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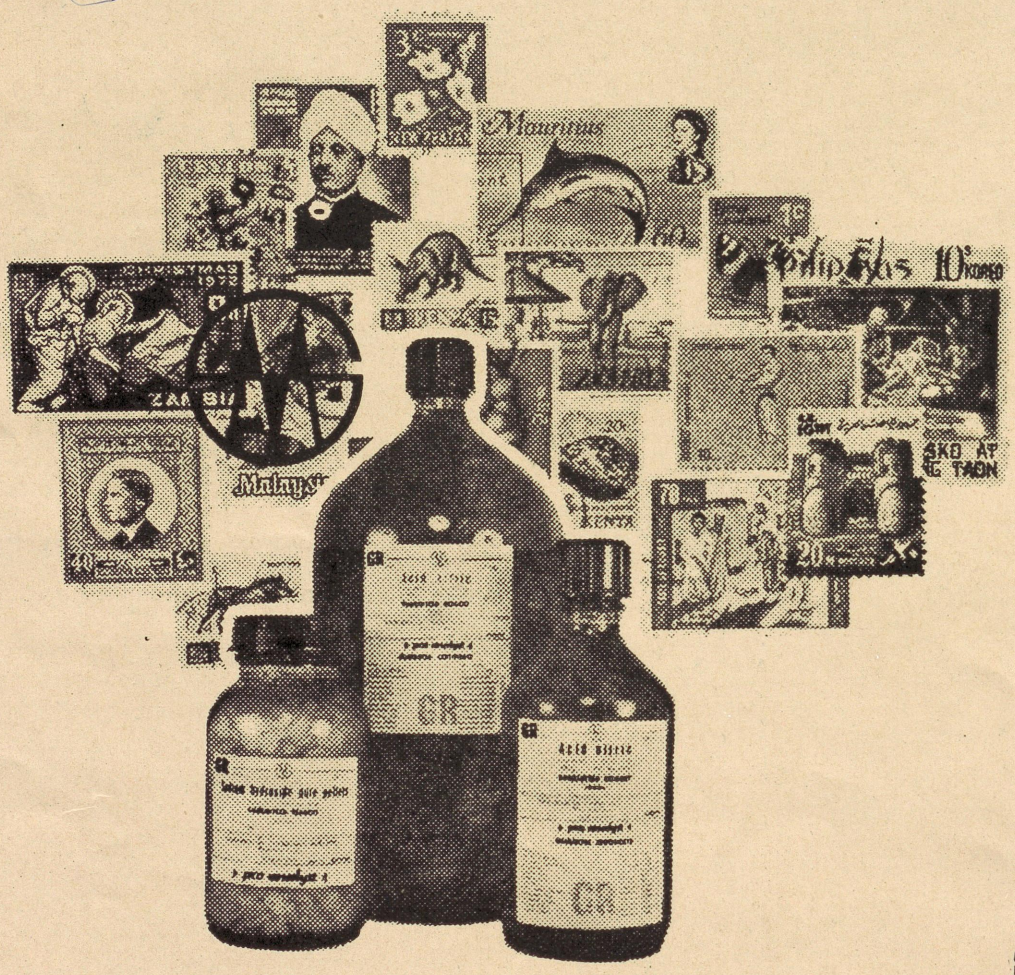

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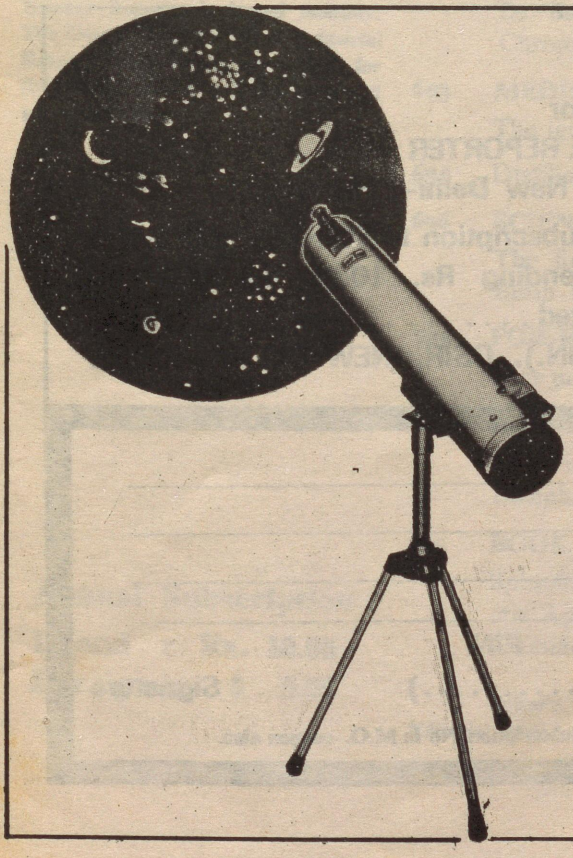

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Dwarf in the middle

Sir, I read Alex Comfort's **The dwarf in the middle** (*S.R.*, June 1978) with great interest. Essentially the same subject is briefly discussed by the "phenomenological existentialist" Colin Wilson in a postscript to his book *The Outsider* (which is a selective analysis of mainly western philosophy and literature published by Pan Books Ltd., London, 1967). Although Wilson briefly deals with aspects of Indian thought in *The Outsider*, he does not discuss the utility of Indian philosophical concepts in analysing "Oceanic" or "I-less" experiences, which are his main concern. He states that he approaches the creation of a new language for "I-less" experiences through phenomenological disciplines and refers to one of the founders of that approach, the philosopher Husserl.

Further articles summing up the state of research on this exciting subject would be appreciated.

ALLAN FONSECA
Bela Vista
Assagao, Goa

Wealth from waste

Sir, Everyday thousands of hens, goats, fishes are slaughtered for human consumption in the country. Many parts of the animals are thrown away as wastes.

For instance, there is gall bladder of the animals which at present is thrown away. The bile juice and bile stones present in gall bladder are of commercial value. There is a process to convert bile liquid into bile paste and get cholic acid and desoxicholic acid from bile. Bile paste could be made by concentrating bile liquid in steam-jacketed vessels with approximately 70%-75% soild content. At the village level, this could also be made by just heating the bile over a waterbath. The paste in this form will preserve well without the addition of any preservative. The paste can be used as a starting material for making cholic acid and desoxicholic acid, but one need not attempt to make such fine chemicals at the village level. The paste could as well be exported or handed over to parties, who can make the fine chemicals from them.

Cholic acid and desoxicholic acid are made by hydrolysing bile in an alkaline medium and neutralising subsequently with acid and purifying and fractionating the compounds by using methanol. The bile paste with 75% solid content contains approximately 50% cholic acid on moisture free basis. The market price of cholic acid at present is Rs. 350/- per kg and that of desoxicholic acid Rs. 700/- per kg.

One can collect sizable quantities of gall bladders at slaughter houses at a nominal cost.

A. JAGADEESH
Convenor
Society of Science for the People
2-275, Nawabpet
Nellore-524002 (A.P.)

Science in regional languages

Sir, I was surprised to read the suggestion made by N. M. Singhi in *S.R.*, June 1978, that the medium of instruction should be the regional language. Such ludicrous ideas are put forth by people who are completely ignorant of the rapid strides made by science and technology today, and it is strange that a person of his calibre should hold such a view. Apart from the enormous expenditure involved, in just how many years can we hope to see the entire gamut of science and technology translated into the regional languages? Even if this is accomplished, would a budding scientist be able to propound his views as effectively as he would in English?

K. SMILES MASCARENHAS
Raman Research Institute
Hebbal P.O.
Bangalore-560006.

Absolute zero

Sir, I read the article **Near absolute zero—expanding applications** (*S.R.*, May 1978 by Latika S.R. Becker. The article, particularly the 'creeping film' phenomena, is very interesting. The 3rd column on the first page of the article says, "He-II has many other strange properties besides superfluidity. It conducts heat a thousand times better than copper."

In the same column, below former lines, it says, "The most important difference between the two phases is that the normal phase transports heat, whereas the superfluid phase is accompanied by no heat transfer whatsoever."

I think the two statements need to be corrected.

S. BHATTACHARYYA
B. E. College
Sibpur(W .B.)

II

Sir, I want to know how heat is converted into electrical power without the necessity of a turbine. Is there any such device installed in India?

RANDEEP DAS
2, Naktala Lane
Calcutta-700047

III

Sir, I want to know the reason for superfluidity of helium at 2.2K. Is there any change in its structure or anything else?

UMESH KR. PANDEY
Shakurbasti
Delhi-110034

I. The paragraph in the article in which the last statement appears describes the two-phase mathematical model of flow phenomena in liquid helium II. Since the paragraph speaks only of liquid helium, your confusion in understandable. The heat conductivity of He II is indeed 1000 times greater than copper; according to the two-phase model of He II ("normal fluid" phase, "superfluid" phase) the heat energy is transported by internal convection currents of the "normal fluid" phase and the "superfluid" phase. If a capillary tube of He II is slightly heated at one end, the "normal fluid" phase carries the energy from the heated to the cold end, while the "superfluid" phase flows in the opposite direction carrying no heat whatsoever. Thus, masses of liquid transferred by each current compensate exactly for each other so that no real macroscopic fluid flow occurs.

II. I would like you to refer to my article *Slag and potassium removal in coal-fired MHD generator* (*S.R.*, Oct. 1976) which explains the mechanism of a magnetohydrodynamic generator. Many laboratories in India like Bhabha Atomic Research Centre (BARC), Bombay, and Bharat Heavy Electricals Ltd., Tiruchirappali, are conducting scientific and technological investigations in the MHD power generation process.

III. The basic causes of the phenomenon of superfluidity are not fully understood; however the most comprehensive theory to date explains the behaviour of liquid helium at the transition point (2.2 K) as a "phase" change from a classical liquid to a quantum liquid. Normally, at sufficiently low temperatures liquids solidify and form a crystalline lattice. But in the case of liquid helium this is not true; it is believed to be due to the relatively weak interactions between helium atoms. So, below the transition point, the behaviour of helium atoms is governed by the laws of quantum mechanics (consult a basic textbook on quantum physics) and described by Bose statistics. Liquid helium is the only system where quantum effects appear before the liquid has solidified. In all other media, the interaction between atoms is sufficiently strong so that the body solidifies before quantum effects appear.

LATIKA S.R. BECKER
5133, Panorama Dr.
Huntsville, Ala., 35801 (USA)

Living in desert

Sir, In his interesting article **The tricks of living in desert** (*S.R.*, May 1978), the author has metioned that many desert mammals are able to raise their body temperature to a high degree in response to thermal stress. How do their brains and CNS cope with the increased temperature ? It is well-known that brain of mammals is highly sensitive to temperature fluctuations.

How do the desert animals escape heat death which severely affects human beings moving in desert ?

RAMESH P. SINHA
Moradabad (U.P.)

It has recently been reported that the desert antelope has a special arrangement of blood vessels at the base of the brain that maintains the brain at a tolerable temperature even when the temperature of the rest of the body rises in response to the increase of atmospheric temperature. Camels and other desert mammals, perhaps, possess a similar arrangement of blood vessels which helps them to withstand a wide range of temperature fluctuation.

Many desert mammals, particularly camels, are physiologically well adapted to avoid 'explosive heat death'. In a man staying in desert for a considerable period, blood rapidly becomes highly viscous as desiccation proceeds. It has been estimated by J.L. Cloudsley Thompson of USA (1977) that after about 12%-18% of the body weight has been lost, blood cannot circulate freely inside the narrow blood vessels to carry away the metabolic heat, and as a consequence 'explosive heat death' results. In camels, on the other hand, water is at first eliminated from the tissues while the viscosity and the volume of blood remain almost constant for a long time. In this way, camels escape 'explosive heat death.'

SAMAR CHAKRABARTI
Deptt. of Zoology
Hooghly Mohsin College
Chinsurah (W.B.)

Immunity

Sir, I read the article **Can birth defects be prevented?** (*S.R.*, May 1978) by S.M. Tuli with great interest.

For immunization of girls, what is the procedure for acquiring immunity by "deliberate exposure" to those infections for which reliable vaccinations are not yet available (e.g. measles, chickenpox, rubella, etc.)?

2. What factors are taken into consideration for a deliberate exposure?

L. N. GADDAMWAR
Microbiology Deptt.
Bhavan's College
Bombay-400058

Girls, before their reproductive life, may be exposed to such infections

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deliberately. Such exposures can be arranged by providing company of children suffering from measles, chickenpox, rubella, etc., say in camps during school vacations or by visiting friends or neighbours actually suffering from the disease. Prospective mothers, having thus been exposed to the disease, would develop immunity to confer protection to the future fetus.

S. M. TULI
Deptt. of Orthopaedics
Inst. of Medical Sciences
Banaras Hindu University
Varanasi-5(U.P.)

Chemical reactions

Sir, After reading the article **Why do chemical reactions occur?** by Y.K. Gupta (*S.R.*, July 1978) I found an error—which cannot be taken as a minor one. The article contains only mechanism of chemical reactions and the correct title of the article should have been "How do chemcial reactions occur?"

I liked 'Science Spectrum' (*S.R.* July, 1978). It contained several interesting articles.

SANJAY WADHWA
Maulana Azad Medical College
New Delhi

Enzymes

Sir, P. S. M. Tripathi has given readers of *S.R.* an impressive and lucid account of enzymes (*S.R.*, June 1978), useful especially to junior college students. He has also mentioned six references for further reading, published before 1970.

In the past ten years, significant advances have been made in the application of enzymes in therapeutics, enhancing their medicinal value. Besides hyaluronidase and a few other enzymes mentioned under medical uses in the article, I would like to add for the benefit of readers information regarding some more important medicinal enzymes, particularly those employed as mucolytic and fibrinolytic agents and described in standard books on pharmacy and medicine.

Streptokinase is a protein obtained from culture filtrates of certain strains of haemolytic streptococcus group C is and used by intravenous infusion in the treatment of thrombo-embolic disorders such as pulmonary embolism and arterial and venous occlusions. It may also be useful in cardiac infarction. It is administered with other thrombolytic agents like heparin. Streptodornase is another streptococcal deoxyribonuclease used in conjunction with streptokinase. Streptokinase-streptodornase mixture combines the fibrinolytic effects of streptokinase and the effect of streptodornase in lysing pus. It is used topically or by instillation into closed body cavities to remove clotted blood or other purulent accumulations. Sultilains contain proteolytic enzymes derived from *B. subtilis* and used for wound debridement.

Urokinase, an enzyme obtained from human urine, has great potential value in the treatment of acute coronary and cerebral thrombosis. It converts plasminogen into plasmin, another proteolytic enzyme which has significant fibrinolytic properties. Brinolase is yet another fibrinolytic enzyme from *Aspergillus oryzae*, recently added.

Muramidase, also known as Lysozyme/Globulin G_1, is a crystalline mucolytic enzyme, widely distributed in nature and present in tears, egg-white, nasal mucus and other secretions and in many animal tissues and certain plants. It is a mucopolysaccharide which is active against Gram-positive bacteria and also against some viruses. It has been used in the treatment of bacterial and viral infections, given intravenously or intramuscularly. When muramidase is given with other antibiotics like penicillin and chloromycetin, the growth of staphylococci is more effectively inhibited than by the antibiotics alone. Pancrelipase, a preparation obtained from the pancreas of the hog, containing principally lipase together with protease and amylase, acts like pancreatin, but is much more active than the latter.

Enzymes are becoming increasingly important in therapeutics, and as they are from tissues of plants and animals, they may be more acceptable to the body with few side-effects. Biomedical engineering/technology has a role to play in the alleviation of human sufferings.

S. SANKARA SUBRAMANIAN
Professor of Chemistry
Jawaharlal Institute of Postgraduate Medical Education & Research
Pondicherry-605006

Solo-man

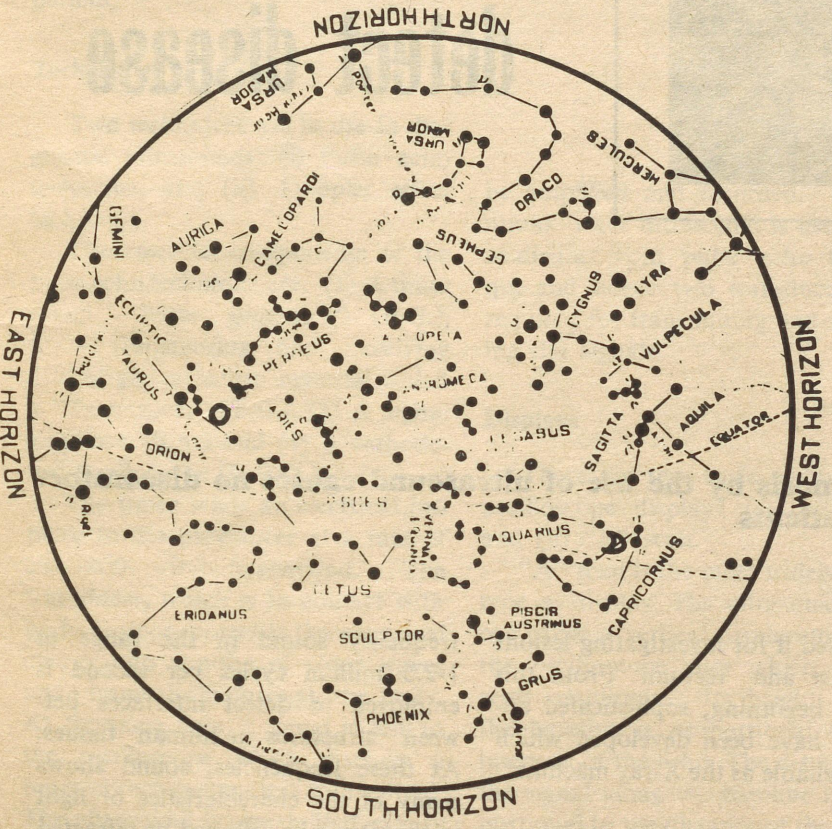
Sir, Apropos of Prof. B. K. Behura's letter (*S.R.*, July 1978) on Solo-man, we would like to add : The Solo-man represented by eleven fossilized skull fragments and two tibiae recovered by Haar in 1922 was preliminarily described by W.F.F. Oppenoorth in 1932 who originally named it as *Javanthropus soloensis*. Later on, he renamed it *Homo soloensis*, also commonly known as Java Man. However, the latest trends tend to call it *Homo sapiens soloensis* as there is now a growing tendency to regard the Neanderthals and their contemporaries elsewhere as being distinct from *Homo sapiens* (modern man) at the species level. The samples of such populations should be treated now as distinct subspecies.

