluminium and its alloys. Several of the components of passenger cars are also made of aluminium by pressure or gravity die casting. Pistons, cylinder heads and car wheels are a few examples. Latest application is the use of aluminium in car batteries. The battery developed by Alcan International in Canada is reported to have an aluminium anode and air cathode, the cells delivering about 500 watts of power. Use of such batteries helps save on oil consumption and reduce atmospheric pollution. Aluminium has a vast potential for replacing steel in railway wagons as well. The advantages are numerous. More pay load per train and lower energy costs are the major advantages besides the high scrap value.

Food, packaging and consumer durables industries

Aluminium is widely used in the food processing industry. It is so common as house hold utensils that it needs no special mention. The properties of aluminium foil are ideally suited for packaging applications. The use of aluminium foils in packaging and decoration has witnessed a spurt by the introduction of multiple laminates. The range is endless when one thinks of the various films like cellophane, polyester, etc. Tea, coffee, cigarettes, pharmaceuticals, biscuits, butter, cheeses and a variety of other items are neatly packed using aluminium foils. Food is served in the aeroplanes and now in trains in aluminium foil packs. These are disposable and are far more hygienic.

Fruit juices, cool drinks, beer, etc., are available in disposable aluminium cans in several of the advanced countries, although in India, this form of packing is yet to make a dent. Collapsible aluminium tubes are used in packing tooth paste, shaving creams and beauty creams. Aerosol cans are mostly made out of aluminium extruded tubes and a variety of sprays are available today starting from deodorants to pesticides.

Aluminium in the form of tubes has an equally wide range of applications. It can be found on the house tops as a TV Antenna, on the road side kiosks as beautifying railings, on the fields as irrigation tubes, as busbars in electrical industry, as cooling coils of heat exchangers, as missile tubes and shell casing in defence, etc.

Construction and general engineering

The use of aluminium as a building material is finding more and more applications. Corrugated aluminium sheets are used for roofing where reduced roof load and minimal maintenance are warranted. Doors made of aluminium are light weight, corrosion resistant, rot proof and termite proof. They also do not swell, split or warp. Aluminium window units are now widely used and are available in modular and non-modular sizes for residential, commercial and industrial types of construction. Aluminium sheets and strips can be used to manufacture air-ducts, louvers, gutters, windowsills, panels and prefabricated interior partitions.

Many kinds of rods, bars, pipes, flanges and fittings are possible in aluminium for decorative use. The fact that these aluminium components can be anodised, plated and colored adds to their decorative value. Aluminium is also available in powder and granular forms. Aluminium powder is used as a pigment in many types of paints for the protection of concrete, wood, etc.

Aluminium finds a very important application in the transmission and distribution lines for electrification. Although its conductivity is lower than that of copper, the fact that aluminium is 1/3rd as heavy as copper makes it cost effective as an electricity conductor both in overhead and underground cable systems. It is a natural progression for aluminium to be used as conductors in transformers.

Aluminium constitutes about 7% of the earth's crust and the earth is endowed with unlimited source of bauxite for the extraction of primary aluminium metal. However the production of aluminium is highly power intensive with about 40% of the cost of production accounted by electrical energy. High cost of power gave rise to a number of research studies over a period of time for reducing the energy consumption. The power requirement came down to about 13,500 kWh per tonne from the 40,000 kWh required at the beginning of the 20th century. The one major advantage with aluminium is that the scrap arisings can be recycled with negligible consumption of power and its excellent reuse potential in whatever form it is available unlike the mild steel or iron. Engineering plastics are posing a major threat to aluminium and other metals in a variety of applications, but aluminium is bound to find a place in the Indian households and the industry for many years more. Thanks to the bountiful bauxite deposits estimated at 2500 million tonnes ranking fourth largest in the world.

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Towards a glowing skin

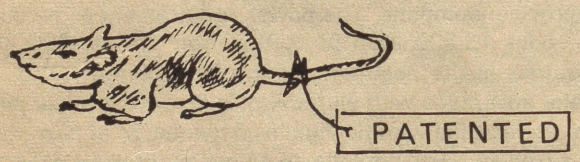
RETIN-A, a vitamin A derivative containing retinoic acid, has been used since the 1960s to treat acne. A recent study (*Journal of American Medical Association,* 22 January 1988) confirms the effectiveness of Retin-A in improving the skin. John Voorhees and his colleagues at the University of Michigan Medical Center conducted a 4-month trial on 30 subjects between ages 35 to 70. All 30 subjects showed marked improvement —fewer wrinkles and a "pink rosy glow".

However, a recent study (*Science,* February 1988) at the Center for Investigative Dermatology at Rockefeller University claims that Retin-A can cause dermatitis (redness and inflammation of the skin) and increased photosensitivity. It also has a word of caution against its long term effects.

Patented mouse

FOR the first time in the world a patent has been granted for an animal —a genetically altered mouse. The patent was awarded to Harvard University by the US Patent and Trademark Office based on the development in 1984, by Philip Leder and Timothy Stewart, of a mouse which readily expresses the myc oncogene and is extremely susceptible to the development of tumors.

The patent was granted on the basis of a 1980 US Supreme Court ruling that 'everything under the sun made by man' is eligible for a patent. The patenting has however sparked off a controversy over the ethical implications of designating inventors for higher life forms.



Stemming the rot

MICROBIOLOGISTS of a British firm are on their way to developing copper-rich fir trees that yield insect-and rot-proof timber that would last for ever (*Nature,* 31 March 1988). The everlasting timber is bound to slow down the felling of trees for the purpose of wood.

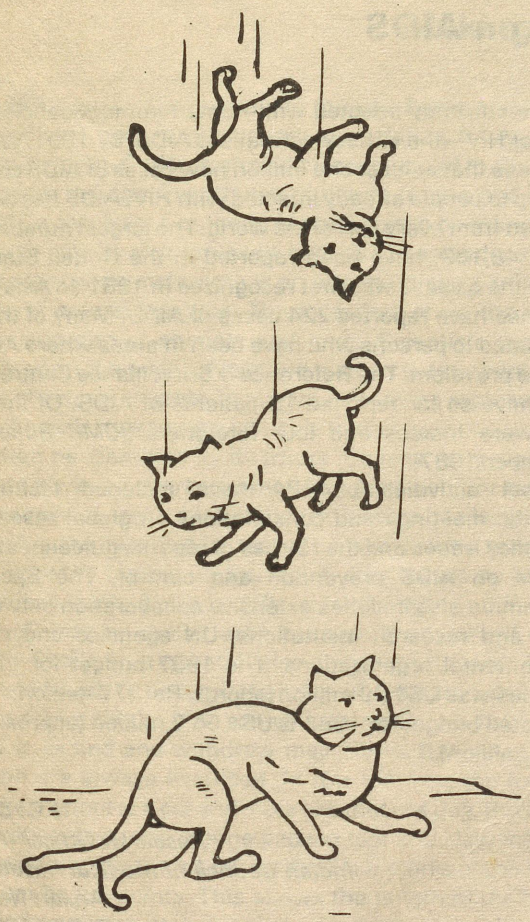
In fact, treating wood with compounds of copper is a standard method of preserving wood against insect and fungal attacks. But some plants have now evolved to flourish in metal-rich soils accumulating heavy metals in their tissues.

The microbiologists feel that this metal-accumulating ability can be established in big conifers by genetic engineering or selective breeding. The resulting copper-rich fir trees could easily grow in metal-polluted wastelands thus freeing more valuable land elsewhere.

Illegal parking to be a sticky business

ILLEGAL vehicle parking has assumed the proportion of a major traffic hazard. But now here's a pitiless solution to combat this menace. Chemists of a British firm, DREADCO, propose a sticky glue for use against illegal parkers (*Nature,* 17 March 1988). Based on anaerobic glues which set solid in the absence of oxygen, the chemists are devising a thick, resilient and slightly tacky version of such a glue for use as a road surface.

Lawfully moving traffic has nothing to fear from this glue. In fact, its slight tack enhances road grip and inhibits skidding. But the moment a vehicle is parked illegally, it cuts off air from the glue beneath its tyres. The glue sets and the owner on returning finds his vehicle glued to the spot.



Fall of the cats

A unique study on cat-falls seems to have found the old adage, that 'cats have nine lives', to be not far from the truth. The study (*Journal of American Veterinary Medical Association,* **191,** 1399-1403: 1987) was done by two veterinarians in New York City, W.O. Whitney and C.J. Mehloff. Obviously aided by the numerous skyscrapers and the prevalent habit of keeping cats as pets, they studied 132 cat falls. Most victims landed on concrete after a free fall from 2 or more storeys with a maximum of 32 storeys (1 storey = 5m)

17 cats were euthanatized by owners unable to afford treatment. Of the remaining 115 cats, 104 survived while 11 died. Suprisingly, the incidence of injuries as well as mortality peaked for falls around 7 storeys and decreased for falls from greater heights. For instance, a cat that free-fell 32 storeys was released after just 2 days with nothing more than a chipped tooth and mild pneumothorax!

Reversing alcohol-induced memory loss

A group of scientists at the Institute of Psychiatry, London have managed to reverse alcohol-induced memory losses in rats (*Nature,* 31 March 1988). They transplanted cholinergic-rich fetal-brain cell suspensions into the brain of alcohol-treated rats. Memory losses produced by alcohol intake were found to be reversed by the transplants

The scientists are now looking into the possibility of extending this technique to human beings.

Checking the chicken

THE killer bacteria Salmonella often thrive in inadequately cooked chicken and cause an extreme form of food poisoning. Existing laboratory tests take from 18 hours to 5 days. But now a simple over-the-counter test developed by Robert Hird, a California microbiologist gives a result in just 15 minutes! Called Chik Chek the cheap and reliable test (*Discover*, October 1987) also works on beef, pork, dairy products and eggs.

The kit contains several swabs and two chemicals. A swab is dipped in juices from poultry or other foods. One of the chemicals which breaks down in the presence of the bacterial enzyme is added to the swab. After 10 minutes the second chemical is added. If the swab turns purple, harmful bacteria are present. If it remains colorless or slightly yellow, food is safe.

Hasan Jawaid Khan

Global programme on AIDS

THE acquired immune deficiency syndrome (AIDS) pandemic poses serious questions for public health worldwide. Despite considerable research, a vaccine may be farther away than was thought a year ago. In addition, a cure for AIDS is still lacking. In the absence of a vaccine, or effective, curative treatment, education and information on how to avoid AIDS remains the key to controlling its spread. To fight against this dreaded disease, the World Health Organization (WHO) had launched its Special Programme on AIDS (SPA) on February 1, 1987. This programme is now called the "Global Programme on AIDS". The goals of SPA were to (i) prevent AIDS virus transmission; (ii) care for AIDS virus-infected people; and (iii) unify national and international efforts against AIDS. The global strategy of the Special Programme on AIDS has since been endorsed by the World Health Assembly, the United Nations General Assembly and the Economic and Social Council of the United Nations.

By 1st January 1988, SPA had received requests for collaboration from 132 countries. Initial support of national AIDS programmes has been carried out in 109 countries and more are scheduled. In concert with SPA, 70 countries have completed short-term plans of 6-12 month duration and 26 countries have completed medium-term plans of 3-5 years. National AIDS Committees have been established in more than 150 countries.

Till 1st January 1988, 73,747 AIDS cases had been officially reported to the WHO from 129 countries. WHO estimates that between 5 million and 10 million persons may be currently infected with human immunodeficiency virus, or HIV—the virus which causes AIDS. By 1991, WHO estimates that at least one million new cases of AIDS could develop in people already infected with HIV. AIDS has been reported from every part of the world. The largest number of cases, 48,139, have been reported in the United States, where the disease was first recognized in 1981. In Asia, 19 countries have reported 224 cases of AIDS. Many of them are related to persons who have been in areas where AIDS is more prevalent. The Reference /Surveillance Centres in India have so far reported 13 patients of AIDS. Of these, nine were Indians and four foreigners (*ICMR Bulletin*, December 1987).

Global activities of SPA have included technical scientific meetings and consultations on global research and policy issues and the release of reports, guidelines and articles on AIDS prevention and control. The Special Programme also includes extensive collaboration between WHO and research institutions, UN agencies and non-governmental organizations. The 1987 budget for these activities was US$ 29 million (approx. Rs. 377 million). The estimated budget for 1988 is US$ 66.2 million (approx. Rs. 860.6 million).

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Workshop on pollution control in thermal power stations

THE Central Power Research Institute (CPRI), Bangalore, is a national power research organization engaged in research and development programmes related to all aspects of power generation, transmission and distribution. The institute is currently active in studies on operational problems including the environmental pollution aspects of thermal power stations in the country. In India by the turn of the century, more than 70,000 MW of thermal power will be generated using high ash content coal (about 50%). The environmental pollution due to thermal power generation will increase beyond acceptable limits unless stringent measures based on Environmental Protection Act, 1986 are strictly enforced. Hence, pollution control in operating plants has become mandatory and the need to monitor and control the power plant pollutants like particulate matter, SO_2, NO_x,CO and hydrocarbons besides water pollutants has become imperative and an integral part of present day power plant operation technology. The present workshop to be held on 17 & 18 November 1988 in the Institute is a step forward in bringing awareness in this direction. The topics covered are: (a) Power Plant Siting; (b) Environmental Impact Assessment; (c) Pollution Monitoring & Control; and (d) Emerging Technologies for Pollution Control.

All communications to: Dr P.R. Krishnamoorthy, Joint Director,Materials Technology Division, Central Power Research Institute, P.B. No.1242, Bangalore-560012.

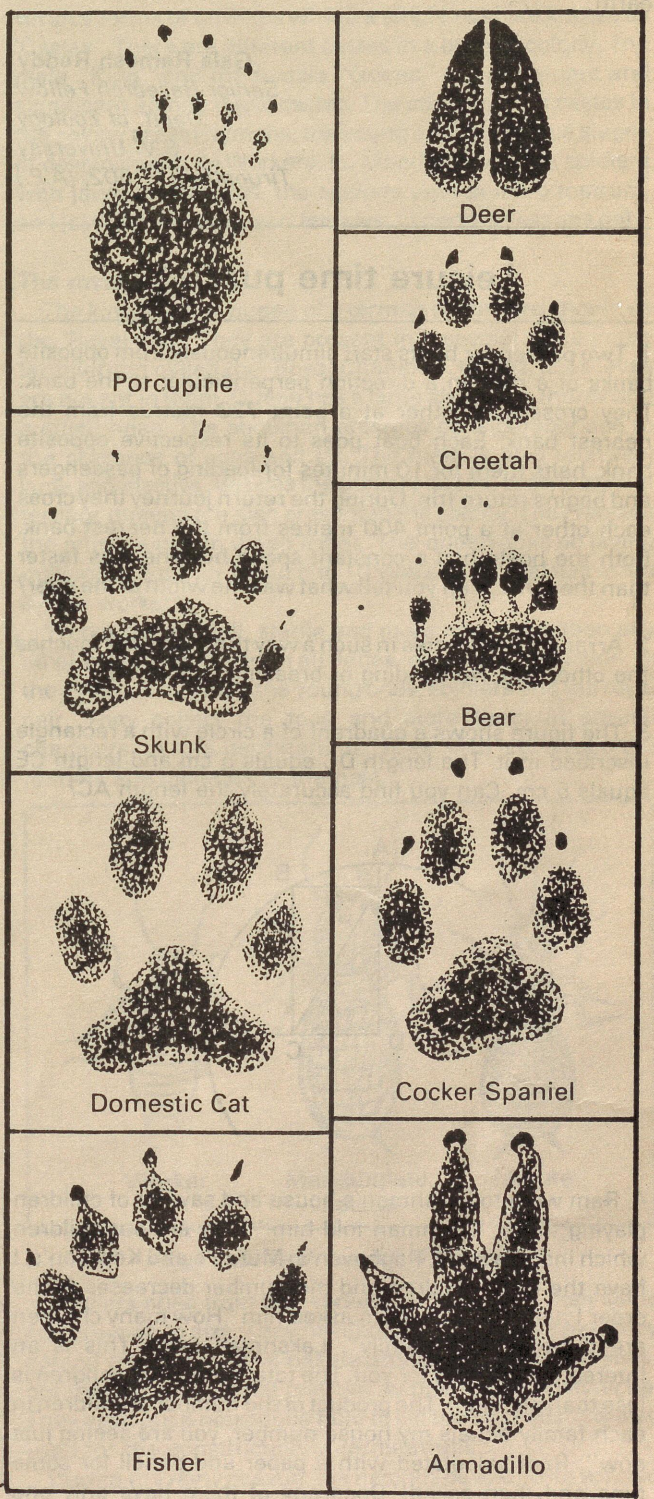
Making animal tracks

MERE exposure to animal life through books and films will not help in cultivating appreciation for wildlife among children. Children should be encouraged to observe their surroundings. Importance of nature, fauna and flora should be inculcated in them. Making tracks of animals is one such activity that can serve both as fun and education.