Important features of the fossilized skulls show that they are quite long (longer than man, length of the larger skull approximates 221 mm and breadth about 144 mm) with remarkable cranial flattening, thick cranial vault, long frontal bone, sharp slope in the frontal region, an elevation in the

(*Continued on page* 655)

Planets and their positions

November 1978



MOON

☽ FIRST QUARTER 7TH

○ FULL MOON 15TH

The moon

NEW moon occurs on 1st at 1-37 a.m. and again on 30th at 1-49 p.m. and full moon occurs on 15th at 1-30 a.m. I.S.T. The moon passes about seven degrees north of Mercury and five degrees north of Mars on 2nd, four degrees south of Jupiter on 21st, about three degrees south of Saturn on 24th and about three and a half degrees north of Venus on 28th.

The lunar crescent becomes first visible after the new moon day in the evening of 2nd.

The planets

Mercury (Budha) an evening star, sets about an hour after sunset during the month. At the end of the month it is too near the sun to be visible. It passes 2 degrees north of the star Antares (*Jyestha*) on 10th. It also passes about 2 degrees south of Mars on 5th. It is at the greatest eastern elongation of about 23 degrees from sun on 16th. It becomes retrograde on 26th. It is in Scorpio (*Vrischika*). Its visual magnitude varies from −0.2 to+1.3.

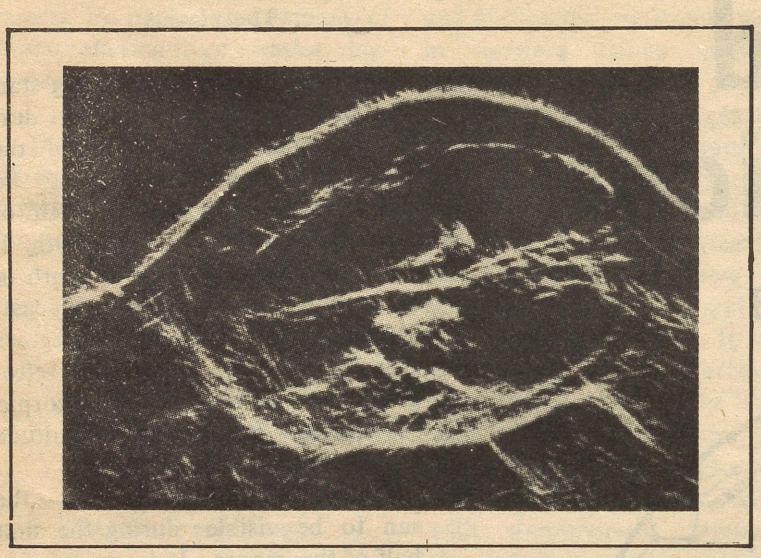
Venus (Sukra) is too near the sun to be visible during the first half of the month. It is in inferior conjunction with the sun on 8th. Thereafter, it reappears as a morning star and rises about one and a half hours before sunrise. It becomes direct on 28th. It is in Libra (*Tula*). Its visual magnitude varies from −3.2 to−4.2.

Mars (Mangala), visible in the evening sky, sets about an hour after sunset during the first half of the month. Thereafter, it is too near the sun to be visible. It is in Scorpio (*Vrischika*). Its visual magnitude is about + 1.6.

Jupiter (Brihaspati), visible in the morning sky, rises about one and a half hours before local midnight during the first half of the month and about two and a half hours before it during the second half. It becomes retrograde on 26th. It is in Cancer (*Karkata*). Its visual magnitude is about −1.9.

Saturn (Sani), visible in the morning sky, rises about an hour after local midnight during the first half of the month and just around midnight during the second half. It is in Leo (*Simha*). Its visual magnitude is about +1.1.

(*Source*: Nautical Almanac Unit, India Meteorological Department, P-546, Block 'N' (1st floor), New Alipore, Calcutta-700053).



Ultrasonics can detect disease

SHARAD LAKHANPAL

Diagnosis by the use of ultrasound causes no discomfort to patients

DESPITE all evils associated with war, it has made some significant contributions to the welfare of mankind. The Second World War and the succeeding period brought forth the use of ultrasonic devices like the radar and sonar to detect a submarine, an aeroplane or a rocky surface at the bottom of the sea. Medical scientists have succeeded in employing ultrasonics to probe the depths of human body.

The first attempt to use ultrasonics in medical diagnosis was made in 1937 by Dusik brothers in Austria, but their method eventually proved to be impracticable. Ultimately, a successful, two-dimensional medical ultrasonic scanner was developed in America by Reid and Wild in 1957. They used it for investigating lesions of breast and rectum. From this modest beginning, sophisticated apparatus have been developed which are as reliable as the X-ray machine.

Principles

The basic principle of the ultrasonic technique is deceptively simple. High frequency sounds are sent into the human body, and their echoes, as they bounce back from organs and structures within the body, are recorded.

The realm of ultrasonics lies beyond sound frequencies of 20,000 cycles per second, the uppermost limit of human hearing. For medical diagnostic purposes, inaudible high frequency sound in the range of 1-2.5 million cycles per second is employed to detect interfaces between structures in human tissues. At these frequencies, sound shows many of the characteristics of light in that it can be reflected or refracted whenever it meets structures of different acoustic impedance. The ultrasonic beam travels like a cone from its source, and, whenever it strikes a structure at 90°, it is reflected back directly to its source.

There are four factors which allow ultrasound to be of value in medicine:

1. It can be transmitted at a constant speed through the soft tissues of the body.
2. When a pulse of ultrasound

Dr. Lakhanpal is chief resident in Dept. of Medicine, M. G. Memorial & Associated Hospitals, K. G. Medical College, Lucknow

meets a boundary between two structures of differeing acoustic properties, part of the pulse is reflected back from the boundary as an echo and the rest passes on.

3. The returning echo can be detected and processed.

4. The passage of ultrasonic waves through the human body does not constitute any hazard to the patient.

Techniques

Two techniques are in use in diagnostic ultrasounds: (ii) Pulse echo technique, and (ii) Doppler effect technique.

The essential components of the pulse echo technique are: (1) A timer called "Pulse generator" (P.G.), (2) A transmitting and receiving disc of piezo-electric material called a "Transducer" (T.D.), (3) A signal amplifier (S.A.) and (4) A cathode-ray oscilloscope (C.R.O.).

The timer sends an electrical impulse to the transducer at a rate of 200-1000 impulses/second. The transducer, which is in contact with body surface, converts the electrical energy into a pulse of sonic waves and transmits it through the body. At the same time, a signal is sent to the oscilloscope which displays a pulse at each instant it is transmitted. The ultrasound is transmitted in very brief pulses, each followed by an interval. During this interval, the echoes are reflected back to the transducer which acts as a receiver. The transducer converts the sonic energy back into electrical energy; and this signal is amplified and displayed on the oscilloscope.

When ultrasound echoes from a stationary surface, the frequency of the reflected beam is the same as that of generated beam. However, if the reflecting surface is in motion, the returning ultrasound will be at a different frequency from that of the generated ultrasound. This is Doppler effect. The shift in frequency can

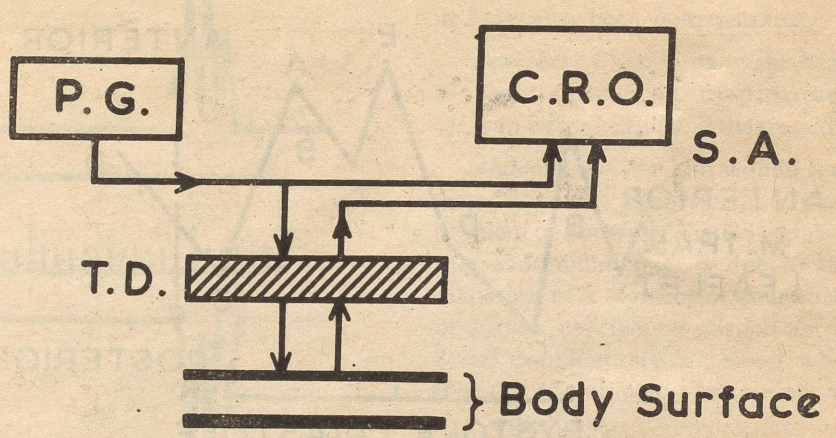


Fig. 1. Pulse echo technique

be amplified and recorded. Continuous wave ultrasound is used here as distinct from pulse echo technique and hence two transducers are required for transmitting and receiving the signals.

Displays

There are two basic methods of oscilloscope display: (i) "A" scan and (ii) "B" scan.

"A" scan is the most widely used type of display. The ultrasonic echoes cause a vertical displacement of the oscilloscope spot which represents amplitude. Its height above the baseline is proportional to the intensity of the echo. The distance of the signal along the baseline is proportional to the distance of the echoing surface from the transducer.

In "B" scan technique, the echoes are recorded as bright dots along the base line of the oscilloscope and measure the distance of the transducer from the source of the echo. The amplitude of the echo is displayed as varying brightness of the dots.

Lately, some new methods to display the information have come up. "M" scan display is most commonly used to record movement of structures within the heart. As the line of oscillating bright dots produced by echoes from the moving structures within the heart is swept across the oscilloscope screen, a recording is made by photography.

Another method is to use an analogue converter. By this method the movement of only one structure, usually the anterior cusp of the mitral valve, can be measured accurately and correlated with other parameters such as electrocardiogram, phonocardiogram, apex cardiogram, etc. A recent development is the use of an array of multiple ultrasonic transducers to show the movement of cross-sections of the heart and record it on cinematographic film.

Application in clinical medicine

The use of ultrasonics in medicine has many advantages. The application of ultrasound for diagnostic purposes causes no discomfort to the patient. So, it has a high patient acceptability. It is a non-invasive technique, and for most ultrasonic examinations, no preparation of the patient is required.

A common diagnostic problem arises when a mass is found either clinically or radiologically, but it is not known whether it is a tumour or a cyst or another fluid-containing lesion. Ultrasound is the only non-invasive diagnostic technique which can make this differentiation. If the mass is fluid-containging, it will be transonic and there will be little atte-

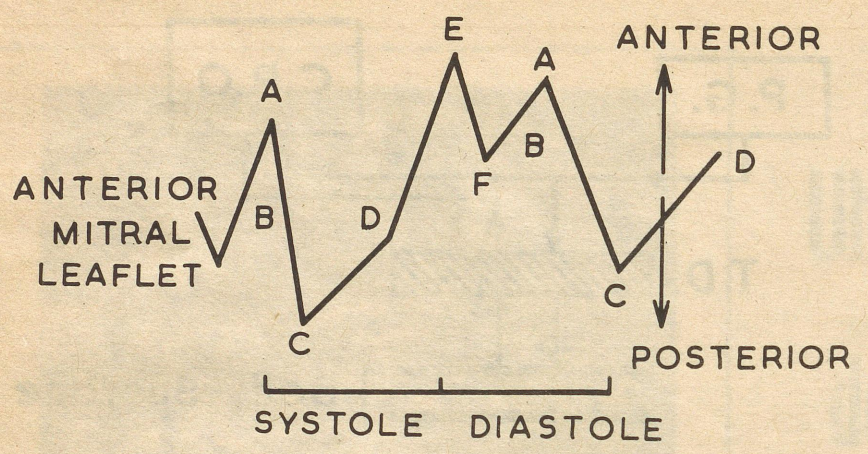


Fig. 2. Echodiagram of normal mitral valve

nuation of the ultrasound beam as it passes through the lesion. If the mass is solid, multiple echoes will arise within it. Fluid within the pleural cavity and peritonial cavity can also be demonstrated by this technique.

After an ultrasound instrument is accurately calibrated, the depth of a lesion from the surface can be obtained, so also its dimensions. By serial examination it can be shown whether the lesion is increasing in size or not. This can be of value in patients with aortic aneurysms and the information is difficult to obtain by any other means. Reliable knowledge of the depth and location of a lesion is of considerable help for needle biopsy or aspiration.

Echocardiography

The application of diagnostic ultrasound to cardiac lesions is called echocardiography. Normally the mitral valve, which connects the left atrium (auricle) with the left ventricle of the heart, opens during contraction (atrial systole). At the beginning of ventricular systole, the mitral valve closes to prevent reflux of blood from the left ventricle into the left atrium. At the onset of ventricular diastole (expansion), the mitral valve opens to its fullest extent (E) and partially closes during early diastole (F), after which it remains semi-open till the next atrial systole. The speed of the semi-closure of the mitral valve during diastoles can be measured by the slope of the E-F segment as shown in Fig. 2. In the diseased condition, however, certain abnormalities appear in the echocardiograms. Examples are given below.

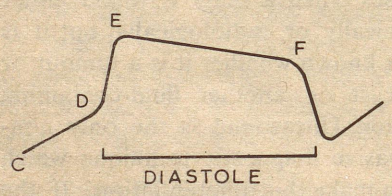


Fig. 3. Mitral stenosis

When the two leaflets (anterior and posterior) of the mitral valve are impaired, resulting in the narrowing of its orifice, the disease is called *mitral stenosis*. It causes a decrease in the amplitude of the anterior leaflet movement, reduction of the E-F slope and a sustained anterior position of the anterior leaflet during diastole.

Left atrial myxoma is a tumour arising from the muscle tissue of the left atrium which may intermittently obstruct the mitral orifice. This condition may be recognised as an aggregation of multiple echoes behind the anterior leaflet and there may be diminished E-F slope because of mitral valve obstruction.

Idiopathic hypertrophic subaortic stenosis is a disease affecting the muscle tissue of the heart which is increased in bulk and disturbs the normal functioning of the cardiac muscles. It is characterised by abnormal anterior movement of the mitral valve leaflet during systole.

The heart is enclosed in a double membrane bag called the pericardium. Due to certain aetiological processes, fluid may collect in between the two membranes of the pericardium. This condition is called *pericardial effusion*. It is difficult to distinguish it from dilatation of the heart in a chest radiograph because both will appear as an enlarged heart shadow. However, in echocardiography, echoes arising from walls of the dilated heart are continuous with those arising from the chest wall in front and the lungs at the back. On the other hand, in pericardial effusion the echoes from the heart walls are separated from the chest wall and lungs by an echo-free area.

In addition, the echocardiogram has been successfully employed to evaluate left ventricular volume and function, left atrial size and thrombi and pathologic anatomy in various congenital heart lesions.

Echoencephalography

The use of ultrasound in the diagnosis of morbid conditions affecting structures inside the cranium is termed as echoencephalography.

In normal echoencephalogram, three groups of echoes are seen :

The nearside group consists of echoes from the side of skull nearest the transducer. Echo from the outer table of skull

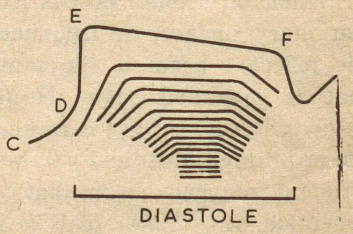


Fig. 4. Left atrial myxoma

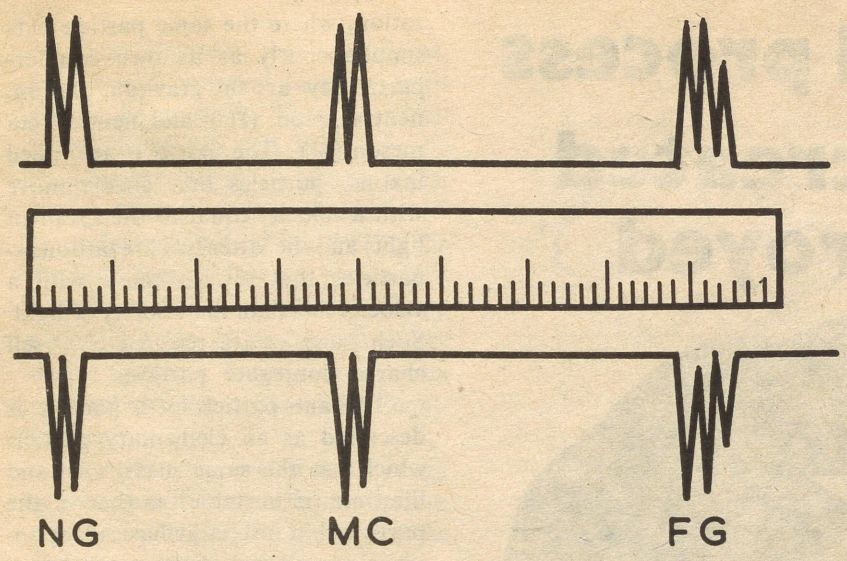


Fig. 5. Normal echoencephalogram

appears 5-7 mm from the start of traces and that from the inner table at 9-14 mm.