The story of animal tracks is an important chapter in the history of animal kingdom. The footprints show the kind, nature and size of animals and birds. Scientists depend heavily upon the study of feet and teeth in determining the habits of extinct animals. In many cases, living representatives of fossils may furnish valuable information. An animal can often be identified by its tracks. Usually, long slender legs are always a characteristic of animals built for speed. For example, a deer which stands on its toes has long legs. Its hoof is the two middle toes. The two outside toes are small growths farther up the leg. A deer leaves an easily recognised track. But it is difficult to distinguish different kinds of deer by their tracks because they are all very similar. Similarly, a cheetah also stands on its toes. They later add length to its legs. The track of a cheetah shows a soft pad and claws. It is known that most cats have the ability to extend and withdraw their claws. But claws of a cheetah are always extended. In this manner, the foot is less like the foot of a cat and more like that of a dog. But bear prints show five toes, a large padded foot and claw marks. Observe from the track how far the claw marks of the bear are from its toe points. This shows the length of the front claws. Sometimes, only four toes are seen on bear tracks. Often, the small inside toe leaves no mark unless the prints are deep. For making tracks of animals, some materials are required, viz., newspaper, black soil (not potting soil or red clay), two disposable aluminium pie pans, a drawing paper, scissors, Plaster of Paris, a measuring cup and a large container.

First spread the newspaper on the desk or on a table top. Then fill one of the pie pans with soil. Add water a little at a time. Work the mud until it feels like modelling clay. Spread the mud evenly in the pan and use another pie pan to flatten the mud with finger and smooth the surface of the mud. Set the mud pie pan aside for some time. Now, decide which animal track is to be cast. Draw the track on the drawing paper. Cut out the track. Be sure to cut out each toe or claw mark separately. Number these marks so that the track can be correctly arranged later.

Then, again, spread the newspaper on a desk or table top. Take the mud pie made previously and place the animal track in the centre of the mud pie. Using a sharp pencil, trace the track in the mud. Remove the paper track and press the track design one or two centimeters into the mud using fingers, a pencil or a stick. Mix the Plaster of Paris in a large container. Add three parts of plaster to two parts of water and stir quickly. As soon as the plaster is wet, pour it



into the track in the mud. While the plaster is drying, write the name of the animal on the track. The tracks of animals and birds tell us the history of their ancestors, the kinds of birds and animals that lived then, and clues about the age of earth.

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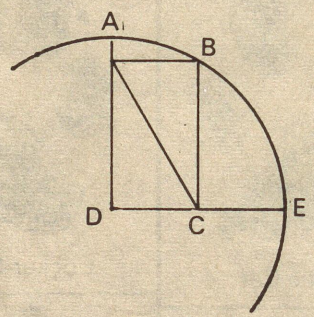
Leisure time puzzles

1. Two passenger boats start simultaneously from opposite banks of a river in a direction perpendicular to the bank. They cross each other at a point 720 metres from the nearest bank. Each boat goes to its respective opposite bank, halts there for 10 minutes for loading of passengers and begins return trip. During the return journey they cross each other at a point 400 metres from the nearest bank. Both the boats had a constant speed but one was faster than the other. Can you tell what was the width of the river?

2. Arrange 6 cigarettes in such a way that each one touches the other five. No bending or breaking is allowed.

3. The figure shows a quadrant of a circle with a rectangle inscribed in it. The length DC equals 5 cm and length CE equals 5 cm. Can you find accurately the length AC?



4. Ram went to Lakshman's house and saw lot of children playing there. Lakshman told him "They are our children which include mine, Raghavan's, Murali's and Kesavan's. I have the most children and the number decreases in the order I just told you". Ram asked him "How many children are there in each family". Lakshman said "This is an interesting problem for you. The total number of children is less than eighteen. The product of the number of children in each family equals my house number, you are seeing just now". Ram calculated with a paper and pencil for some time and then asked "Does any of them have only one child"? Lakshman said, no, Ram was able to tell the correct answer immediately. Can you figure out now the number of children each family had?

5. A king ordered 100 gold coins each (1 gold coin contains 10 grams of gold) from 10 goldsmiths. All the ten delivered the goods but one goldsmith cheated and put only 9 grams instead of ten in each gold coin. The king came to know of this but did not know which one cheated. He wanted to catch the culprit red-handed. One way of doing this could be to weigh all the 10 samples and find out the offender. But the king was a clever man. He caught the culprit in a single weighing using a 1 kilogram balance with an accuracy of one gram. Can you find out how?

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Science quiz

1. In cold countries glycerol is added to water in car radiators as it helps to:
   (a) Lower the specific heat of water
   (b) Lower the viscosity of water
   (c) Lower the freezing point of water
   (d) Improve the lubricity
2. The steroid-like vitamin formed in the body on its exposure to sunlight is:
   (a) Vitamin E
   (b) Vitamin D
   (c) Vitamin K
   (d) Vitamin A
3. The ultrasound that bats produce can be as high as:
   (a) 200000 cycles per seond
   (b) 20000 cycles per second
   (c) 50000 cycles per seond
   (d) 80000 cycles per seond
4. Which of the following substances is used as a refrigerant in refrigerators?
   (a) Chloroform
   (b) Carbon disulfide
   (c) Liquid nitrogen
   (d) Dichlorofluoromethane
5. The nylon stockings are extremely popular among ladies because the fabric:
   (a) Does not form a bead on burning
   (b) Does not retain the original shape after use
   (c) Has drip-dry properties and flexibility
   (d) Has silky feel
6. The first known superconductor is:
   (a) Niobium
   (b) Mercury
   (c) Lead
   (d) Gold

7. Of the following scientists who was not awarded the Nobel Prize twice:
   (a) Madam Curie
   (b) Linus Pauling
   (c) John Bardeen
   (d) Albert Einstein
8. Which of the following is not a pesticide:
   (a) D.D.T.
   (b) Benzene hexachloride
   (c) Urea
   (d) Aldrin
9. Safflower oil is recommended because it is rich in:
   (a) Free fatty acids
   (b) Saturated fatty acids
   (c) Polyunsaturated fatty acids
   (d) Vitamins A and D

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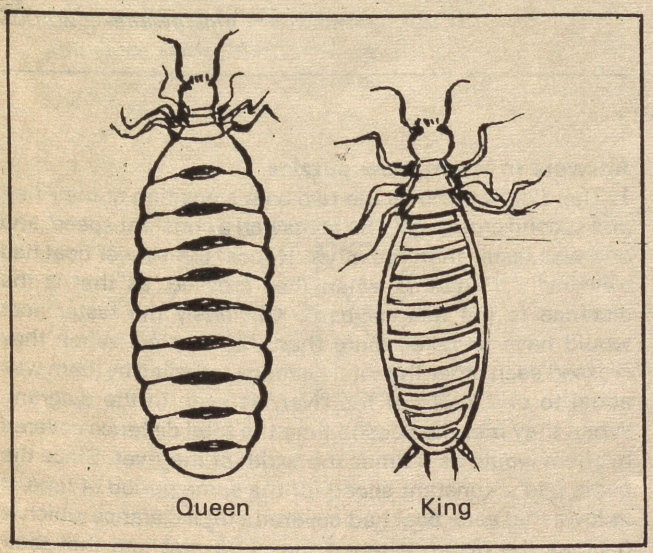
Termites—the animal architects

TERMITES are popularly known as the 'White ants'. They belong to the group 'Isoptera' of the Insect world. They usually live inside the mounds of soil called 'termite hills' or 'termitaria'. The excellent skills they exhibit in the construction of termitaria, forming well organised new colonies and leading a disciplined social life are exemplary to the whole animal world.

Though they cause heavy damage to wooden furniture, clothes, books, plants, crops, etc. they play an important role in the ecosystem. They demineralise organic wastes, convert waste plant material into humus and enrich the soil fertility. On the other hand, they become food to a variety of animals like birds, reptiles, anteaters, mammals and even to man.