Midline complex is a double trace representing both walls of the third ventricle of the brain. The upper and lower traces should line up with no more than 2mm difference. The width of the double midline echo indicates the size of the third ventricle.

Farside group represents echoes from the inner table of the opposite side of the skull, the outer table and the far side skin-air interface.

In head injury, blood frequently collects to form a clot within the cranial cavity, which is known as *haematoma*. This may be recorded as : (i) abnormal echoes from the inner table of the skull on the side of haematoma, (ii) midline shift away from the haematoma, or (iii) as the ultrasound does not pass easily through a clot, the midline echo is often weak and difficult to establish.

The brain may arbitrarily be divided by a membrane in the cranial cavity, called *Tentorium cerebelli*, into two parts. The part above this membrane is called supratentorial and the one below it is infra-tentorial. Tumours in the supratentorial brain usually cause a shift of the midline and add to the diagnostic information.

The swelling of the optic nerve head of non-inflammatory origin, called *papilloedema*, is an ominous sign in neurology, and may be present without any associated localising signs. In such patients, an echoencephalogram is helpful in localising the lesion.

Application in other systems

Urinary tract. Sometimes intravenous pylography may indicate a space occupying lesion in the kidney but the problem is whether it is a renal cell carcinoma or a cyst. Similarly, intravenous pylography may visualise only one kidney and the problem is whether the other kidney is non-functioning or undeveloped. These differentiations can be made with the help of diagnostic ultrasonics. Tumours of the bladder and enlargement of the prostate can also be diagnosed with ultrasound.

Liver. Using "A" and "B" scan techniques, cirrhosis, hepatitis, primary and secondary tumours, abscess and cysts can be diagnosed with considerable accuracy.

Gall bladder size and stones therein have also been demonstrated.

Pancreas. Carcinoma of the head of pancreas and pseudo-pancreatic cyst can be identified and diagnosed.

Abdominal aorta. Ultrasound is of help in solving the frequent clinical problem of knowing whether a pulsating abdominal mass is due to the dilatation of a segment of the aorta or a mass overlying a normal aorta. Serial examinations can assess whether the dilatation is increasing in size with time.

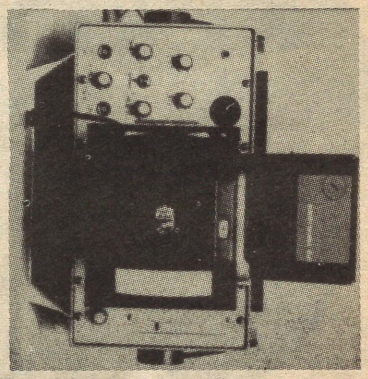


Fig. 6 Echoencephalograph—front view

Ultrasound in diagnosis is a technique which complements the information obtained by clinical examination, biochemistry, haematology, and especially radiology and isotope imaging techniques and is not a substitute for any one of these.

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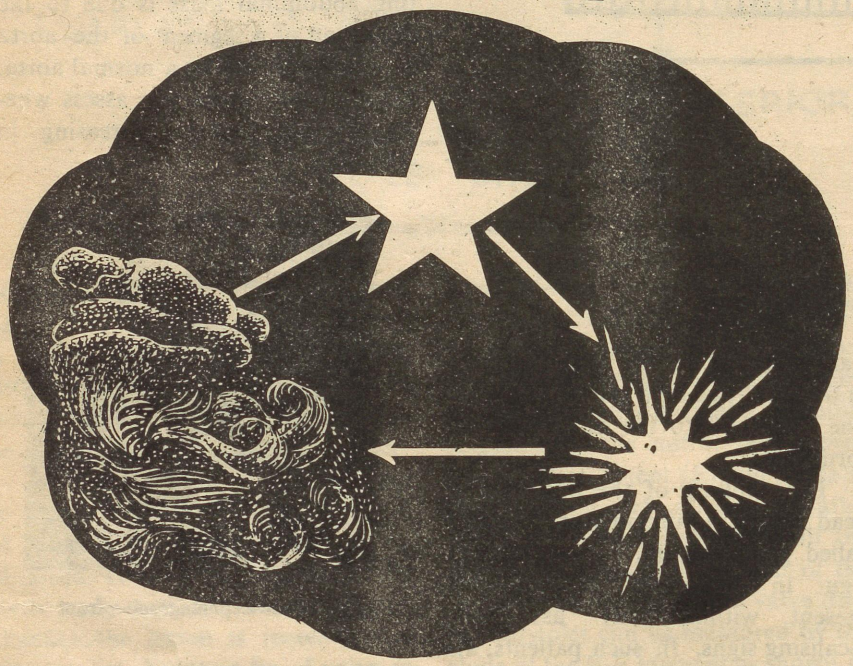
The eternal process
Matter is created and destroyed



M. MEYYAPPAN

Scientists now believe that annihilation of matter with anti-matter in the Universe may be the source of cosmic particles

P. A. M. DIRAC'S equation of relativistic quantum theory of electron admits solutions called negative energy states of electron. These negative energy states were interpreted as the existence of a particle of mass identical to that of the electron but of opposite charge. This proposed particle, now called positron, was not discovered until 1932 when Carl David Anderson of California Institute of Technology, USA, found it during his cosmic ray studies with cloud chamber.

After the discovery of positron, physicists concluded that in general each elementary particle should have its own counterpart, now called antiparticle or charge conjugate particle. This was verified with the discovery of antiproton and antineutron soon after high energy particle accelerators became available. However, there are four exceptions to this generalization, where the same particle acts simultaneously as its own counterpart. They are the graviton, photon, neutral pion (Π°) and neutral eta meson (η°). The first two are called luxons—particles that always move with a velocity equal to the speed of light; and the latter two are tardons—particles that always move with a velocity less than the velocity of light. Such particles are referred to as self charge conjugate particles.

The anti-particle of a particle is described as an elementary particle which has the same mass, spin and life-time (if unstable) as that of the particle, but its charge has the opposite sign and the alignment between its spin and the magnetic moment is opposite to that of the particle. So antiproton is a negatively charged proton, while neutron and antineutron of a given spin, though electrically neutral, differ by their magnetic moment in direction. The antiparticle of a particle may be conceived as its mirror image.

When the particle and antiparticle combine, they annihilate each other liberating a large amount of energy. This process is called annihilation of matter or dematerialization. The process reverse to annihilation is called materialization, where matter is created out of energy. Both the annihilation and creation are governed by the fact that the total number of particles (antiparticles to be counted as minus) must be zero and that electronic charge must be conserved. So energy is liberated if particle and its antiparticle combine in equal proportion. In the reverse process, matter is always a pair—particle and its antiparticle.

The creation and annihilation of matter can be understood clearly from the principle of equivalence of mass. Einstein's Special Theory of Relativity shows that mass is a form of energy. The principle of equivalence of mass and energy states that, for

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an isolated system, the sum of rest, kinetic and potential energies must always be constant. There is a possibility, therefore, that mass can be changed into energy, and vice versa. The instability of phase stable orbits in cyclotron (*S.R.*, Feb. 1977), the binding energy that is responsible for the stability of all the existing nuclei and the liberation of energy during nuclear fission and fusion substantiate the mass-energy equivalence.

From the principle of mass-energy equivalence, it is clear that to produce a pair of particles, the energy of the photon must be equal to or greater than certain minimum value, called threshold energy, below which the process of materialization cannot occur. This threshold energy is equal to the energy equivalent of the sum of the rest masses of the created pairs. In case of electron-positron pair production, the threshold energy is

$$h\nu_{min} = m_o^- c^2 + m_o^+ c^2 = 2\, m_o c^2 = 1.024 \text{ MeV}$$

(1 MeV is the amount of kinetic energy acquired by an electron to pass through a potential difference of one million volt and is equal to 1.602×10^{-13} joule). The wavelength of this photon is 0.0122° A. This is a highly energetic gamma ray photon.

A photon of energy greater than 1.024 MeV can create an electron-positron pair when it passes through the field of a nucleus. The presence of a nucleus is necessary to conserve energy and momentum. The probability of pair production increases steadily with energy. If the energy of the incident photon is less than 1.024 Mev, either photoelectric effect, the emission of electrons from the atomic system or Compton effect, the scattering of photons after imparting a fraction of its energy to an electron in the system , will result. The excess over the threshold energy exists as the kinetic energy of the pair particles. In electron- positron pair production, the energy balance equation is

$$h\nu = T^- + T^+ + 1.024 \text{ MeV}$$

where $h\nu$ is the energy of the incident photon, T^- and T^+ denote the kinetic energy of the electron and positron respectively.

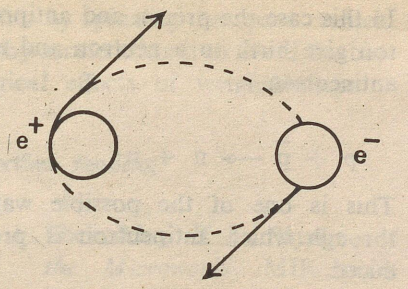

Fig. 1. Positronium

The annihilation, in general, results in the formation of one or more gamma ray photons. In electron-positron annihilation, only gamma ray photons are produced. In nucleon-antinucleon annihilation, however, two or more neutral and charged pions are produced. This is because the nucleons have strong interactions with the pi-meson field, much stronger than with the electromagnetic field. The annihilation therefore gives rise to a pair of pions rather than a pair of gamma ray photons.

Electron-positron annihilation

A positron not in contact with ordinary matter would be stable, but it is very short-lived in the world, just as an electron would be in the antiworld. This means antiparticles, like positrons, are rare guests to our world, while particles like electrons to the antiworld. The positrons and electrons, existing side by side, tend to combine and destroy each other. The average life of the positron in the cosmos is about 10^{-9} sec. The result of positron-electron annihilation may be any one of the three possible cases:

1. If a positron unites with a free or loosely bound electron, two photons of equal energy about 1/2 MeV each will be emitted in the opposite directions, so that both energy and momentum are conserved.

$$e^+ + e^- \longrightarrow 2\gamma$$

2. If a positron combines with an electron which is tightly bound to a nucleus, a photon of energy 1 MeV will be emitted. This is the least that will happen, as the positrons traversing through matter would practically lose all their kinetic energy before annihilation.

3. Rarely, the annihilation of positron and electron results in positronium (Fig. 1). Positronium is a bound positron-electron system and is analogous to atomic hydrogen. There are two possible forms of positronium=ortho and para.

In orthopositronium, the spins of electron and positron are parallel and it has a mean life of 1.4×10^{-7} sec. The conservation of angular momentum in the decay mode of orthopositronium necessitates the emission of three gamma ray photons of equal energies of 0.34 MeV.

The parapositronium is theoretically possible. Here the electron and positron have antiparallel spins. This structure is much less stable against annihilation, as it can decay into two photons with a mean life of about 10^{-10} sec.

Nucleon-antinucleon annihilation

If the distance between proton and an antiproton is comparatively greater, they form a hydrogen-like atom called nucleonium. In it the proton and antiproton rotate about their common centre of gravity. It is, like positronium, quite unstable for mutual annihilation.

When an antiproton ($\bar{p}$) gets annihilated with a proton (p), or an antineutron ($\bar{n}$) with a neutron (n), or a nucleon of one kind with an

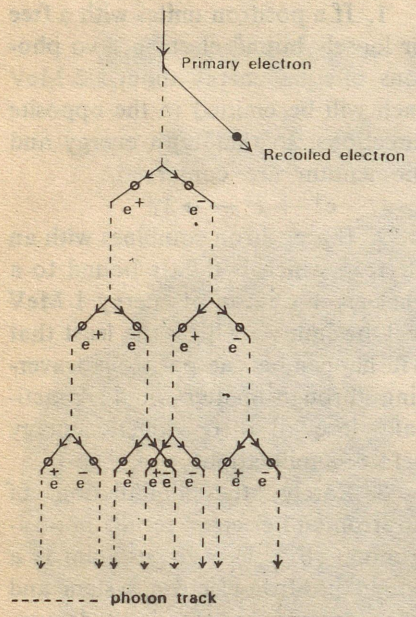

Fig. 2. Cascade shower

antinucleon of another kind, several neutral and charged pions are produced.

$$p + \bar{p} \rightarrow 2\pi^+ + 2\pi^- + 2\pi^\circ$$
$$n + \bar{n} \rightarrow 2\pi^+ + 2\pi^- + 2\pi^\circ$$
$$p + \bar{n} \rightarrow \pi^+ + \pi^\circ$$
$$n + \bar{p} \rightarrow \pi^- + \pi^\circ$$

Any number of pions can be produced in such reactions provided the total charge and energy of the system remain conserved. Sometimes the proton-antiproton annihilation leads to the formation of lambda-antilambda pair.

$$p + \bar{p} \rightarrow \lambda_\circ \bar{\lambda}_\circ$$

Both lambda and antilambda particles are unstable hyperons, the so-called strange particles, and are 2183 times as massive as an electron. They decay with a mean life of 2.2×10^{-10} sec. yielding,

$$\lambda_\circ \rightarrow p + \pi^- \quad (67\%)$$
$$\rightarrow n + \pi^\circ \quad (33\%)$$
$$\bar{\lambda}_\circ \rightarrow \bar{p} + \pi^+ \quad (67\%)$$
$$\rightarrow \bar{n} + \pi^\circ \quad (33\%)$$

When a proton encounters an antiproton, the electric charges of the two particles may be neutralized. This reaction is called recharge. In this case the proton and antiproton give birth to a neutron and an antineutron.

$$p + \bar{p} \longrightarrow n + n$$

This is one of the possible ways through which antineutron is produced.

Sometimes the nucleon-antinucleon annihilation results in the formation of very short-lived (10^{-23} sec) particles, called resonances, along with pions. These particles are usually neutral omega meson (ω°), with a mass 1530 times the electron mass, and rho ($\rho^\pm$, ρ°) mesons with masses about 1490 times the electron mass. These resonance particles are extremely unstable and usually decay into pions.

Antiparticles in the Universe

With different antiparticles one can easily conjure up different antiatoms, such as antihydrogen consisting of antiproton with a positron rotating about it, and even antiworld, where all the materials are built up with antiatoms of different elements. How does antimatter come into existence? In 1973, Russian scientists at the Institute of High Energy Physics, Serpukhov, created antitritium, the counterpart of tritium, a heavy radioactive isotope of hydrogen. For the creation of such an antiatom, they beamed energetic protons (30 BeV) on an aluminium target.

Today astronomers have located some 2000 radio sources such as Crab Nebula, Cassiopeia A, Messier 87 and Omega Nebula in the Milky Way (*S.R.*, August 1975, pp. 362-66) and a few outside it such as Cygnus A. The signals emitted by these sources are now supposed to be generated by highly accelerated charged particles, which may have been created by the annihilation of matter. The



Fig. 3. MESSIER-87. The radio waves from the bright jet at right is unusually strong— may be due to the annihilation of anti-matter

strong radio signals from Cygnus A and its double structure indicate that they may be two colliding galaxies in mutual annihilation.

Scientists also suggest that the annihilation of matter with antimatter in the universe may be the source of cosmic particles. The annihilation of uranium, the heaviest possible element existing in nature, with its counterpart produces an energy about 10^8 MeV. It is much less than the maximum energy of the cosmic ray primaries, which is of the order of 10^{12} MeV. It is now believed that, if not completely, at least a portion of the high energy cosmic rays may be due to the annihilation process in the interstellar space.

The cosmic ray showers can be explained by the process of annihilation and creation in succession. The multiplication continues until the energy of the photon falls below the critical energy or the electrons are stopped by ionization. Such showers are often produced in the atmosphere, starting with high energy photons from the decay of π°-mesons,

one of the components of primary cosmic ray.

The concept of matter-antimatter is also extended to quark-antiquark and gravity-antigravity. It has been said that protons are built up of combinations of three still more fundamental particles, called quark, and also that one quark is thirty times as massive as a proton. Most of the masses of these quarks exist in a nucleon as binding energy, to hold it. The repulsion of one body by another by means of gravitational interaction is called antigravity. Anti-gravity should not be confused with artificial gravity, which is created either by spinning the space vehicle or by accelerating it to avoid the biological effects of weightlessness.

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LETTERS (*Continued from page* 646)

vicinity of bregma, powerful supra orbital torus and a cranial capacity ranging from 1150 cc to 1300 cc. The morphological features like relatively longer skull and heavy supra-orbital torus are similar to those of classic Neanderthals. However, the Solo-man resembles man in having well expressed styloid process and very deep glenoid fossae. Poirier in 1973 referred to it as Neanderthaloid, i.e., a group of Neanderthals whose taxonomic position is not very clear. Another view advocated by Weidenreich holds that the Ngandong skulls resemble *Pithecanthropus* more closely than *Sinanthropus*, that they represent the next stage in evolution above *Pithecanthropus*, and are probably his descendents and that they are more primitive than Neanderthaloids.

The Ngandong Beds, which yielded remains of Solo-man, are geologically of Upper Pleistocene time (about 70,000 years old). The bone and stone implements found in association with these fossils are also indicative of a more or less similar age of this significant primate.

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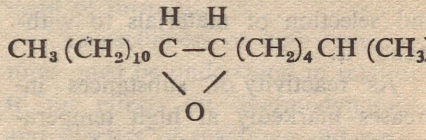
Odour

Sir, I have read the informative and interesting article **Chemical nature of odour** by S.K. Zutshi (*S.R.*, April 1978). I would like to add a few lines on this subject.

The validity of vibrational theory of Dyson-Wright and stereochemical theory of Moncrieff-Amoore was probed by Blum *et al.* (University of Georgia, Maryland, U.S.A., 1971). The two theories were subjected to experimental evaluation by way of determining the responses of ants to their natural alarm pheromones and to related compounds. 4-methyl-3-heptanone, the alarm pheromone of *Pogonomyrmex badius*, was selected as model compound for this study. Their results were consistent with the olfactory theory which suggests that size and shape of a molecule are critical determinants of its odour qualities.

Smell is the most direct of the senses—odour molecules simply bind to specific receptor neurones and trigger off an electrical response. But nothing was known of the molecular mechanism by which binding of odorant molecule to the membrane of a receptor is translated into an electrical response. Recent work of George Dodd and his team (University of Warwick, U.K., 1977) on frog (*Rana temporaria*) has proved that cyclic AMP is involved in the process of generating an electrical response when an odour molecule binds itself to an olfactory receptor neurone.

In the Table for sex attractants, Zutshi has given the old structure of sex attractant of gypsy moth, *Porthetria dispar*, given by Jacobson (Agricultural Environmental Quality Institute, Maryland, U.S.A., 1960, 1961). Synthetic and commercial samples of this attractant were inconsistent in attractiveness, evident by the erratic activity in the field and laboratory bioassays. This prompted a reinvestigation of its physical, chemical and biological properties. In 1970, Bierl *et al.* (Agric. Environ. Qual. Inst., Maryland, U.S.A.) were able to determine the true structure of the fantastically potent sex attractant of this insect (Fig 1). It is cis-7, 8-epoxy-2-methyloctadecane.



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Oh! The high temperatures

Man's progress has gone hand in hand with his ability to produce progressively higher temperatures

HEM SHANKER RAY

V. N. SHARMA

NATURE has given us a lower limit of temperature, the absolute zero. But, it has not given us an upper limit. In science today temperatures of the order of hundreds of thousands of degrees are conceivable. Such temperatures have been detected and measured too.

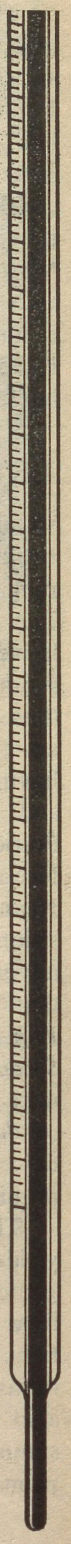
A layman's world knows a rather limited temperature range. His body temperature is 'very high' when it is 40°C-41°C, that is, 3°-4°C above the normal. The weather temperature touches a 'record' high when it is about 45°C. Here 'high' is defined in relation to what is safe and bearable for the human system. The layman is, of course, familiar with fire. In an ordinary fire the temperature is usually below 1000°C. In a laboratory today, 1000°C is considered only moderate. The temperature is considered high only when it exceeds 1000°C. Here 'high' or 'low' is defined from the technological point of view—in terms of difficulties in attainment of the temperature and selection of materials to withstand it.

As reactivity of substances increases markedly at high temperatures, it may seem that high temperatures actually leads to chaos, of course, in the chemical sense. But it is not so. It only opens up the immense opportunities one has for chemical synthesis and transformation reactions at elevated temperatures. Many inorganic materials are fabricated at high temperatures.

The earth itself is a product of high temperature reactions. During its creation, the primordial matter in molten state was immersed in an environment of reducing gases. Heavy metals reduced from inorganic matter sank to, the interior because of their high density. Unreduced sulphides and oxides floated to the top as upper layers because of their lower densities. No wonder nearly half of earth's crust is oxygen and the outermost layers oxides, mainly silica. Subsequently, there followed through millenia geochemical changes of infinite variety in endless cycles.

Much of today's chemical and metallurgical operations attempt to reproduce in small scale these high temperature reactions of nature. Iron is produced by reducing iron oxide ores, ammonia is synthesized from nitrogen and hydrogen using high pressure and temperature, and carbon is converted into artificial diamond by a process of 'laboratory scale metamorphosis'.





Man's progress and high temperatures

Historically, fire has been thought

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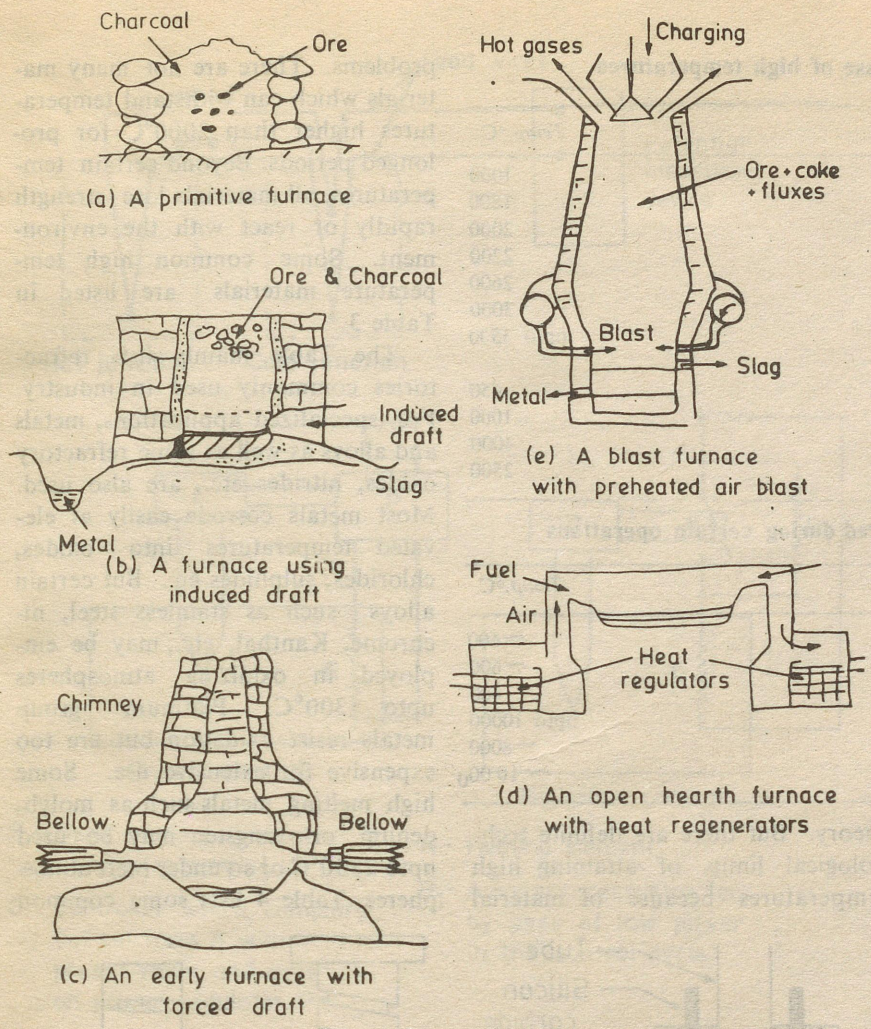


Fig. 1. Development of combustion furnaces

to have magical and mystical powers. It has been used in making of the witch's brew as well as priest's offering to God and has been the chief aid of alchemists. Fire has been worshipped as a god. All this because it creates high temperatures at which unusual things happen.

It is interesting to note that man's progress went hand in hand with his ability to create progressively higher temperatures. In the chalcolithic period (*chalcos*-copper, *lithos*-stone), the early man could make only open pit fires giving rather low temperatures (about 600°C). He could thus carry out some low temperature smelting operations and produce limited quantities of low melting alloys such as bronzes. Subsequently, the primitive furnace was improved. Provisions were made for natural draught from below and then forced draughts through bellows. Use of forced draught in a coke-fired furnace gives a temperature upto 1350°C.So it was possible to melt copper and impure iron. But this temperature remained as the upper limit until the middle of the last century.

Only in the 19th century was it realised that preheating of air is necessary to obtain higher temperatures. The open hearth process of Siemens and Martin employed heat regenerators to utilize heat of the flue gases to raise the temperature of the incoming air. It was also realized that the temperature can be further raised by oxygen enrichment of air (actual realization of this principle had to wait for many years until large scale production of oxygen became possible). Using preheated air and fuel, temperatures of the order of 1600°C or higher could be obtained and large-scale steel production became possible. Today, much higher temperatures are produced not only by burning fossil fuels (coal, coke, petroleum oil products) with preheated and oxygen enriched air, but also by a variety of other means. Fig. 1 shows schematicallly the development of furnaces.

The usefulness of high temperatures must be understood in relation to the effects on thermodynamics and kinetics of reactions and structure of materials in general. Thus, high temperatures make possible reactions which do not take place at ordinary temperatures. Secondly, the reaction rate increases exponentially with temperature (roughly it

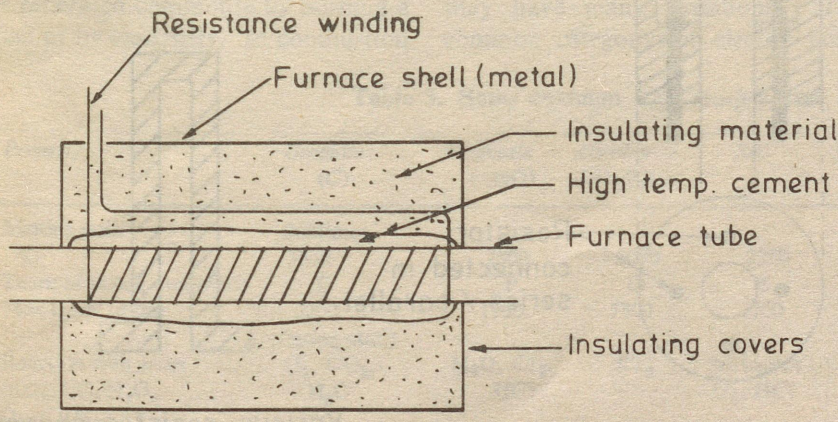


Fig. 2. Design of a laboratory resistance furnace

Table 1. Some examples of use of high temperatures

Process	*Temp.* °C
Petroleum processing	1000
Iron and steel production	1800
Calcium carbide production	2000
Silicon carbide production	2200
Boron carbide production	2600
Graphite manufacture	3000
Metallothermic reduction of rare metal oxides	upto 3500
Power and Propulsion	
Steam turbine	650
Gas turbine	1000
Chemical rocket	4000
Nuclear heat transfer	2500

Table 2. High temperatures produced during certain operations

Operations	*Temp.*°C
Rocket chamber coolants	~600
Aircraft brakes	~600
Surface temperature on supersonic planes	400
Space vehicle reentry temp.	upto 10000
High explosives	~8000
Nuclear fireball	~ 10 000

doubles for every 10°C rise in temperature). This is a tremendous advantage. The pressure cooker speeds up cooking enormously by simply raising the boiling point of water (and, therefore, the cooking temperature) by 30°C-40°C. Thirdly, higher temperatures produce liquid phases which are easily separated and collected. A liquid metal is separated from unreduced gangue more easily than a solid metallic product. Again, if vapours are produced by heating, as in distillation, an easy separation from condensed phases is achieved. Because of these and other advantages, high temperatures are commonly employed in many industrial operations. Table 1 lists some of them.

High temperatures today are produced by several energy conversion processes. Burning of fuels is only one of them. They can also be produced by converting other forms of energy like electricity, mechanical energy, sonic and ultrasonic waves, various radiations including solar energy etc., into heat. All these can generate intense heat at least in theory. But there are definite technological limits of attaining high temperatures because of material problems. There are not many materials which can withstand temperatures higher than 2000°C for prolonged periods. Beyond certain temperatures, all materials lose strength rapidly or react with the environment. Some common high temperature materials are listed in Table 3.

The Table mainly lists refractories commonly used in industry. For specialized applications, metals and alloys as well as some refractory oxides, nitrides etc., are also used. Most metals corrode easily at elevated temperatures into oxides, chlorides, sulphides etc. But certain alloys such as stainless steel, nichrome, Kanthal, etc., may be employed in oxidizing atmospheres upto 1300°C. Platinum group metals resist oxidation but are too expensive for extensive use. Some high melting metals such as molybdenum or tungsten may be used upto 2300°C or so under inert atmospheres. Table 4 lists some common

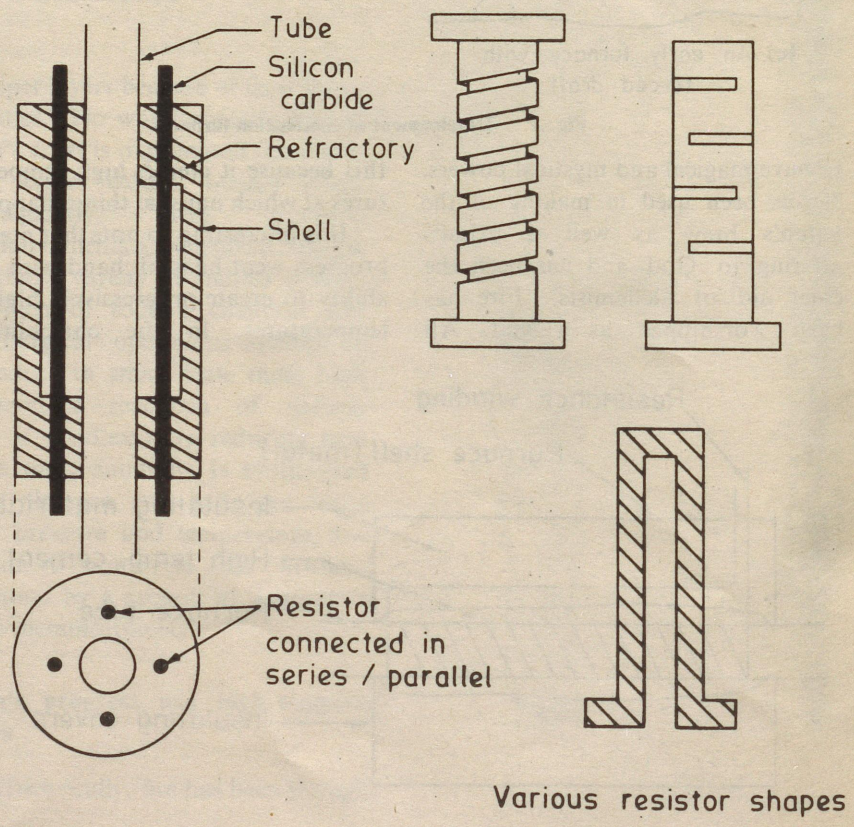


Fig. 3. Use of non-metallic resistor elements

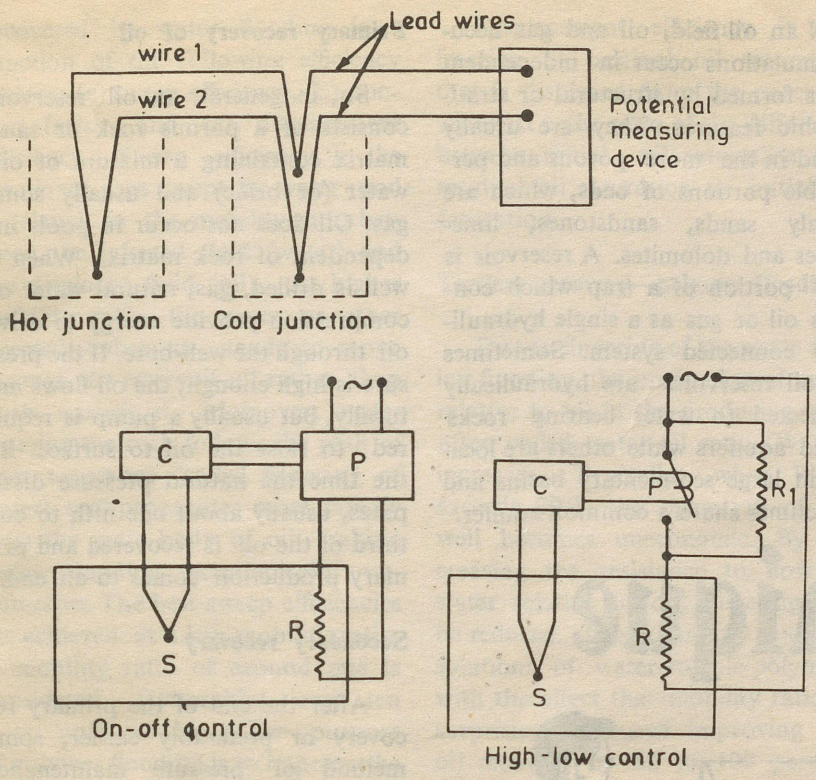


Fig. 4. Use of thermocouple

resistor materials and conditions of their use.

Attainment of high temperatures

In the laboratory or industry heat is generated commonly by burning a fuel or by electricity. In combustion reactions, the temperature is controlled through preheating of air or fuel, oxygen enrichment of air and proper choice of the fuel. The control generally is poor. Better control is obtained in electrical heating which may have many variations. The common categories of electric heating are: resistance heating, induction heating, arc heating and electron beam heating. The first two are by far the most common. A simple design of an electric wire-wound heating furnace is shown in Fig. 2.

Measurement and control

The use of mercury thermometer for measuring temperature is well known. But this device becomes unsuitable above 300°C or so because of the increasing vapour pressure of mercury (boiling point 440°C). For measuring higher temperatures, the most commonly used device is a thermocouple.