Termites are polymorphic in that they occur in different forms having structural and functional differences. The various forms of termites within a single nest are known as 'Castes'. There are different castes in a termite colony. The male "King" and the female "Queen" are prominent and significant among these castes. The other types of castes in the colony are (a) Nymphs, the young ones at various stages of development, (b) Workers, (c) Mandibulates, the soldiers with jaws, (d) Nasutes, the soldiers with pointed rostrum, and (e) Winged males and females, in certain seasons only.

The royal pair

The king and the queen of a termite colony are known as the 'Royal pair'. They are present in a special place in the termitarium called the 'Royal Chamber'. Wings, jaws, eyes are absent in them. Queen has a large abdomen, thorax and a small head. The abdomen enlarges considerably due to the presence of eggs and fat. The male is also relatively large and inactive. Besides the primary queen, secondary and tertiary queens are also present in the colony. They replace the primary queen when it dies. The queen goes on laying millions of eggs for about 6 to 10 years. The royal pair is fed by the workers.

Workers are small, sterile and more numerous than any other caste. They perform all duties, except reproduction, in the colony. They feed the young ones, soldiers and the royal pair. They collect the food and store them in special chambers in the termitarium. They also construct the tunnels and galleries in the nest.

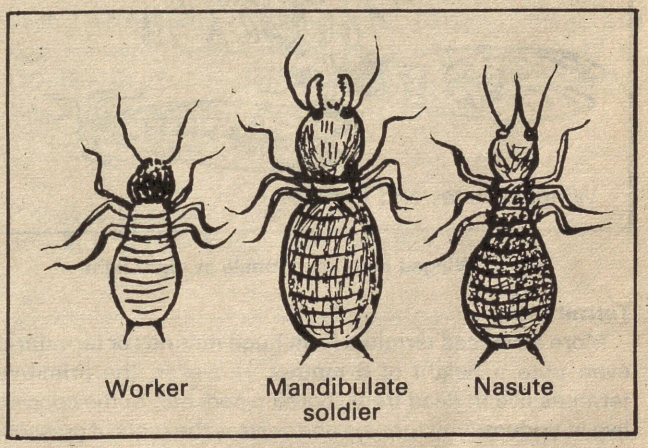


Fig. 1. Different castes of termites

Soldiers arise from the workers by casting off their skins and growing in size. They have toothed jaws and eyes. They defend the colony. The nasute soldiers do not have jaws, but they have a 'frontal rostrum' with an opening at its tip. They eject out a poisonous fluid to kill the enemies. It is also used for the construction of termitarium.

During the rainy season, the nymphs develop into winged males and females which come out of the colony during

night time. They are found flying near the street lights and other places. The two pairs of wings are of equal size and extend beyond the abdomen. There is a weak spot at the base of these wings to shed them easily. The grouping of the winged males and females near the lights at night is known as 'nuptial flight' or 'swarming'. They lose their wings and fall to the ground. Most of them become a prey to other animals. The surviving couples dig up the soil, form a nuptial chamber, mate and gradually develop a new colony.

. Termites feed on wood, parts of living and dead plants, plant derivatives like paper, clothes, etc. Plant material consists of cellulose which termites cannot digest. Therefore, they depend on protozoan 'Trichonympha present in their intestine. Trichonympha digests cellulose with the help of an enzyme, cellulase. The protozoan, in turn, gets the shelter and food in the intestine of the termites. So, a kind of 'symbiosis' exists between the termites and the Trichonympha. The hard, labouring workers also feed on the cast off skins, dead animals, their own faecal matter,and of other individuals. They transfer the Trichonympha into the mouths of other castes while feeding them. The royal pair are given a special share of food.

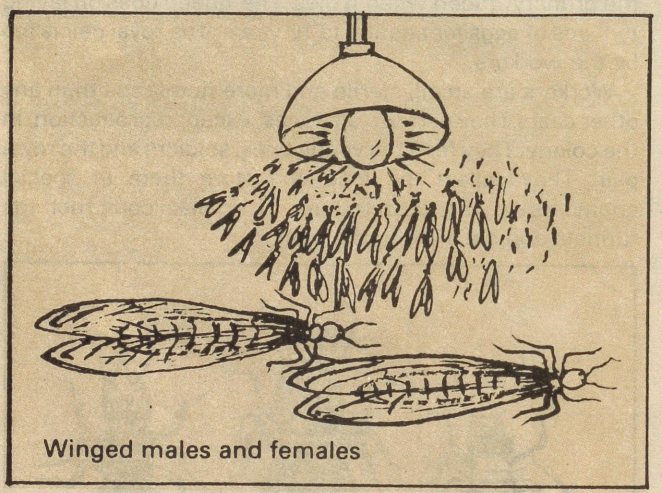


Fig. 2. Winged male and female at night light

Termitarium

More advanced termites form huge mounds or termitaria even upto a height of 6 metres. However, the primitive termites live in dead trees, bored wood, etc. Some species live in undergound tunnels and destroy the roots of grasses, vegetation and crops.

The termitarium is constructed mainly by the workers by using excavated mud, wood and excreta mixed with their saliva. The nasute soldiers also mix their frontal gland secretions with the mud and other materials. The walls of termitarium so formed become as hard as cement. In the termitarium, there is a special chamber, the 'Royal Chamber', for the king and the queen. There are also galleries for other castes, chambers for storing food and culturing fungus gardens. All these chambers are

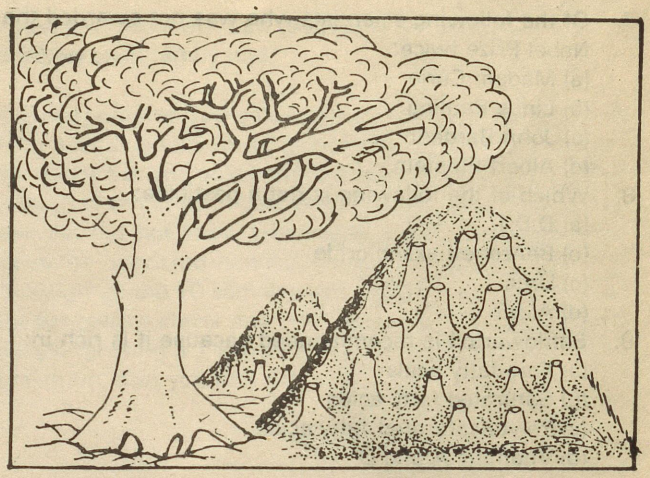


Fig. 3. Termitarium

connected with each other through a network of passages. For ventilation many openings are left in the outer walls. The temperature and humidity inside the chambers is maintained constant with the help of fungi. The workers remove excreta and the dead ones by feeding on them. Very good sanitary conditions are therefore maintained.

If man can forget the harmful effects of termites, he would appreciate their architectural talents and their fascinating civilization. In fact, the civilization in termites is the earliest of all animal groups. It is very curious, most complex and most intelligent social order to appear on the globe. From several points of view this civilization of termites though fierce, sinister and repulsive, is superior to that of bees, of ants and even that of man himself!

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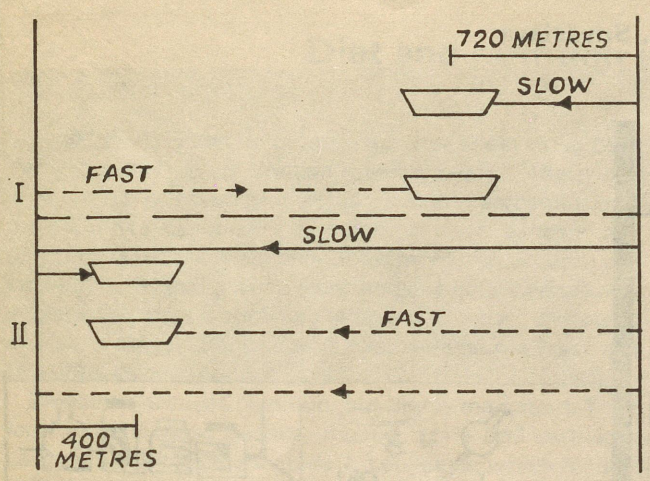
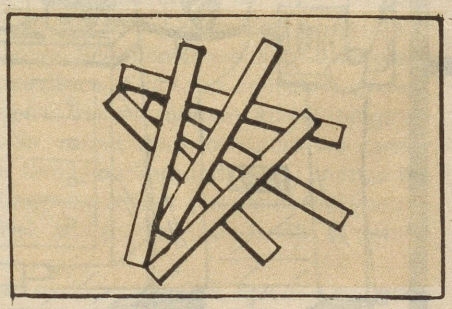
Answers to leisure time puzzles