The thermocouple is made by joining two wires of dissimilar metals (or alloys). When the joint is heated, a potential develops across the open ends. In actual practice, the open ends must be connected to a potential measuring device such as a potentiometer (Fig. 4). The potential measured is a function of the difference in the temperatures of the 'hot' junction and the 'cold' junction. Table 5 lists thermocouples which are commonly used in laboratories and also industries alongwith the specific condition of their use.

High temperatures are also measured using optical pyrometers. In the most common type, radiation from the heat source is compared against an internal standard filament whose radiation has been precalibrated against known tempera-

(Contd. on page 706)

Table 3. Some common high temperature refractories

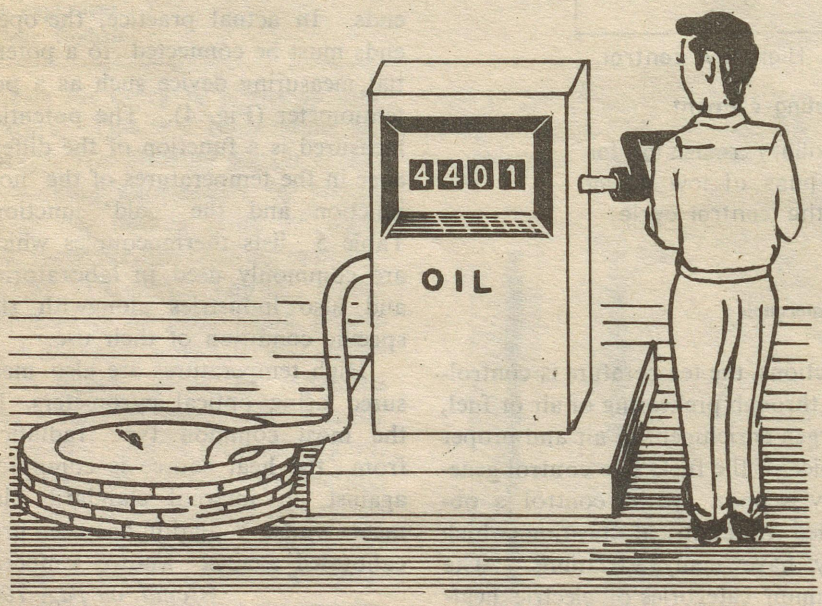
Property	*Graphite (C)*	*Magnesia (MgO)*	*Alumina (Al_2O_3)*	*SiC*	*Magnesite $MgCO_3$*	*Silica (SiO_2)*	*Mullite*	*Fire clay*
Melting point, °C	Sublimes 3500	2800	2030	2250	2800	1830	2000	1840
Thermal shock resistance	E	P	G	E	F	E	G	F
Max temp. of use	2200 (reducing atm.)	1900	1800	1700	1900	1500	1700	1500
Reaction with gases (CO_2, CO, H_2O, O_2, Cl_2H_2, HCl, S_2,	O_2, CO_2, H_2O	H_2O, Cl_2. HCl	Cl_2	All except H_2, HCl	Cl_2, H_2 HCl	Cl_2, S_2	Cl_2, S_2	Cl_2, S_2

80 % more oil can be recovered by polymer flooding, than by using water flooding alone.

N.C. DEY

G.S. MONY

A technique



for more oil from wells

IN an oil field, oil and gas accumulations occur in independent traps formed by structural or stratigraphic features. They are usually found in the more porous and permeable portions of beds, which are mainly sands, sandstones, limestones and dolomites. A reservoir is that portion of a trap which contains oil or gas as a single hydraulically connected system. Sometimes the oil reservoirs are hydraulically connected to water bearing rocks called aquifers while others are located in large sedimentary basins and sometimes share a common aquifer.

Primary recovery of oil

So, in general, an oil reservoir consists of a porous rock or sand matrix containing a mixture of oil, water (or brine) and usually some gas. Oil does not occur in pools independent of rock matrix. When a well is drilled, gas, natural water or compression provide energy to drive oil through the well-bore. If the pressure is high enough, the oil flows naturally, but usually a pump is required to raise the oil to surface. By the time the natural pressure dissipates, usually about one fifth to one third of the oil is recovered and primary production comes to an end.

Secondary recovery

After the end of the primary recovery or preferably earlier, some method of pressure maintenance must be used for the recovery of more oil. The most widely used methods are water flooding and gas injection. In some fields, steam injection is also used. *In situ* combustion process is adopted for very high-viscous oils. Gas injection to repressurise the reservoir is costly and so water flooding is the principal method of secondary recovery, specially because it is less expensive. Water flooding was first used 100 years ago, but it gained popularity only in the 1950's. As water is injected into the formation at high pressure, the gas within the formation distributed throughout the oil zone is first compressed. Eventually, sufficient pressure builds up and increased flow of oil into the producing wells is observed.

Polymer flooding

To understand the purpose of polymer flooding , it is necessary to know the principle of water flooding. The fraction of oil that can be

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recovered by water flooding is a function of the following efficiency factors; (a) sweep efficiency, (b) contact factor, and (c) displacement efficiency. Sweep efficiency is the fractional area swept by water and is related to the mobility ratio between the injected fluid (water) and the displaced fluid (oil). At higher mobility ratio, the water or other injected substance tends to move through the reservoir-oil rather than push against it. Moreover, water entering the rock follows the path of least resistance (called fingering of water) and propagates more rapidly than the main body of oil, making water flooding economically unattractive. The best sweep efficiencies are achieved at a low mobility ratio. A mobility ratio of around one is considered favourable; over ten it is unfavourable. The purpose of polymer flooding is to improve the sweep efficiency by lowering mobility ratio.

Mobility ratio (M) is given by the formula :

$$M=(K_w/\mu_w)/(K_o/\mu_o)$$

where K_w is permeability of water, μ_w is viscosity of injected water, K_o is permeability of oil and μ_o oil viscosity. It is evident from the equation that mobility ratio can be decreased either by decreasing K_w or by increasing μ_w. Thermal methods, viz., steam injection or *in situ* combustion also decreases μ_o and improves the recovery by lowering the value of mobility ratio.

Contact factor is the fraction of the swept volume that has been reached or contacted by the injected fluid. It is defined as the ratio between reservoir volume contacted by water, and total reservoir volume swept. Contact factor may approach 100 per cent in homogeneous clear sand reservoir but 75%-90% range is considered average in typical reservoirs.

Displacement efficiency is the fraction of original oil saturation that is displaced from the pores by water. It is the ratio of the difference between initial oil saturation and residual oil saturation to initial oil saturation.

Tertiary recovery—polymer flooding

Due to fingering of the water during flooding, the proportion of water relative to oil in the producing well, often called water-oil ratio (WOR), increases. Typically, when WOR exceeds 20:1, the operation of the well becomes uneconomic. By increasing the resistance to flow of water relative to oil, fingering can be reduced. This is done by injecting solutions of water-soluble-polymers with the effect that mobility ratio is surprisingly reduced improving the oil recovery by 50 to 100 percent over that which could be realised with water alone.

The process. A polymer is a large molecule made up of thousands of repeating units called monomers. Monomers join to form long chain molecules of molecular weight of millions. Polymer flooding is done by injecting a slug of water-soluble polymer solution. Generally, polymer slug ranging from 6% to 33% of the volume of reservoir pores are used. The polymer slug is then displaced with drive water. In a typical case (Fig. 1), 30 per cent pore-volume slug of 0.05 per cent solution of hydrolysed polyacrylamide of intermediate molecular weight is injected and followed by water.

Eighty per cent more oil can be recovered by polymer flooding than by using water flooding alone.

Choice of polymers. Although understanding of the process is still incomplete, there are certain minimum criteria for the suitability of a polymer to the polymer flooding scheme. The polymer must be soluble in water. It must reduce the

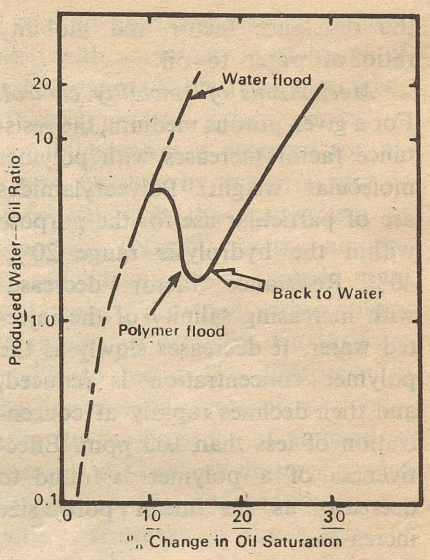

Fig. 1. Field flood results

mobility of the injected water, and propagate through rocks without plugging the pores and with minimum adsorption. It should have adequate mechanical, chemical, thermal and biological stability and be economical. Most polymers used for the purpose are derived from polyacrylamides. Some bio-polymers, viz., xanthan gum, guar gum and modified cellulosics also possess the above mentioned properties.

Mobility control

Soluble polymers added to water flood only reduce the mobility of water without affecting the oil mobility. A convenient parameter used by petroleum technologists is resistance factor (R) which is the ratio of water mobility to polymer solution mobility in porous medium at the same oil saturation;

$$R=(K_w/\mu_w)/(K_p/\mu_p)$$

where subscripts w and p refer to water and polymer respectively. Unlike individual mobility, the resistance factor (R) is not affected much by the oil content of the porous medium. Mobility ratio of polymer solution to oil can be estimated from

the resistance factor and mobility ratio of water to oil.

Mechanisms of mobility control. For a given porous medium, the resistance factor increases with polymer molecular weight. Polyacrylamides are of particular use for the purpose within the hydrolysis range 20%-40% Resistance factor decreases with increasing salinity of the injected water. It decreases slowly as the polymer concentration is reduced, and then declines rapidly at concentration of less than 100 ppm. Effectiveness of a polymer is found to decrease as the mean pore size increases.

Permeability of a porous medium to water is reduced by polymer flooding because of certain factors like (a) retention of polymers within the porous medium, (b) viscoelastic effect, and (c) microgel formation.

Applications

Polymer flooding is most useful for moderately heterogeneous reservoirs when the water-oil mobility ratio is between 5 and 40. Since it is more difficult to inject viscous polymer solution than water, the reservoir must have good permeability. If the permeability is too low or the crude viscosity is too high, an economical injection rate cannot be attained. In stratified reservoirs, however, more oil can be produced with less water, using polymer flooding.

Polymer flooding has certain disadvantages too, the most important of them being the degradation of polymers. Polyacrylamides are adversely affected by shear. Special care must therefore be exercised in the surface handling of polyacrylamide solution to reduce excessive shear in pumps, valves and well head equipment. On the other hand, biopolymers are susceptible to bacterial attack.

Polymer flood project was initiated in the Zaloni Second Sand Pool (Assam) by Oil India Ltd. in December, 1975. The impact of the polymer treatment on production is expected to be felt only after the project has been in operation for about 4 to 5 years. But reservoir engineering study results show that an oil recovery of around 38 per cent of the original oil-in-place can be expected through polymer flooding. This may be compared to oil recoveries of around 21 per cent and 34 per cent under primary depletion and water flooding respectively.

In Sanand, Sobhasan and North Kadi oil fields, the mobility ratio of oil to water is rather unfavourable. The possibility of using polymer flooding technique in Sanand (20 km from Ahmedabad) is being investigated intensively on laboratory scale by Oil & Natural Gas Commission with American collaboration.

Polymer treatment may also help to reduce water production in some of the wells of North Kadi, Sobhasan, Nahorkatiya, Moran, Lakwa-Tipams and Rudrasagar as also in Aliabet-offshore. However, extensive field trials and laboratory studies are necessary in each case before any large scale use can be envisaged.

Research is in progress on the improvement of polymer flooding technique. Extensive development programme has been done in the USA on application of polymers like polyacrylamides for imprvoing recovery of oil.

The use of polymers in water flooding is expected to increase in the coming years since the bulk of oil remaining in the fields has already reached or will soon reach the economic limit on primary and secondary recovery methods.

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Corringendum

In **Masking in Chemistry and Industry** (*S. R.*, August 1978) page 546, *read* Fritz Feigl *for* Fritz Feil.

The enzyme, nitrogenase, plays an important role in nitrogen fixation

They grab nitrogen of the air

RAGHUVIR SINGH

THE term nitrogen fixation was coined to identify the process whereby molecular nitrogen is converted into nitrogenous compounds such as ammonia. In the biochemical sense, the definition implies that fixation of nitrogen is an integral part of the overall metabolic process taking place within the system of biological agents responsible for nitrogen fixation. The subject of nitrogen fixation has advanced from two main approaches. One is related to the study of natural nitrogen fixation caused by bacteria and other living organisms. The other approach is to see whether any fixation of nitrogen can be achieved chemically under conditions similar to those found in bacteria. Here we shall be more concerned with the former approach.

Atmospheric nitrogen is the ultimate source of nitrogen for the synthesis of nitrogenous organic compounds. Throughout the plant and microbial kingdom, there are species that are capable of reducing nitrogen to ammonia. They are called nitrogen-fixing organisms. Such organisms include species of heterotropic bacteria, both aerobic (*Azotobacter vinelandii*) and anaerobic (*Clostridium pasteurianum*), photosynthetic bacteria (*Rhodospirillum rubrum*); several algae; and a symbiotic system, consisting of bacteria *Rhizobium* together with certain plants, principally legumes. In the last case, neither the bacteria nor the plant alone can fix nitrogen. The symbiotic bacteria such as *Rhizobium* are important for normal bacterial life in the soil, but they do not fix nitrogen as such. In contrast, the asymbiotic bacteria live and fix nitrogen in the soil, but are important only ecologically in the context of barren soils. They may easily be cultured in the laboratory and most of the information regarding the chemistry and biochemistry of natural nitrogen fixation is obtained from them.

Certain plants, especially the legumes (Clover, alfalfa, beans, peas, etc.) grown in soil deficient in fixed nitrogen, exude substances which attract a specific species of *Rhizobium* to the root hairs. The bacteria multiply within the infected root cells of the host causing formation of nodules on the root. The nodules, called 'bacteroids', carry out fixation of nitrogen, and provide the host plant with ammonia in exchange of carbohydrate. Table 1 lists a number of such nitrogen-fixing species.

Molybdenum is essential for nitrogen fixation by bacteria and is associated with the metabolism of dinitrogen ($N \equiv N$). In the absence of molybdenum, these bacteria grow well only if provided with a source of ammonical nitrogen, but they are unable to metabolize dinitrogen in the presence of excess of molybdenum. In the presence of ammonical nitrogen, the bacteria do not produce nitrogenase, the nitrogen-fixing enzyme. However, if the source of ammonia is removed, the bacteria produce nitrogenase and metabolize dinitrogen easily. The amount of molybdenum required for nitrogen fixation is usually very small, for example, the bacteria *Beijerinckia indica* require only 0.004-0.035 pp m for half optimal growth. Nitrogen fixing organisms contain other metal ions as well, but they are concerned with associated enzyme systems and not directly with nitrogen fixation.

Ammonia is the prime form of inorganic nitrogen utilized by all living cells in the natural systems. No evidence has so far been obtained of the formation of hydroxylamine, hyponitrous acid, di-imine, hydrazine or any other substance as intermediate which might be construed on thermodynamical considerations.

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Table 1. Some biological nitrogen-fixing systems

Asymbiotic	*Symbiotic*
(a) Anaerobic	(a) Root nodules
C. pasteurianum	Legumes, Rhizobium and leguminous plant, non-legumes, microbe and tree or shrub
Chlorobium (Photosynthetic)	
Chromatium	
(b) Aerobic	(b) Leaf nodules
Azotobacter	Bacteria and leaf of *Psychotria emetica*
Anabena (photosynthetic)	
Azotomonas	
Beijerinckia	
(c) Facultative	(c) Lichens
B. polymyxa,	*Nostoc*, *Anabena*,
Klebsiella sp.	*Tolypothrix* and fungus

Table 2. Substances which interact with the nitrogenase system

Substance	*Interaction/product*	*Relative rates*
N_2	$2NH_3$	1.0
N_2O	N_2+H_2O	3.0
N^-_3	NH_3+N_2	3.0
CN^-	CH_4, NH_3, $MeNH_2$	0.6
$CH \equiv CH$	$CH_2=CH_2$	4.0
CH_3 NC	$CH_3NH_2+CH_4$	0.8
H_2	Competitive inhibitor of nitrogen fixation	
N_2H_4	Inhibitor	

Dinitrogen in its intermediate stages of reduction is held by the enzyme, only ammonia is free. In fact, hydrazine is not reduced by the enzyme but poisons it.

Bacteria are very efficient nitrogen-fixers because they operate under mild conditions of temperature and pressure with carbohydrates or similarreducing agents. The enzyme nitrogenase, tested *in vitro*, requires considerable amounts of adenosine triphosphate (ATP) for its function. Approximately 12 moles of ATP are hydrolyzed to reduce 1 mole of dinitrogen to 2 moles of ammonia, which correspond to a free energy value of 105 K cal $mole^{-1}$ of dinitrogen. All nitrogen-fixing bacteria contain hydrogenase and can generate dihydrogen (H_2), although not all hydrogenase containing bacteria fix nitrogen. The bacteria do not utilize dihydrogen as such, rather dihydrogen is a competive inhibitor of nitrogen fixation.

Enzyme systems are usually more specific than the nitrogenase system, because the latter reduces a number of dinitrogen-like molecules, such as acetylene, which are competitive inhibitors of nitrogen fixation. Some of the dinitrogen analogous are listed in Table 2. In some cases, the triple bond is reductively split as in dinitrogen, but acetylene is reduced to ethylene free from ethane and methane. Carbon monoxide is not reduced but it does inhibit the reduction of ammonia. All these substances have a high affinity for class b transition metal ions and similarity between these compounds suggests that they are all bound to the nitrogen-fixing site during enzymatic reduction.

Earlier attempts failed to get active nitrogen-fixing cell-free extracts from bacteria, leading to the view that nitrogenase is very unstable. Recently it was demonstrated that, for isolation of cell-free extracts, molecular oxygen must be eliminated from the bacterial extract. This discovery stimulated the present interest in nitrogen fixation. It was also found that nitrogenase alone does not cause reduction of dinitrogen. The system also needs an electron carrier such as ferredoxin, and a reducing agent (sodium pyruvate) which appears to be specific and activates an ATP generating system. Ferredoxin accepts electrons from pyruvate in course of the phosphorochostic reaction, and it has the capacity to transfer them to a number of enzymes including nitrogenase. The pathway for pyruvate oxidation in *Clostridium pasteurianum* is indicated in Fig. 1. From this scheme it is clear that ferredoxin functions as an electron acceptor in pyruvate oxidation. Reduced ferredoxin can then be reoxidized in systems that reduce nitrites and hydroxylamine to ammonia, and $NADP^+$ to NADPH. Ferredoxin is essential for nitrogen fixation in *Clostridium pasteurianum*.

An important non-biological reductant for nitrogen fixation is hydrosulfite ($S_2O_4^{-2}$), which is a universal reductant for the nitrogenase reaction. It circumvents the usual electron carriers, that is, it interacts directly with the enzymatic machinery for the reduction. Use of hydrosulfite is very convenient, because it simplifies the spectrum of components necessary to achieve nitrogen fixation.

Nitrogenase obtained from several sources in a pure state has been examined. It can be separated into two proteins called smaller and larger proteins which may further be broken down into sub-units. The larger protein contains molybdenum, iron, cystein and labile sulfide in the ratio 1:20:20:15 and is usually referred to as molybdenum-iron protein, fraction 1, molybdoferredoxin, azo fermo and Fe-Mo proteins. The smaller protein contains two iron atom and sulfide groups per mole and called Fe protein, fraction 2, azo-ferridoxin and azofer protein. The smaller protein is labile but can be stored at liquid nitrogen

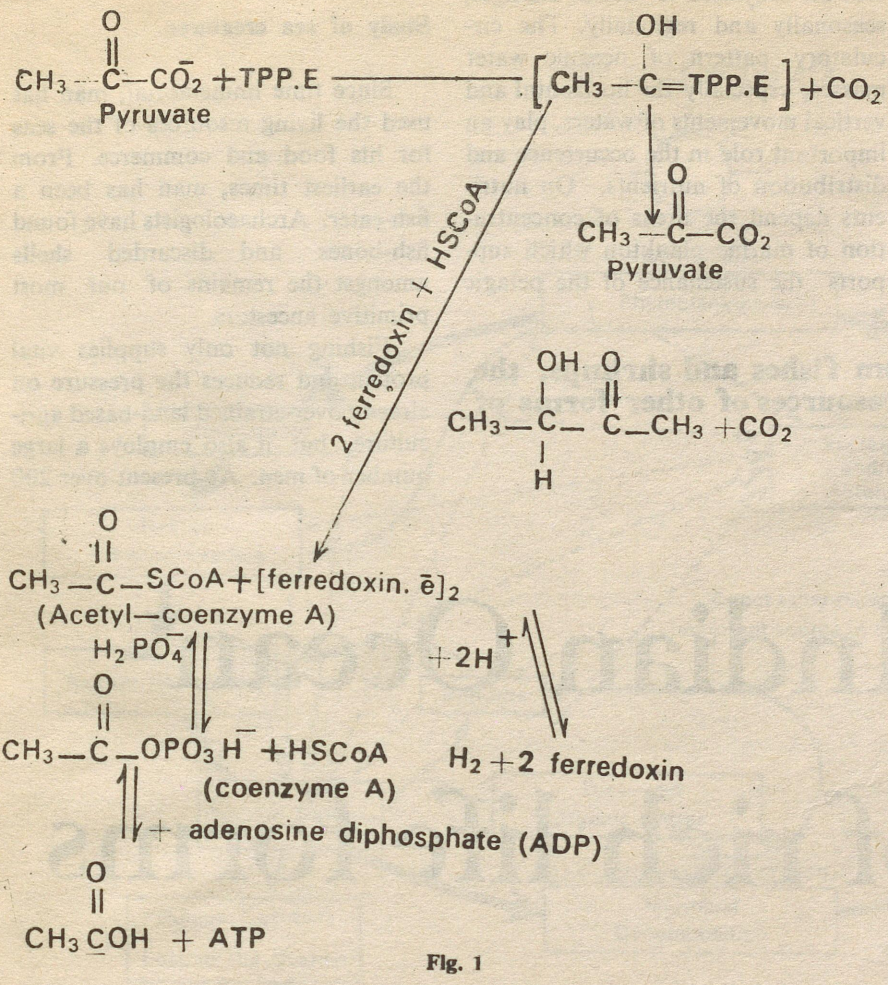

Fig. 1

temperature. It is particularly sensitive to oxygen. The larger protein obtained from one species of bacteria can be activated by the smaller protein from another if the two species of bacteria are closely related. The activity falls as the difference between the two types of bacteria increases. However, it is not possible to combine fractions from aerobic and anaerobic species. It is also known that when all conditions of nitrogenase activity are satisfied (ATP, reductant etc.,) the Fe-protein catalyses a reduction of some of the iron in the Mo-Fe protein. The two nitrogenase proteins have sometimes been considered to have distinct functions, one as a dinitrogen-trapping agent and the other as the reducer. However, except for the indications from Mössbauer spectroscopic data, there is no definite evidence in support of their distinct roles.

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The Indian Ocean- Home of rich life forms

P.G. JACOB

Studies show that, apart from fishes and shrimps, the Indian Ocean has abundant resources of other forms of marine wealth

FOR the first time in history, man is looking at the oceans, that cover three quarters of our planet's surface, as a real estate. Recent developments in technology have unlocked the sea depths Oilmen can locate oil, drill and cap wells under enormous pressures of 2100 meters of water. Mining companies know how to sweep minerals off the cold, abyssal plains 60,000 meters down. Fishermen in modern, mechanised trawlers can easily draw bottom fishes off the ocean floor with a kind of vaccum cleaner. Industrialised nations are waiting only for their legal rights before the race for the sea resources begins in earnest.

The world's oceans cover most of the planet's surface leaving only 29 per cent of it to the continental land masses. The ocean, though a single phase environment, is a heterogenous medium. The temperature, salinity, dissolved organic and inorganic matter, dissolved gases and physical nature of the seas are subjected to various changes, seasonally and regionally. The circulatory pattern of oceanic water masses, especially the horizontal and vertical movements of waters, play an important role in the occurrence and distribution of nutrients. On nutrients depend the areas of concentration of marine plankton which supports the sustenance of the pelagic fish constituting an overwhelming bulk of the marine fisheries of the world. Conditions in the aquatic environment and their changes influence the aperiodic and seasonal migrations and occurrence of the living resources, their spawning, recruitment, survival, growth and other life activities. The essence of the relationship of oceanography to fisheries is analogous to that of meteorology to agriculture. Therefore, no rational study of the living beings, especially of those which are economically important, is possible without detailed oceanographic studies.

Study of sea creatures

Since time immemorial, man has used the living resources of the seas for his food and commerce. From the earliest times, man has been a fish-eater. Archaeologists have found fish-bones and discarded shells amongst the remains of our most primitive ancestors.

Fishing not only supplies vital protein and reduces the pressure on already over-strained land-based agriculture, but it also employs a large number of men. At present over 200 nations are engaged in fishing the seas. The current retail value of the world catch is estimated at 200 thousand million rupees. The widening gap between rich and poor is strongly reflected in the world fishery statistics. Among the countries which land about three quarters of the world catch, there is only one developing country, Peru.

Man's ever-increasing need for protein would force him to look beyond the species he currently uses as sea food. A logical development would be to move down the food chain, as the seas support a greater quantity of life at the lower levels.

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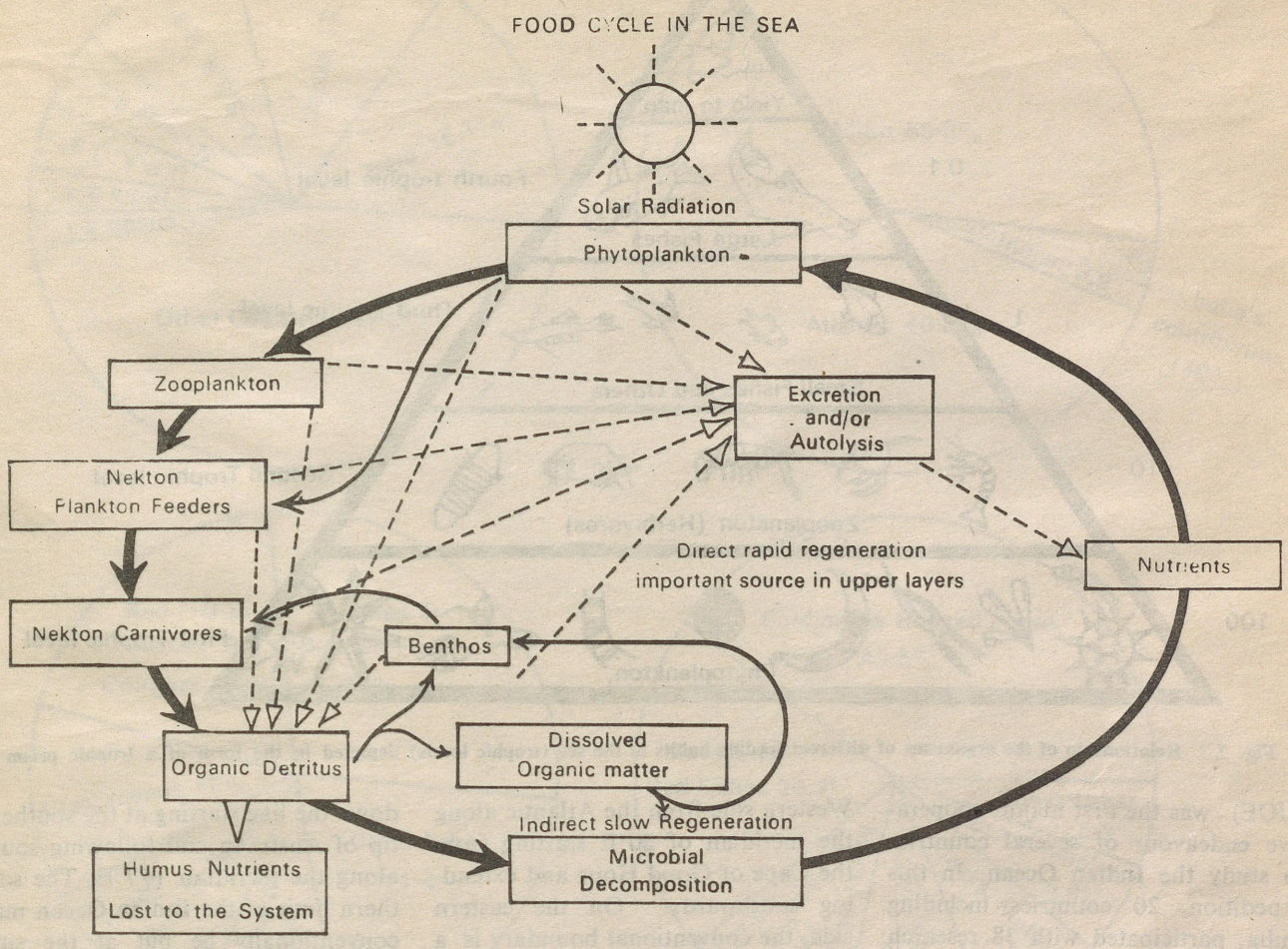

Fig. 1. Production and pathways of living resources (food cycle) in the sea

Man will also have to 'farm' the seas in addition to merely hunting for living resources. The farming of shell fish is an exceptionally efficient way of producing protein. Some existing Spanish mussel beds yield annualy three hundred thousand kilograms per hectare. Whereas the average yield of trawled fish in continental shelf waters is only 25 kg to 75 kg per hectare.

It is now clear that the days are gone when seas and the oceans were looked upon only as channels of trade routes, for colonisation of distant lands or for the mere thrill of exploring the unknown regions. While the oceans still hold many secrets, concerted efforts are being made to study their yet untapped resources and ways to exploit them to our best advantage. However, any exploitation must be done rationally because it would not be proper for us to deprive the coming generations of this valuable resource through neglect. The living resources of the sea, though self generating, are not inexhaustible, and this calls for a scientific approach in their exploitation.

Studies on the Indian Ocean

The knowledge of the seas around India has been derived until recently mainly from the observations made by research ships such as the *Challenger* (1872-76), *Gazelle* (1874-76), *Investigator* (1884-1925), *Vitiaz* (1886-1909), *Egeria* (1894), *Valdivia* (1898-1899), *Gauss* (1901-1903), *Discovery* I (1901-1904), *Sea Lark* (1905), *Planet* (1906-1907), *Aurora* (1911-1912), *Dana* I (1921-22), *Dana II* (1935), *Snellius* (1924-1930), *Discovery II* (1929-31), *Mahabis* (1933-38), *Albatross* (1947-1948), etc., during their scientific cruises. The research ships of the International Geophysical Year (I.G.Y.) Programme also have added to the knowledge about the Indian Ocean. The International Indian Ocean Expedition

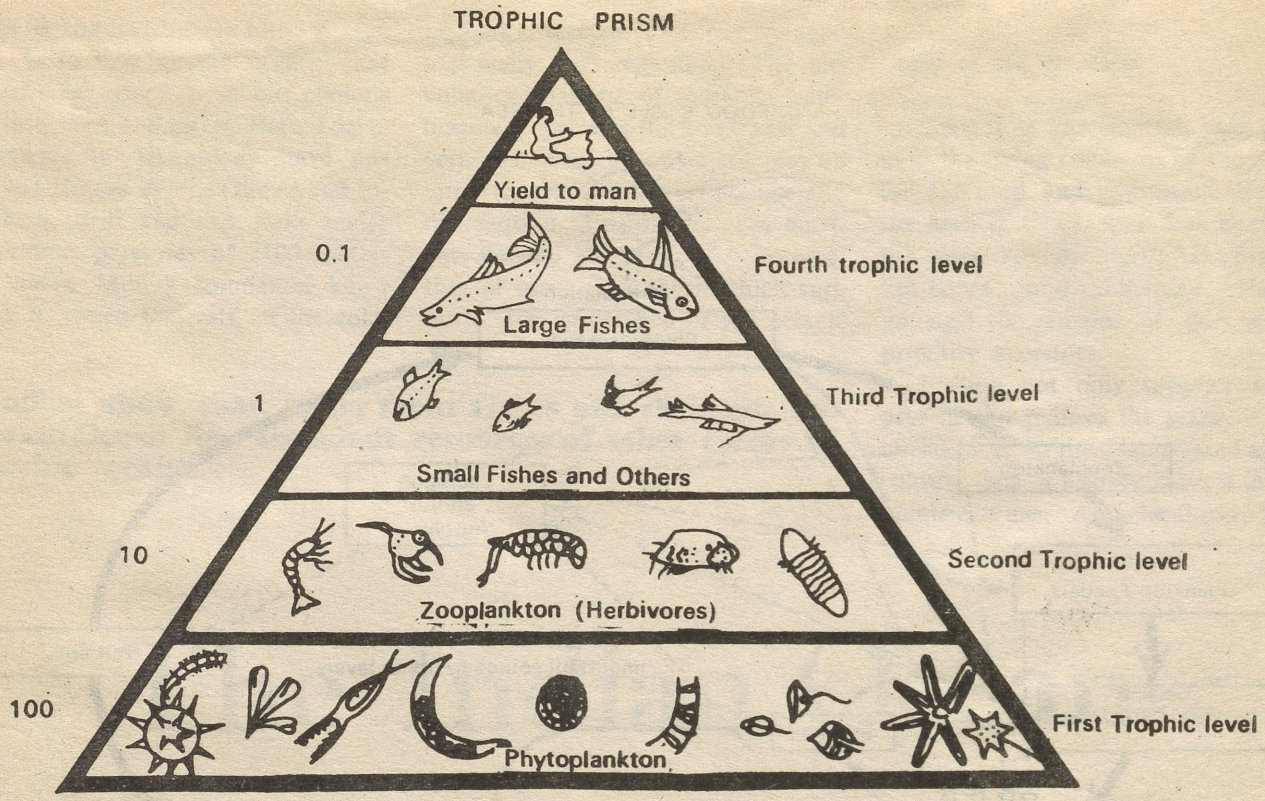

Fig. 2. Relationship of the organisms of different feeding habits in the sea (trophic levels) depicted in the form of a trophic prism

(IIOE) was the first major cooperative endeavour of several countries to study the Indian Ocean. In this expedition, 20 countries including India, participated with 38 research vessels and a large compliment of scientists. The expedition lasted for over 4 years, beginning from 1960 during which exhaustive studies were made on the physical, chemical, biological, meterological and geological aspects of the Indian Ocean. A number of organisations (both government and autonomous bodies) are now engaged in the studies on different aspects of marine science in India. A vast amount of valuable data have been collected and several scientific papers, reports and atlases have been published based on these studies.