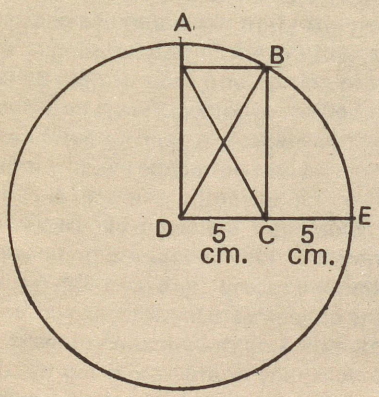
1. The diagram shows the two boat's position at their first and second crossings. The boats had a constant speed, and one was faster than the other. Hence, the slower boat had travelled 720 metres when they crossed, as that is the distance to the nearest bank. Obviously the faster boat would have travelled more than 720 metres. When they crossed each other the total distance travelled by them was equal to one width of the river, as seen in the diagram. When they met the second time the total distance covered by them would be 3 times the width of the river. Since the boats had a constant speed for the same period of time, it follows that each boat had covered a total distance which is 3 times the distance when they first met and that their combined distance equals 3 widths of the river. Hence the



slower boat would have covered 3 ×720=2160 metres, when it met the other boat the second time. This distance is 400 metres more than one crossing of the river as seen in the diagram. Hence the width equals 2160—400=1760 metres. The problem can also be solved by using X for distance and equating the time taken.



3. Since A C = DB in the rectangle ABCD
and since DB = DC+CE =10 cm
(Radius)
A C = 10 cm



4. As the sum of the number of children Lakshman and others had was less than 18, and as it was in descending order for Lakshman, Raghavan, Murali and Kesavan, it can be

4	3	2	1
5	4	3	2
5	3	2	1
6	5	4	1
8	5	3	1

or various other combinations which will satisfy the condition of 17 or less.

As even after knowing the house number Ram could not decide means there are two or more combinations having the same product.

They are Product
8x5x3x1 — (a) = 120
6x5x4x1 — (b) = 120
5x4x3x2 — (c) = 120

Now the second question is meaningful. For Ram's second question, Lakshman said no. That means Kesavan had 2 children. Hence (c) is the unique answer.

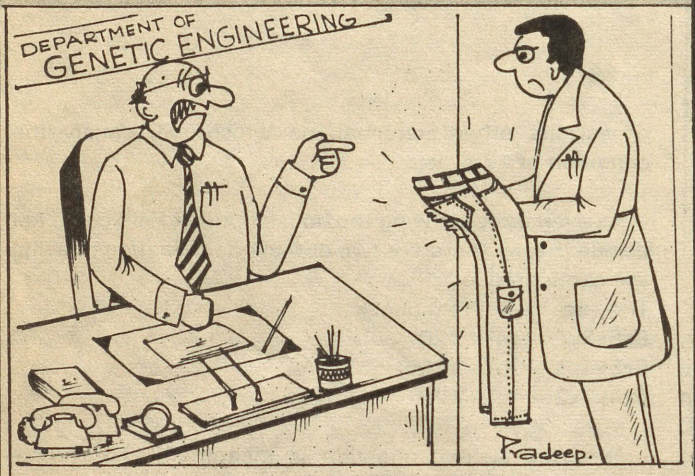
5. The king labelled the 10 bags containing 100 gold coins each as 1, 2, 3, ..., 10. He took 1 coin from bag No. 1, 2 coins from bag No.2 and so on and weighed them together in a single weighing. The difference between 550 and the weight obtained gives the number of the bag containing the lighter coins. For example, if all gold coins had 10 grams each it would weigh (10+20+...+100)=550 gm. If the second bag contains the offending coins, the total would be (10+18+30+...+100) =548. Hence 550—548 = 2 is the bag No., that contained the underweight coins.

Answers to science quiz

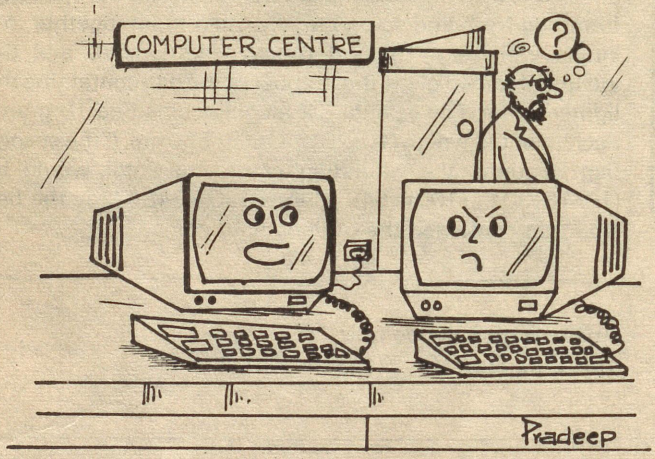
1(c), 2(d), 3(a), 4(d), 5(c), 6(b), 7(d), 8(c), 9(c)

CARTOONS

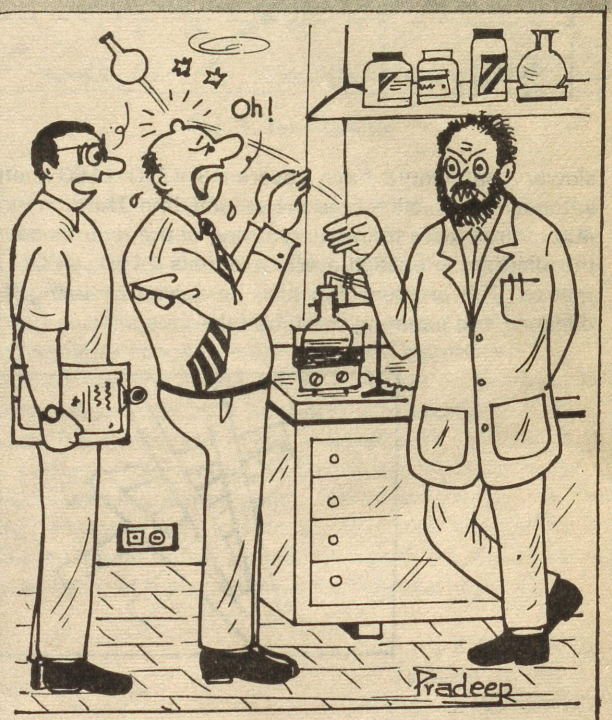
By Pradeep K. Srivastava



"My God! So, this is one of the new GENES you developed after one year of dedicated research!"



"I always remember the soft touch of that young girl, who used to operate me."



"Sorry Sir! He became so much devoted and dedicated to develop this new drug for schizophrenia that he himself has become schizophrenic."

Diet and nutrition in cancer prevention

CANCER is a family of diseases that seem to be best characterised as "uncontrolled growth". There are three basic types of cancer; carcinomas, sarcomas and leukemia-like cancers. The most common cancers are carcinomas, which are malignant tumors that occur in the epithelial cells that cover tissues and line body cavities and in glandular organs such as the breast. Cancers of mouth, stomach, lungs, prostate and gastro-intestinal tract are classified as carcinomas.

Sarcomas are less common, but highly malignant. They form in connective tissues, muscle, bone and cartilage. Leukemia-like cancers include 1. Leukemia, which results from the over-production of white blood cells, followed by their underproduction; 2. Lymphomas, tumors in the lymphoid tissues which cause the over-production of lymphoid cells (cells found in bone marrows from which all blood cells are thought to arise); and 3. Multiple myeloma, a bone-marrow tumor, which is the rarest form of cancer, that causes the over-production of plasma cells. An adult who has cancer will most often have a carcinoma, while young children most often have leukemia.

There are things you can do to help protect yourself and your family from cancer. Scientists have discovered many factors that can cause cancer. Eighty per cent of all cancers, in fact, may be related to the environment and to things we eat, drink and smoke, rather than to factors we cannot control such as our family background. If you change the things you can control, there is strong evidence that you can reduce your own risk and that of your family of getting cancer.