The Indian Ocean has an area of about 75 million sq. km including the Antarctic Ocean and some of the adjacent seas, as against 106 million sq. km of the Atlantic and 180 million sq. km of the Pacific. The Indian Ocean is separated on the Western side from the Atlantic along the meridian of 20°E starting from the Cape of Good Hope and extending southwards. On the eastern side, the conventional boundary is a line starting from the Malay Peninsula along the 100°E meridian upto the Tropic of Capricorn and further down the line starting at the southern tip of Australia and following south along the meridian 147°E. The southern limit of the Indian Ocean may conventionally be put at the subtropical convergence zone at 40°E. The great Asian continent acts as a natural boundary in the north. The

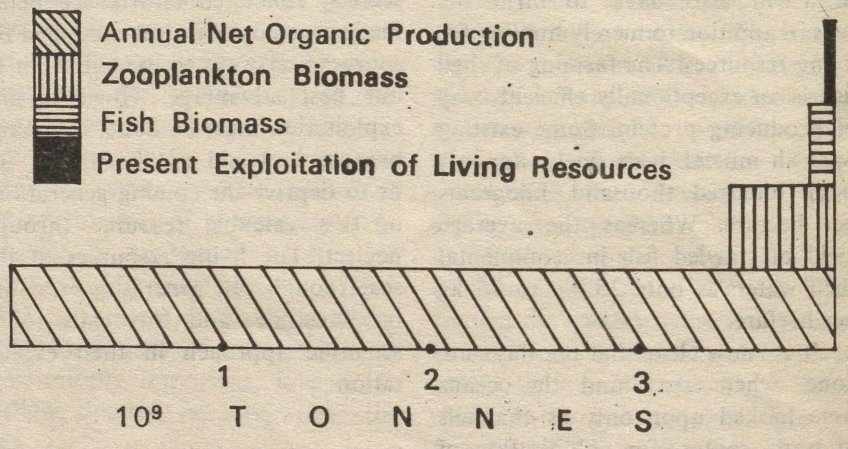

Fig. 3. Quantity of organic production and organisms of the Indian Ocean (between longitudes 20°E and 120°E and from the Asian land mass to 45°S latitude—total area: 51 million sq. km)

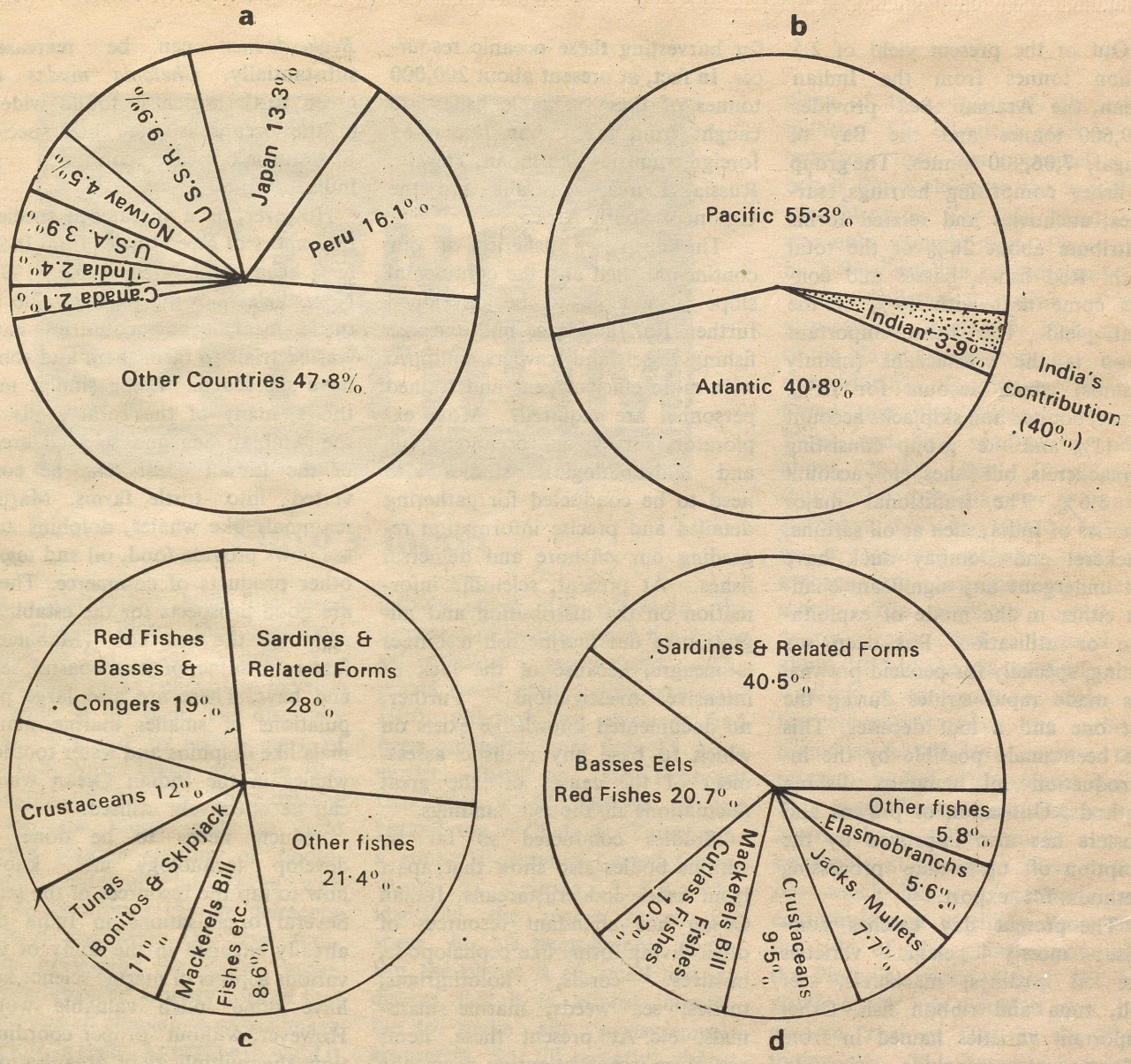

Fig. 4. (a) World fish catch with percentage contributions of the first 7 countries (based on catch data from 1966 to 1971); (b) Fish landings of the 3 major oceans during 1968; (c) Percentages of different groups of fishes caught from the Indian Ocean during 1967; (d) Percentage of different groups of fishes landed in India during 1969

Indian sub-continent is surrounded by the Arabian sea on the west coast and the Bay of Bengal on the east coast. To the south of the Arabian Sea and Bay of Bengal, the Indian Ocean stretches to the south till it meets the Antarctic Ocean.

Status of marine fisheries in India

India contributes about 40% of the fish landings of the Indian Ocean and ranks seventh among the major fish producing countries of the world. But when viewed against the world production of 61 million tonnes of marine fish in 1970, India's share was only just over a million tonnes representing about 2%. At present, a quarter of a million persons are engaged in actual fishing, producing an annual yield valued at Rs. 1200 million. The industry also provides employment to 1.4 million persons. There are about 10,000 mechanised crafts which catch 15% of the total production. Over 600 million rupees worth of sea food is exported to different countries.

Studies made during the International Indian Ocean Expedition reveal that there are several areas in the Indian Ocean which are exceptionally rich in nutrients, organic production and zooplankton biomass which could sustain large stocks of fish. During 1968, the total fish landings from the Pacific, Atlantic and Indian oceans were 31.3, 23.1 and 2.2 million tonnes respectively. But many fisheries scientists feel that there is ample scope for further expansion.

Out of the present yield of 2.5 million tonnes from the Indian Ocean, the Arabian Sea provides 9,39,600 tonnes and the Bay of Bengal, 7,06,900 tonnes. The group of fishes comprising herrings, sardines, anchovies and related forms contribute about 28% of the total catch. Red fishes, basses and congers come next with 19% of the total yield. The third important group is the crustaceans (mainly shrimps) which account for 12%. Tunas, bonitos and skipjacks account for 11% and the group consisting of mackerels, bill fishes, etc., account for 8.6%. The traditional major fisheries of India, such as oil sardine, mackerel and Bombay duck have not undergone any significant changes either in the mode of exploitation or utilisation. But deep sea fishing, specially for penaeid prawns, has made rapid strides during the last one and a half decades. This has been made possible by the introduction of modern fishing methods. Utilisation of prawns and lobsters has also improved by the adoption of up-to-date processing methods for export.

The present day catches comprise mostly pelagic varieties like oil sardines, mackerels, seer fish, tuna and ribbon fish. Other important varieties hauled in from offsore waters include sciaenids, cat fishes, flat fishes, pomfrets, sharks and rays. Efforts made by the Exploratory Fisheries Programme have shown that good fishing grounds for Ghol (*Pseudosciaena diacanthus*), Dara (*Polydactylus indicus*), Karkara (*Pomadasys hasta*), Koth (*Otolithoides brunneus*), bill fishes, tuna and many others exist in our offshore areas. But so far, no serious attempts have been made to tap these oceanic riches in a big way. India's geographical location and the Andaman-Nicobar group of islands in the Bay of Bengal and the islands of the Laccadive Archipelago give a decided advantage over other nations for harvesting these oceanic resources. In fact, at present about 200,000 tonnes of these valuable fishes are caught from the Indian Ocean by foreign countries like Japan, Taiwan, Russia, Korea, Australia and the Union of South Africa.

The deep sea fisheries of our continental shelf and the continental slope also have to be developed further. For this, large multipurpose fishing vessels and trawlers equipped with more efficient gear and trained personnel are required. More exploratory surveys and oceanographic and hydrobiological studies also need to be conducted for gathering detailed and precise information regarding our offshore and demersal fishes. At present, scientific information on the distribution and migration of our marine fish resources is meagre, because of the lack of intensive investigations. Further, no documented knowledge exists on which to base any realistic assessment of the causes of the great fluctuations in the fish landings.

Studies conducted so far by various bodies also show that, apart from fishes and crustaceans, Indian Ocean has abundant resources of other living forms like cephalopods, bivalves, corals, holothurians, turtles, sea weeds, marine mammals, etc. At present these items are given scant attention from the point of view of their commercial exploitation. Seaweeds yield valuable phycocolloids like agar-agar and algin which are used in many industries. The skeletons of stony corals have several industrial applications. India has good resources of corals and it is possible to develop foreign markets for them. *Beche-de-mer* or cured holothurians (sea cucumbers) is considered a delicacy in some of the south-east Asian countries but its production is confiend to the south-east coast of India along the Palk Bay and Gulf of Mannar. With proper exploitation of unexploited grounds the annual production of *Beche-de-mer* can be increased substantially. *Chelonia mydas* or green turtle which is found widely in the oceans is the chief species of turtle meat consumed in India.

However, as a threatened species, the export of green turtles from India has been prohibited since 1975. Nevertheless, owing to the value of turtle meat, many countries have started trials to farm them and some have succeeded. Using similar methods, many of the coral atolls in the Arabian Sea and selected areas of the Indian coasts can be converted into turtle farms. Marine mammals like whales, dolphins and sea cows provide food, oil and many other products of commerce. There are good prospects for the establishment of the sea cow (Manatees) farms in some of our coastal seas and bays. There are also large populations of smaller marine mammals like dolphins and lesser toothed whales in the Indian Ocean which can be effectively utilised.

Much needs to be done to develop technology and know-how to tap the resources of the seas. Several organisations in India are already engaged in the study of the various aspects of marine science and have done much valuable work. However, without proper coordination, the multiplicity of organisations will lead to duplication of efforts and thereby to unhealthy competition, waste of manpower, money and time.

Further reading

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(*Continued on page 690*)

SCIENCE SPECTRUM

Pluto's moon

A satellite has been discovered around Pluto, the outermost planet of the solar system. The planet was so far believed to have no statellite of its own. The discovery was announced by astronomers of the U.S. Naval Observatory in Washington on 7th July. The existence of the new moon came to light during routine scrutiny of photographic plates of Pluto taken with the Observatory's 155 cm telescope in April and May. On 22nd June, while examining the plates, astronomer James W. Christy noticed that there was an elongation of the image of Pluto in them. At first he thought it was due to some camera defect, but on rechecking the photographs taken in 1965 and 1970, the same anomaly was found in the older plates also. Christy concluded that the elongated image was due to some satellite in orbit around the planet which could not be resolved by the 155 cm telescope. This was subsequently confirmed by photographs taken on 6th July by astronomer J.A. Graham using the larger, 400 cm telescope at the Cerro Tololo Interamerican Observatory in Chile. The new satellite has been officially designated as 1978 P.1.

Considering the enormous distance (about 5.6 billion km at its nearest approach to earth) and relatively small size of Pluto, the discovery of its tiny moon is a major astronomical achievement. The planet itself evaded discovery until 1930, although its existence had been predicted more than 25 years earlier. Then, on 18th February that year, it fell captive to the patient eye of Clyde W. Tombaugh, a young assistant at Lowell Observatory in Arizona, U.S.A., who identified the planet as a tiny speck in his photographic plates. But the planet is so small and so distant, that it is almost impossible to make any measurements accurately. So, till recently, almost nothing was known about it except that it orbits the sun in about 248 earth years, rotates once in 6.4 days (calculated from fluctuations of its light), and appears to be no larger than Mars. Pluto's orbit is also unusual; it lies on a plane inclined about 17° with respect to the plane of the orbits of the other planets. The elliptical orbit is so eccentric that near perihelion it brings Pluto closer to the sun than even Neptune. For this reason, it was once thought that Pluto may be a 'lost' satellite of Neptune!

In calculating the orbit of the new satellite, Robert S. Harrington of the Naval Observatory has made some startling discoveries. He has found that the distance between Pluto and the satellite is only about 20,000 km. Considering that the planet's diameter is around 2,700 km, this is too close to be seen as a separate object with an average-sized astronomical telescope. The satellite's orbit is nearly circular and is inclined at about 105° to the plane of the sky. Analysis of the position angles of the elongation gave the orbital period as 6.3867 days—same as the rotation period of the planet itself. This means that, to an observer on Pluto, the satellite would always be visible at the same place in the sky—much like our geostationary communication satellites. From the far side of the planet, however, the Plutonian moon would not be visible at all, nor would it ever be seen to 'rise' or 'set' in the Plutonian sky. This happens because, in the words of astronomers, the two motions (viz., the rotation of the planet and of the satellite around it) have become 'locked' to each other. The diameter of Pluto's moon is estimated at around 850 km.

BIMAN BASU

The birth of massive stars

IT takes a million years for the massive stars to rise from wispy "nothingness" to giant luminaries. Eventually they blow up and die, to become the same wispy nothingness. It is indeed a cycle—from clouds to massive stars, and vice versa. The formation of clouds from

stars is easy to visualise, but not the other way round. The process of formation of stars has been an issue much pondered over in the past, and it is only now that a frame-by-frame picture of the process is emerging (*Scientific American*, April 1978).

Consider, first of all, a huge cloud, in size, say, tens of parsec wide (one parsec is equal to nearly 3×10^{16} metres), as massive as 100,000 stars, but with a density of 1000 molecules per cubic centimeter and temperature 15 K to 20 K. It contains mostly hydrogen molecules, a small portion of hydroxyl radical (OH), hydrogen cyanide (HCN) and carbon monoxide (CO). It also contains dust, as much as one grain for every 10 atoms of the gas. Such a cloud, it must be emphasised, is not out of the ordinary, it is only typical. It radiates, as other similar clouds do, radio waves at millimeter wavelength.

Suppose some disturbance causes a gravitational instability in the cloud leading to its collapse. A core develops, to which matter accretes from all directions, to form a star. As matter is swept in, the density of the core increases faster than its outer layers. Within 10,000 to 100,000 years the temperature of the core of star reaches 8 million to 10 million K, which is large enough to set in thermonuclear reactions. The heat thus produced expands the star. A balance thereafter ensues between the pressure that tries to expand the star and the gravitational forces trying to compress it. At this stage one can, without any hitch, say that a star is born.

The star has formed, but it is still engulfed in the cloud that fathered it. It heats the surrounding gas and dust, which releases the same in the form of far-infrared radiations. This interests astronomers because, though the star may not be visible, a compact source surrounded by far-infrared radiations is a sure sign of the birth of a star. There is also a possibility at this stage that the dust and gas surrounding the star may emit radio waves corresponding to water and hydroxyl molecules present in the eddies and clumps that may temporarily form in the vicinity of the star. When the surrounding dust gets heated to a temperature of 100 K to 150 K, it emits near infrared radiations. The cooler regions of dust, farther away from the star, emit far-infrared radiations.

The star, being massive, evolves faster. Its temperature rises at a considerably rapid rate than its luminosity. Eventually it begins to emit a large amount of ultraviolet radiations and thereby ionises the surrounding region. Hydrogen in the cloud therefore begins to emit radiations in the centimeter radio wavelength, while the dust begins to emit near-infrared radiations. The envelope of hydrogen surrounding the newly formed star is called H II region, and it is this region which now plays a crucial role.