A healthy body can overcome cancer just as it can ward off cancer. There have been many experiments that demonstrate the role of vitamins and minerals in protecting body cells against agents that cause cancer and in stimulating immune response to destroy cancers.

Cigarette smoking, of course, is known to increase the risk of cancer. But research suggests that a diet low in fibre and high in fat with few fresh fruits, vegetables or whole-grain breads and cereals increases the risk of certain cancers. It has been estimated that thirty-five per cent of all cancer deaths may be related to the way we eat. On the other hand, diets high in fibre (the portion of vegetables, fruits, and grains that is not digested by the body) and low in fat, with plenty of fresh fruits, vegetables and whole-grain breads and cereals may reduce the risk of cancer.

Dietary fibre is material from plant cells that is nondigestible or partially digestible. Vegetables, fruits and whole-grain products contain several different types of fibre which may differ in their protective actions. Fibre helps move food quickly through the intestine and out of the body. It helps prevent constipation and promote a healthy digestive tract. To get more fibre in your diet, eat several servings of fibre-rich foods: fruits, vegetables, peas and beans, and breads and cereals made from whole-grains. The skins of fruits and vegetables are high in dietary fibre. You can add more fibre to your diet if you eat foods like potatoes, apples, pears and peaches with their skins on.

Eating too much fat (both saturated and unsaturated) may increase the chances of getting cancers of colon, breast, prostate and endometrium (the lining of the uterus). Reducing fat in your diet may reduce your cancer risk. It also can help control your weight (obesity is another cancer risk factor) and can reduce the risk of heart attacks and strokes. Vegetables of the cabbage family (e.g., cauliflower, cabbage, turnips, etc.) may reduce the risk of cancer of colon. Cruciferous vegetables are a good source of fibre and certain vitamins and minerals.

Scientists have discovered that diets rich in vitamins such as vitamin A and C are associated with reduced risk for certain cancers. Some research findings have linked diets high in vitamin C with reduced risk of stomach and esophagus, and diet low in vitamin A with increased risk of cancers of lung, bladder, and larynx. Although calcium, iron and zinc are not associated with reduced risk of cancer, a balanced diet should provide calcium sources, such as dairy products, and iron and zinc sources, such as dark green vegetables and meat.

Aflatoxins are naturally occurring poisons that are caused by certain molds of some foods, particularly nuts, grains and seeds. Laboratory studies have shown that aflatoxins cause liver cancer in animals and may be linked to cancers of stomach, liver and kidney in humans. This risk can be reduced by keeping nuts, grains and seeds in dry, sealed containers. If such foods become moldy, throw them away.

Heavy drinking of alcoholic beverages, particularly when combined with cigarette smoking, increases the risk of cancers of the mouth, pharynx, larynx, esophagus, liver and bladder.

Some cooking methods, such as cooking on wood stove, are harmful, because smoke from such stoves contains carcinogens (cancer-causing substances such as poly-nuclear aromatic hydrocarbons). One way to guard against them is to use a good coke burning stove which does not emit smoke. Frying at high temperature is also not good; it forms what is known as Maillard product by the reaction between amino acids and sugars (called Maillard reaction). The Maillard product is known to be mutagenic (i.e., it causes genetic damage).

Animal experiments have shown that nuclear radiation and X-rays can increase cancer incidence and mimic the aspect of aging. Strong doses cause whole-cell destruction leading to radiation sickness and death. Free radicals initiated by radiation can do damage that leads to cancer or, by disrupting lysosomal membranes, destroy cells and thus

(Contd. on p. 412)

Noise and its effects

NO one can escape the unwanted sound, called "noise", which has been escalating so rapidly in our environment that it is fast becoming one of the major threats to the quality of human life. Slowly, insensibly, man seems to have accepted noise and the physiological and psychological deterioration that accompanies it as an inevitable part of his life. The problem knows no political or social frontiers. It affects the rich who sleep in a quiet suburb, and travel by plane or cruise by luxury liners, just as much as the poor who invariably live next to a highway or railway or near an airport runway. Because noise does not pose as obvious and immediate a danger to health as polluted water or air, public awareness of noise and public commitment to noise reduction have been modest. However, the annoyance, frustration, impedance to learning and general stress caused by noise pollution may all have considerable effects on future generations.

Let us first examine the various aspects of noise and its measurement. Basically, noise is a complex sound with little or no periodicity and psychologically an undesirable sound for the recipient. Sound is produced by the vibration of bodies or molecules of the medium and propagates as a pressure perturbation. Two physical properties which control the pressure perturbation are its density and elasticity. Intensity and frequency are the two most important parameters which characterize a particular sound. The frequency of sound represents the number of pressure variations per second and is measured in the units of Hertz (Hz). The audible frequency range is from 20 Hz to 20 kHz approximately. If the noise consists of a single frequency sound wave, it is known as a pure tone. If it is composed of a wide mixture of sound waves of different frequencies, it is known as broad band noise. If the noise has frequencies randomly distributed throughout the audible range, it is called white noise. The intensity is a measure of energy flow per unit area and can be specified in terms of the magnitude of the pressure variations associated with the sound. It is proportional to the mean square of the sound pressure. Sound pressure is usually measured in Pascals (Pa).

The magnitude of sound as perceived by ear is defined as loudness. It is a function of both intensity and frequency. The minimum audible sound pressure is 20 Pa at 1 kHz and the maximum 100 Pa. The perceived loudness of a sound depends on several parameters. One of the factors is that the ear is not equally sensitive to all frequencies in the audio range. It is most sensitive between 2 kHz—5 kHz and less sensitive to higher and lower frequencies. Also, the difference in sensitivities is more pronounced at low sound pressure levels than at high pressure levels.

The measurement of noise levels is usually made on logarithmic scale in terms of intensity or sound pressure level. The unit is decibel (dB). Decibel is a ratio of intensities to a reference intensity expressed on logarithmic scale. The logarithmic scale has been chosen for the measurement of sound levels in preference to linear scale because: (i) It allows very large ratio of intensities or pressure levels to be expressed in convenient small units; and (ii) Within limits the response of the ear to variations in sound intensities is also logarithmic.

Many of the effects of noise are level-dependent, that is, the magnitude of the effect varies with the level of noise. One convenient scale for expressing the magnitude of noise is the 'A' decibel scale. This is a physical scale that was designed to approximate human frequency sensitivity by a weighing procedure which gives relative emphasis to the components of sound in the mid- and high-frequency range (500 Hz—4000 Hz). The unit of measurement is dB (A). Some representative values of A-weighted sound levels for common sounds are given in Table 1.

Table 1. Typical sound levels and their effects

Threshold of normal hearing	0 dB (Theoretical) 20 dB (Normal)
Normal conservation	50—60 dB
Speech Interference	75 dB
Annoyance /Irritation	80 dB
Motor activity is disturbed	90 dB
Physiological disturbances	120 dB

Effects of noise pollution

Almost every one has had the experience of being temporarily 'deafened' by a loud noise. This 'deafness' is not total and normal hearing returns within a few hours at the most. However, continued daily exposure to noise over a period of years can cause loss of hearing which may vary from partial to complete. Greater efforts must be devoted to evaluate the relationship between noise exposure and hearing loss, particularly in the context of establishing reliable damage /risk criteria for noise exposure. Such criteria may take the form of standards. Table 2 shows the permissible exposure level of sound.

High-noise levels have a number of extra-auditive effects. Irregular noise is particularly disturbing to sleep. Aged people, the sick and those afflicted with psychic disturbances, as well as children between four and six years old, are very sensitive to noise and could easily be disturbed during sleep by excessive noise. Sudden and unexpected noise has been observed to produce marked changes in the body such as increased blood pressure,

Table 2. Recommended limitation on exposure to noise

Duration per day (Hours)	*Sound level dB (A)*
8	90
6	92
4	95
3	97
2	100
1 ½	102
1	105
¾	107
½	110
¼	115

dB=decibel, a unit to measure sound pressure level, dB (A) for weighted sound level

increased heart beat rate and muscular contractions. Moreover, digestion, stomach contractions and the flow of saliva and gastric juices are also affected. Cardio-vascular as well as ear-nose-throat (ENT) disorders have been reported in subjects exposed to high levels of noise. Noise not only threatens health but can also impair the efficiency of work. Noise has psychological effects as well. Irritability, tenseness, moodiness, insomnia and fear are some of the psychological effects observed at high levels of noise.

Of all present day sources, surface transportation is the most pervasive source of noise pollution and is likely to become worse as the number of vehicles increases. Studies conducted at some of the Indian metropolitan cities indicate that vehicular noise is of the order of 70 dB—90 dB. Social noise varies from 105 dB to 120 dB during cricket matches, festivals and marriages. The results showed that daytime city noises varied from 60 dB in quiet localities to 95 dB in congested busy localities with peaks reaching upto 110 dB. Even at night, the noise levels varied from 50 dB in quiet localities to 90 dB in busy localities. It has also been found that around 10% of police constables developed hearing problems due to traffic noise.

Technologically, noise reduction can be achieved at different points: at the source, by technicaly modifying the machine or by introducing 'damping' devices; between the source and receiver by the use of ear plugs or muffs. New engineering techniques to reduce noise at the source will take time. Nevertheless, it is still possible to control noise to a large extent through town planning and zoning of new colonies and through restriction on the use of loudspeakers, automobile horns, silencerless vehicles, bursting of crackers and operation of television, radio, etc., at high volume. Other measures which can be adopted to segregate noisy areas from residential colonies are the building of barriers on both sides of the highways, growing of forests in between the highway and residential areas, reducing traffic density at residential areas, etc. Studies revealed that trees such as casuarina and neem can also attenuate noise upto 10 dB. Planting of such trees around industrial complexes and highways will reduce noise upto a certain extent. Noise pollution can also be controlled by legal enactment and punitive measures. However, the acceptance and effectiveness of all these measures depends on public awareness of the detrimental effects of noise and on public cooperation.

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High temperature superconductors for microelectronics

THE superconducting temperature frequently observed in $Y_1Ba_2Cu_3O_{7-8}$ (generally referred to as the 1,2,3 compound) is 90°K. Efforts in the laboratories all over the world are concentrated on enhancing the Tc in bulk material and obtaining thin superconducting films of this material for microelectronics applications. The Central Electronics Engineering Research Institute, Pilani, is also concentrating its efforts in this direction.

CEERI incorporated fluorine in the 1,2,3 compound by ion-implanation techniques and observed superconductivity transition at 300°K. A resistance drop of about 30 times (from 300 milliohms to 24.5 milliohms) at 300°K was measured in the fluorinated sample. The zero resistance in the sample was observed at 89°K. Processing at CEERI resulted in improvement of T_c up to 97°K in $Y_1Ba_2Cu_3O_{7-6}$

CEERI has succeeded in fabricating thick superconducting films on oxidized silicon. Superconducting powder of the 1,2,3, compound was prepared and mixed in an organic liquid to obtain a viscous paste. It was then painted on oxidized silicon and subsequently annealed to obtain superconductivity in the film (the film thickness was 50 microns).

The efforts of CEERI are directed towards eliminating the use of chemical techniques to achieve superconductivity at room temperature. Ion-implantation which was used as a substitute was found to be quite promising for generating selectively the high T_C superconducting regions using conventional photolithographic techniques. This would be useful for making semiconductor-based superconducting devices.

New process for manganese ore reduction

FOR the production of a reduced product from pyrolusite ore suitable for production of electrolytic grade manganese dioxide (EMD) and manganese metal (EMM), a new reduction roasting technique using a lowcost reductant like coke dust and coal fine has been developed at the Regional Research Laboratory, Bhubaneswar. It is possible to achieve a reduction efficiency of 85%-90% by the new method. Energy requirement for conversion of manganese dioxide in the ore is much lower than that of any existing process. Process and design engineering know-how for reduction roasting of pyrolusite is available with the laboratory.

FOR HER *(Contd. from p. 409)*

accelerate the aging process. Unless you have some symptoms requiring a chest X-ray, it is better not to go in for one. If an X-ray is absolutely necessary, take vitamin E first if you can.

Smog and industrial air pollution are well known as causes of cancer. In today's overpopulated cities, the air is often polluted with oxidising chemicals such as ozone and nitrous oxide. These compounds are present in smog and do harm to the body in at least two ways. They directly oxidise lung tissue, causing disease and reducing the body's ability to abstract oxygen from the air. The oxidising chemicals also destroy the vitamin A in lung tissue, thereby increasing the risk of cancer. Vitamin A is needed for the health of the mucous membrane of the lung.

Practical tips to reduce cancer risk

1. Choose food high in fibre (fresh fruits, vegetables, and whole-grain breads and cereals). and low in dietary fat.
2. Take food rich in vitamins A,C, and E; such as green vegetables, carrots, oranges, fish, etc.
3. Avoid moldy food, especially peanuts and bread.
4. Avoid eating too much "burnt" or barbecued food and do not drink too hot tea or coffee.
5. Avoid excessive intake of salty foods.
6. Avoid foods coloured with artificial colours.
7. Wash raw foods thoroughly.
8. Avoid excess chlorine and chlorinated compounds in drinking water.
9. Avoid drinking too much alcohol.
10. Do not smoke or use tobacco in any form.
11. Avoid unnecessary X-rays.
12. Avoid excessive exposure to the sun.
13. Avoid smog and industrial pollution.
14. Try to exercise regularly—it improves your immune system and stimulates hormonal metabolism.

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BOOK REVIEWS

WOMEN AND ENVIRONMENT IN THE THIRD WORLD *by* Irene Dankelman and Joan Davidson, *Earthscan Publications Ltd.,* 3 Endsleigh Street, London WC IH ODD, U.K., Pp. 210, £ 5.95

IN any development activity of the Third World countries, women have never been consulted till this day. This has, of course, its origin in their culture, religion and values which have always given a lower status to woman. After all, it is the man only who had dictated the norms in their culture, religion or customs. In recent times, however, the vital role that the woman plays not only in family affairs but also in developmental activities is increasingly being felt. When man is away on his work, women manage family affairs and discipline children who are the future citizens of the world. In rural areas, where man is often away living in a city, the role of woman further assumes significance because it is she alone who has to manage family affairs. Unlike an urban woman, she has no pump to procure water or a refrigerator to preserve food or a gas agency to supply fuel for cooking. She has simply to rely on the resources available at her doorsteps and the neighbouring water bodies and forests. The book under review gives in detail how rural women manage family affairs using the local environment, what problems they are facing today due to increasing deterioration of their environment and how some women are preparing themselves to meet the new challenges.

As one goes through the book one is amazed at the hardships suffered by millions of women in rural areas simply to maintain their families on a hand-to-mouth basis. Life is a drudgery for most of them. From early morning until late into night, women are busy bringing water from distant ponds or streams, collecting firewood and fodder from forests and also lending assistance to men in fields. From the childhood, girls are also trained in these jobs. In short, it is woman who comes directly into contact with the local environment. The book under review advocates that women should therefore be taught about environment and its intricacies and how it should be utilised properly without harming it. Such a strategy would help in imparting environmental awareness to the entire family because it is mostly through mother that children imbibe values, culture and religion.

In addition to the role of woman in the maintenance of environment, the book also gives a number of case studies of how women have fought to save their environment against the greed of forest contractors and miners. One finds that to save forests the Chipko movement organised with the assistance of women in the foothills of the Himalayas is simply one of the better organised and widely publicized movements. Elsewhere, both in India and other developing countries, women are fighting contractors and miners on smaller scales. Some women have also formed cooperatives and improved their lot by managing their environment effectively. Besides, the book also includes interviews of the women who have worked for environmental cause, the efforts that are in progress to train women in environmental matters and also the future prospects of such movements all over the world.

The book is written by women, about women and for women. It therefore occasionally stinks of female chauvinism. It reads as though men are destroying the environment and it is only women who are trying to save it. It should not be forgotten that men are destroying environment for the sake of women, too, not for themselves alone.

Dilip M. Salwi

REFERENCE BOOK ON SOIL CONSERVATION AND REMOTE SENSING *by* Dibakar Sahu, *Roopanand Publishers,* C /36, Unit-8, Bhubaneswar, 751003, Pp 533, Rs. 100.00

A thin layer of soil ranging from a thickness of few centimeters to several meters covers most of the land surface of earth. It is composed of rock and mineral particles of many sizes mixed with water, air and living things, both plants, and animals, and their remains. Soil formation is a very slow process. It takes thousands of years to form a few centimeters of top-soil and it is this top-soil which sustains most plant life on earth.

India being an agricultural country needs fertile land for maximum production of food grains. But indiscriminate agricultural practices, unplanned irrigation, deforestation and excess of mining operations have led to soil degradation beyond control and consequently low agriculture produce. To make such soils fertile again, basic principles and practices of soil conservation have to be strictly followed. Students at undergraduate level of agricultural education need to be imparted basic knowledge of soil and its conservation. Many agricultural universities and soil conservation institutes of various states have therefore included this subject in their undergraduate level course. This reference book on soil conservation and remote sensing has been written with this aim in mind.

The book under review is divided into two parts. The first part defines the terms used in soil science in simple language. At many places appropriate figures have been added to explain the term. In all, more than 2400 terms have been arranged in alphabetical order and serially numbered under each alphabet. The second part is devoted to tables, charts and formulae relevant to soil structure, water, temperature, humidity, nutrients, etc. A list of important grasses, cereals, leguminous fodder crops, green manure crops, which are useful in soil conservation measures, is given. Important references have been listed. An errata of spelling mistakes has also been given. Nevertheless, some spelling mistakes have remained

unnoticed.

The book would be helpful to students of agricultural, technical and para-technical employees engaged in field work of soil science, soil survey, soil conservation and remote sensing in different institutes, departments of government and non-government. It is reasonably priced.

K.Y. Kavathekar

UNDERSTANDING COMPUTERS *by* R.Rajagopalan, *Tata McGraw-Hill Publishing Co. Ltd.,* 4 /12 Asaf Ali Road, New Delhi 110 002, Pp 234, price not stated.

COMPUTERS seem to have become so much essential in our lives that even though a person may not have to use a computer, he would still like to be exposed to its capabilities. The book under review is likely to prove useful to those who want to become conversant with the developments in computer technology.

The book comprises three parts. The first part provides an overview on computers regarding their origin, development, description of main parts and application in diverse fields. The second part, in addition to hardware and software, includes a chapter each on the commonly used programming language BASIC and an introduction to management information systems. The third part covers the emergence of microprocessor or chip and its applications, and personal computer and its role in office automation. New products of information technology like videotex, electronic funds transfer systems, teleconferencing, telecommuting, electronic mail and electronic publishing arising from the marriage of computers with advanced communication systems are described. It also provides an insight into the advanced topics of current interest like artificial intelligence and robotics. The last chapter deals with the current and possible impact of computers on society.

The presentation of the subject is simple and easy to understand. The coverage is also wide. The book will be useful to all, professionals and laymen alike.

Chander Shekhar

ENZYME TECHNOLOGY IN BEAMHOUSE PRACTICE *by* R.Puvankrishanan and Susil C.Dhar, *NICLAI Publication,* Central Leather Research Institute, Madras 600020, pp,(iii + 175), Rs.50.00

THIS is a well written treatise on beam-house practice on the use of enzymes in leather industry and technology. After a brief introductory chapter on the importance of the subject, the authors have devoted two chapters on enzymes giving a general perspective and immobilization of enzymes and microbial cells. The subsequent four chapters deal with the various stages in the processing of hides and skins.

The authors have stressed the advantages of the use of soluble enzymes in case of five operations and immobilized enzymes in two operations of bating and dehairing. The literature coverage on various aspects of the subject is impressive and uptodate. The recent developments in leather technology, chemistry, biochemistry and enzymology have been critically discussed and evaluated. The authors have clearly brought out the advantages of using enzymes as against chemical aids. They have, however, not given the reasons why immobilized enzymes have not been considered as aids in the soaking process of hides and skins. The same question may be asked about another operation relating to the degreasing of hides and skins. The use of enzymes in dehairing and bating has been exhaustively dealt with in the book. The merits and demerits of the use of enzymes viz-a-viz the chemical and physico-chemical operations for processing skins and hides are also mentioned. It is in these two operations of dehairing and bating that the immobilized enzymes have been considered as aids.

The combined use of enzymes such as lipases, protoeases and amylases has been given due importance for achieving better results in the processing of skins and hides. Despite the emphasis on enzymes and devoting more than one third of space to it in the book, the authors have, however, not failed to point out the advantages of solvent method of degreasing. One is not quite convinced as to why so much space in the book has been devoted to enzymes when chemical and physico-chemical operations are not so unimportant as aids and as adjuvants to enzymes in the processing of skins and hides. Such detailed description of enzymes would have been more appropriate for a text-book for graduates in biochemistry and enzymology. A careful perusal of the book shows one lacuna, namely, the absence of information on the alteration in kinetics, stability and other behavioural characteristics which enzymes suffer on immobilization.

The book under review covers proteases, lipases and amylases from different sources and their merits and demerits. However, the users of enzymes in leather research and technology would certainly need to know about the availability and indigenous sources, manufacturers, and annual requirements of enzymes by the industry in the country. Inclusion of such information in the book will offer guidelines to researchers, technicians and entrepreneurs related to the subject.

Chapter 8 is quite interesting in the sense that it deals with utilization of by-products of leather industry such as glue, stock, hide, offal, leather meal, etc., for generating technically useful products. The advantages of utilizing enzymes for this purpose have been lucidly described. It is a commendable feature of the treatise.

One would recommend this book to chemists, biochemists and technologists working in the area of leather research and industry.

Sanjiv Gupta
Sharad S. Singhal
Chanan Singh

BOOK REVIEWS

SECONDARY SCHOOL BASIC BIOLOGY (Part I and II) *by* V.K. Sharma and Vinay Kumar, *Sultan Chand & Sons,* 23 Darya Ganj, New Delhi-110 002, Pp. 186 and 212, Rs.25.50 and Rs.15.00.

TO understand and assimilate the descriptive subject of Biology, it is essential for students to learn the subject thoroughly. Even to attempt objective-type questions, an indepth knowledge of the subject is required.

The books under review have been written to serve as text-books for class X students. Two parts contain thirty four chapters spread over seven units. Part one deals with two units, the living world and the diversity of life, in ten chapters. All chapters have been written in accordance with the Central Board of Secondary Education syllabus.

The books have been written in simple language and the continuity of the subject has been maintained. Questions dealing with every aspect of the topic have been given at the end of every chapter. Good line drawings and figures have also been given. A glossary given at the end of Part two enhances the value of the book.

Important points given at the end of every chapter in part one in the form of "Terms to Remember" will be useful for quick revision. Questions given at the end of every chapter will help students in testing their comprehension of the subject.

Tapan K. Mukherjee

COMPUTERS AND DEFENCE APPLICATIONS *by* R.K. Bagga, *Defence Science Information & Documentation Centre (DESIDOC),* Metcalfe House, Delhi-110054, Pp 76, Rs 5.00

THE aim of the *Popular Science and Technology* (PST) series published by Defence Science Information & Documentation Centre, is to impart knowledge about frontier areas in science and technology to defence services. This issue of the half-yearly PST publication is on computers with applications in defence operations.

The book is divided into six chapters. A brief historical background, fundamentals of computers, and the software which makes them work are described in the first three chapters. The next chapter explains how the sensitive area of defence relies heavily on the advances made in computer technology and how each and every area of military equipment and operations is being automated using microprocessors. It also describes briefly the major role being played in defence by computers for the command, control, communication and intelligence systems to provide accurate information. Chapter V covers the major computer-based technology and weapon development programs which will have major military implications in future, e.g., the SDI programme, artificial intelligence research and expert systems. The last chapter highlights the Indian scenario in the context of worldwide computer technology. Most of the common computer terms and acronyms are explained in the glossary at the end of the book.

This low-priced publication, brought out using a microcomputer would be of interest to a wide range of readers.

Chander Shekhar

Books received

1. **STRUCTURED PROGRAM DESIGN USING JSP** *by* Rod S. Burgess, *ELBS Hutchinson* (1988), (Available from B.I. Publications Pvt. Ltd., 61-63 Lakshmi Building, 4th floor, Sir Phirozshah Mehta Road, Bombay), Pp. 222, £ 4.95

2. **UNDERSTANDING BIOLOGY FOR ADVANCED LEVEL** *by* Glen Toole and Susan Toole, *Hutchinson* (1987), (Available from B.I. Publications, Pvt. Ltd.), Pp. 612, Price not stated.

3. **100 FAMILIES OF FLOWERING PLANTS** *by* Michael Hickey and Clive King, 2nd Ed. (1987), *Cambridge University Press,* Pp. 620, Price not stated.

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