As the temperature of H II region rises, it begins to expand. It pushes itself away from the star into the surrounding cooler molecular clouds, and out into the interstellar

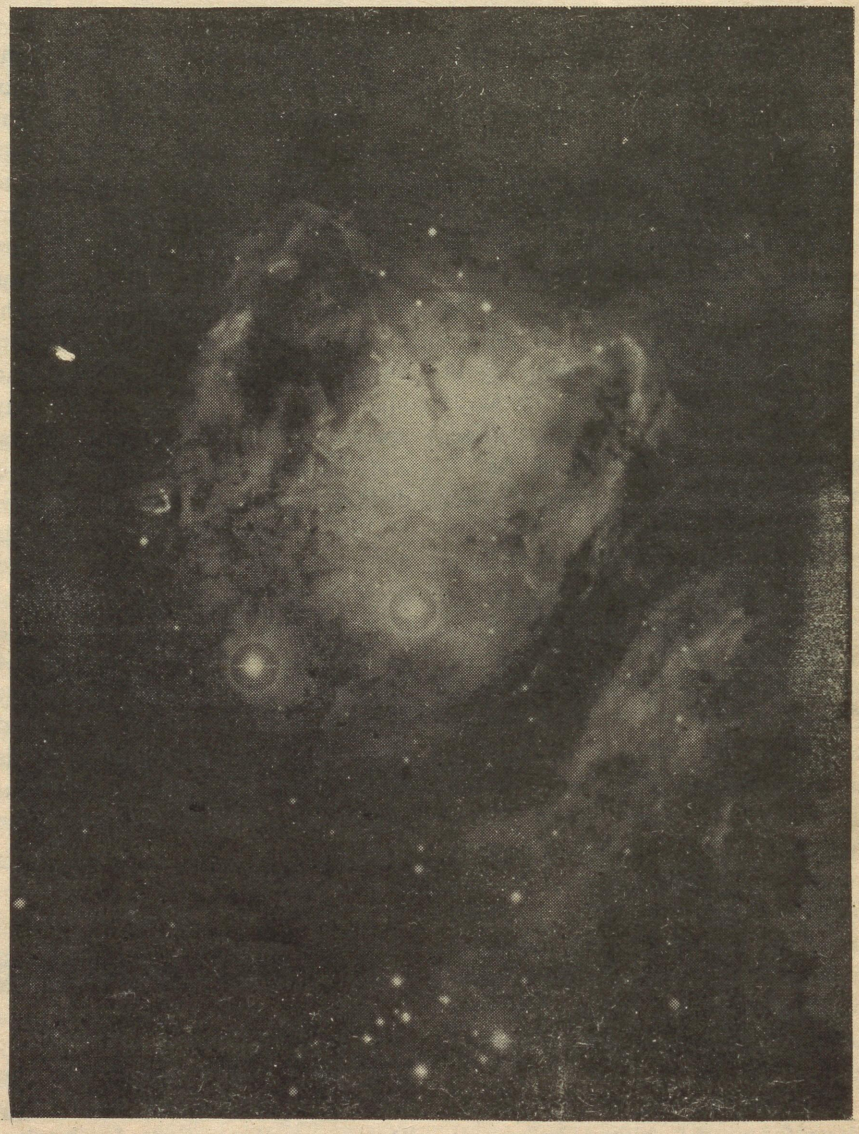

Fig. 1 Great Nebula in Orion; birth place of massive stars

space. Gradually it unveils the cloud about the star. The star is then visible to the penetrating "eyes" of a telescope or even the naked eye of an astronomer. As the H II region gets heated and it expands and finally blows away, it goes on emitting radio waves and infrared radiations, which, in due time, grow weaker to finally die out. It is now easy to visualise how an astronomer can, by glancing at the kind of radiations a particular region of cloud is emitting, tell the state of star it is developing in its womb.

These massive stars are of the spectral type O and B which have bluish-white radiance. They are several times more massive than our sun, and are, correspondingly, several times more luminous and hot. Formation of these stars has been observed in the Great Nebula and M 17 besides some other spots. It has, however, been found that these stars do not form singly but in a cluster of 100 or so. In fact, a cluster does not take birth all at once, but in small groups of 4 to 20 stars. It has also been found that the groups get formed almost in line, at one end are the younger stars and at the other the older ones in order of their ages.

The foremost question that arises now is : What disturbance does cause a cloud to give birth to a star? Secondly, how are massive stars created in clusters, especially in the sequence of their ages? A number of explanations have been offered with regard to the first question : When a massive star explodes to become a supernova in due course, it sends off into space shock waves, which, in their wake, pick up cloud material to create gravitational instabilities that eventually lead to the formation of stars. A shock wave travels, it is claimed, even for a million years after a supernova explosion.

Another possibility of the formation of stars arises when molecular clouds collide. Yet another possibility is based on the evidence that massive stars are mostly found on the spiral arms of a galaxy. It is claimed that there are some kind of density waves that plough through the arms of a galaxy to cause necessary conditions in the clouds to give birth to stars. Regarding the creation of a string of stars, it is claimed that H II region that each star blows off creates, in its wake, conditions necessary for formation of another star. A chain reaction sets in, which stops only when there is not enough cloud material to form a star.

DILIP M. SALWI

Computer graphics—a boon for design

TILL World War II, the advancements in mathematics were not fully utilized in other applied fields mainly because of the difficulty of carrying out the thousands of complex calculations. The advent of large digital computers has changed this picture and now it is possible to do any complicated calculation within a few seconds. Many hardware facilities have been developed to assist the computer user. Computer graphics terminal is one such which minimizes the errors in the computer data for curve plotting or structural designs and results in the saving of computer time which is quite costly.

To use any computer program, the user has to punch cards for giving input data like the experimental data, coordinates of points representing the shape of the component to be analysed, etc. In doing this, the user has to punch hundreds, sometimes thousands of computer cards. With such a large amount of data, it is difficult to eliminate coding or key-punching errors, and corrections consume a lot of time and effort.

The introduction of computer graphics terminal and the related software has reduced considerably the time and effort involved in preparing and checking the data cards. For example, if we have to design a transmission tower, the data is prepared by keyboarding the terminal, the tower coordinates are generated and joined by giving proper commands (Fig. 1). The visual data makes it possible to correct all the input errors.

The real power of the graphics terminal is realized only at this junction. By issuing a few commands, the engineer gets an alphanumeric printout on the screen the coordinates of all the nodes in the structure (this is applicable to 3-D structures also), and also member incidences (i.e., what member connects to what node). After getting this alphanumeric printout the computer is instructed to prepare data deck of the input geometry so that the required program could be run. Thus the punching of data cards and checking them are eliminated.

The graphic terminal can also be used to view a three dimensional structure from any angle, magnify any portion of the structure and also to plot the displacements or any other output of the analysed structure. These types of computer graphics terminals have already been used in the U.S.A. by many private, smaller, structural engineering firms to reduce the cost of preparing and checking the input data thereby reducing the number of costly computer runs. The computer graphic terminal yields a little cheaper and much faster data preparation than labo-

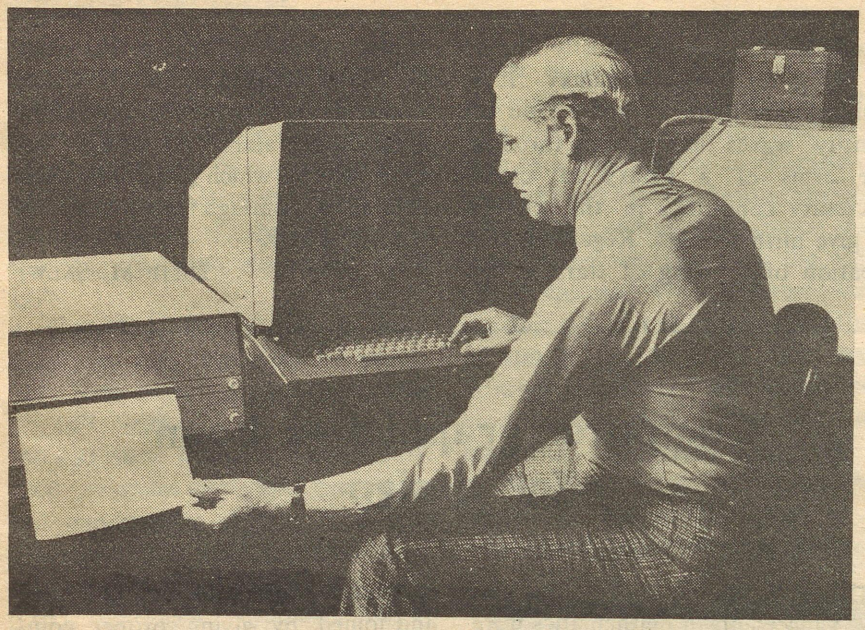

Fig.1. Computer graphics terminal (*Courtesy*: ASCE)

rious manual data preparation. Computer graphics terminal can also be used in conjunction with the finite element method to design all engineering structures, including mechanical elements. They can also be utilized for the design of electrical network problems and in problems of similar nature in physics and chemistry.

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Image intensifiers

IMAGE intensifiers are electron-optical devices which enable man to see and work effectively in darkness. Although not suitable for use in total darkness, they can provide usable images in conditions of minimal illumination, for example, on an overcast moonless night in winter. Even though they are used extensively for military applications, they have many other applications such as navigational aids, particularly in confined waters, and for surveillance and traffic control, in low ambient light conditions. They also improve the effectiveness of astronomical telescopes. When it is necessary for the observer to be remote from the viewing instrument, the intensifier can be coupled optically to a television camera. Such a system allows monitoring in a hazardous environment, or allows a number of observers to view a scene simultaneously, or one observer to monitor several screens.

Working principle

In an image intensifier, an image of the scene being viewed is intensified electron-optically and viewed directly on a luminescent screen. The initial image is focussed onto the input face of a transparent photocathode; this then emits a corresponding 'image' of photoelectrons which is accelerated onto the screen. As each photon from the scene is made to produce several tens of photons at the screen, the final image is greatly intensified.

The average number of photons emitted per second by an element in a night scene is linearly proportional to the brightness of the element. Image intensifiers rely for their operation on available light at extremely low levels of intensity such as that from the stars or reflected town glow. Table 1 shows the range of scene illuminance (brightness) normally experienced.

An electrostatically-focussed single-stage image intensifier is shown schematically in Fig. 1. Light from the object is focussed onto the input tube by means of an objective lens and transmitted through the fibre-optic window onto the semi-transparent multi-alkali photocathode. A corresponding electron pattern is emitted. These electrons are then accelerated by a voltage of upto 16 kV onto an aluminised phosphor screen. An inverted intensified photon image is generated, and this is transmitted through the output window to appear as a directly viewable image on the screen of the intensifier. The level of intensification of the image depends mainly on the photo-cathode sensitivity, the accelerating voltage, and the tube magnification. The typical luminescence gain of an intensifier of this type would be between 100 and 2000, depending upon the parameters mentioned above. A gain of 2000 is sufficient to give an extremely bright image of a moonlight scene.

Table 1. Range of scene illuminance

Direct sunlight	10^5
Bright daylight	10^4
Very dark day	10^2
Twilight	10
Full moon	1
Starlight	10^{-3}
Overcast starlight	10^{-4}

For applications where a gain of 50,000 or more is required, single-stage intensifier can be coupled in cascade (Fig. 1). This has been made possible by the development of high resolution vacuum-tight fibre-optic windows. The three stages of the cascade intensifier together requires a high voltage supply of 45 kV. This is derived from an oscillator, encapsulated with the intensifier, operating from a low-voltage d.c. supply such as alkaline batteries. The integral-oscillator cascade image intensifier has a well-defined automatic brightness control characteristic and a fast response to sudden changes in scene brightness.

With a three-stage cascaded intensifier, the persistence of the three phosphor screens in series can be disturbing when observing scenes with moving highlights; because, in multi-stage tubes, the afterglow remains visible for several seconds as a result of the amplification. So, image persistence is a limitation of this type of intensifiers apart from their high physical volume and weight.

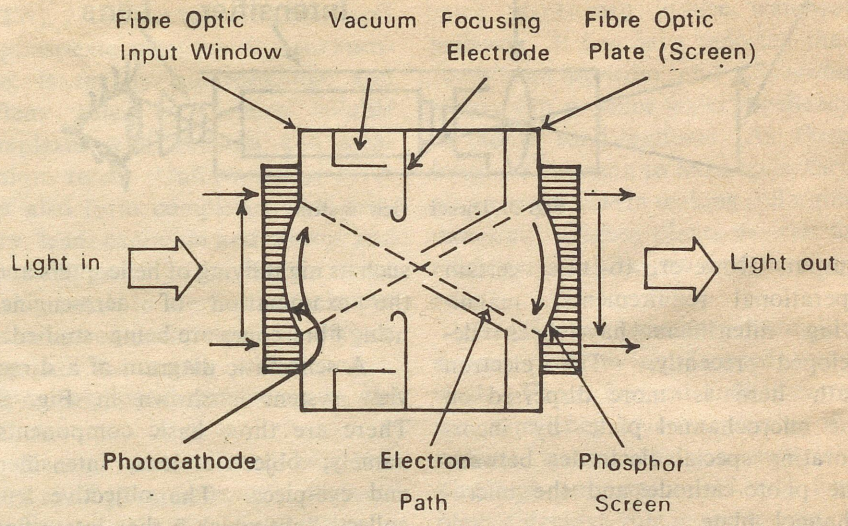

Fig. 1. Single-stage image intensifier

Microchannel image intensifiers

The limitations of the electrostatic type of image intensifiers led to the development of image intensifiers in which microchannel plates are used for electron multiplication. Before discussing this type of intensifiers, brief description of the operation and characteristics of the microchannel plates is given below.

A microchannel plate is an array of minute channel electron multipliers that can be used for amplifying an electron beam containing spatial information. Electrons entering a channel strike the wall and produce secondary electrons which are accelerated along the channel by an axial electric field applied between the electrodes (Fig. 2). Transverse energy of emission causes electrons to traverse the channel so that they again collide with channel wall and produce still more secondary electrons. This process is repeated many times so that a large number of electrons emerge from the channel output and are accelerated across a narrow gap to a phosphor screen giving an intensified image on the screen.

The electron gain of a channel depends upon the applied voltage, the length-to-diameter ratio of the channel, and the secondary emission characteristics of the channel wall. Since the gain does not depend upon the absolute dimensions of the channel, the diameter can be chosen to match the resolution requirements without changing the gain.

In a microchannel plate intensifier the microchannel plate is mounted just in front of the luminescent screen. The photo electrons impinge on the microchannel plate, and after multiplication in the channels, are accelerated towards the screen which is mounted very close to the plate. A field strength of about 5 kV/mm across the gap between micro channel plate and screen gives a satisfactory image on the screen.

Normally, the electron-optical lenses of intensifiers of this type are designed to achieve unity magnification of the image from input to

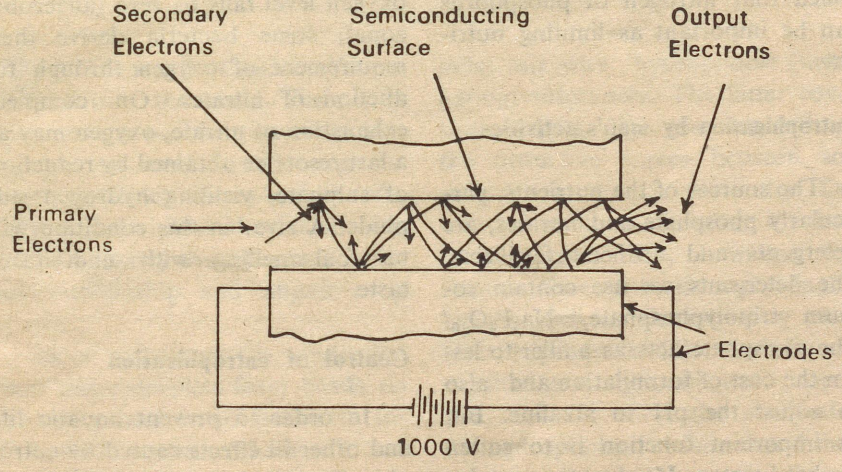

Fig. 2. Electron multiplication in one channel of a microchannel plate

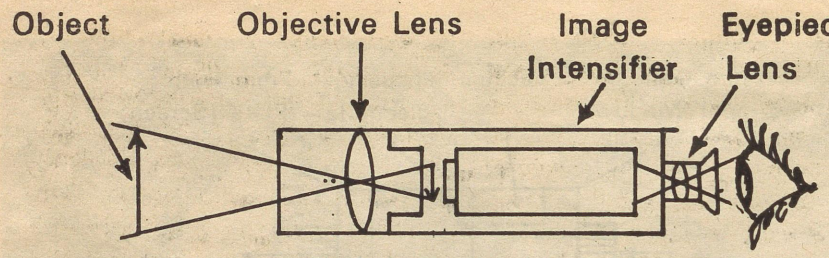

Fig. 3. Direct view system

output. However, to meet certain operational requirements, magnifying intensifiers have been developed recently. The electron path here is more dispersed on the microchannel plate by incorporating special electrodes between the photo-cathode and the microchannel plate.

Image intensifier systems

Image intensifier systems fall into two categories: direct view systems, and low-light-level television systems. The former are devices that can be viewed directly by eye; they are mainly used for night viewing applications such as surveillance and driver viewers. The latter systems are normally used for remote surveillance, although other applications such as night flying of helicopters and the examination of aero-engines using fibrescopes are being studied.

A schematic diagram of a direct view system is shown in Fig. 3. There are three basic components, namely, objective lens, intensifier, and eye-piece. The objective lens collects light which is then intensified by the image tube. Unless the lens collects sufficient light, the system will not be usable, no matter how effective is the image intensifier.

Low-light-level television systems are based on combinations of vidicon camera tubes and the image intensifiers. Both are housed in the same vacuum envelope.

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Eutrophication

THE term eutrophication, which is frequently used in connection with water pollution in recent years, refers to the enrichment of waters with plant nutrients. This enrichment can take place either by natural process which is a very slow process or by the pollution of water by man's activities. The major plant nutrients are carbon, hydrogen, oxygen, sulphur, potassium, magnesium, nitrogen and phosphorus. In addition, trace amounts of organic and inorganic materials are also needed for plants as nutrients. Of these, only nitrates, phosphates and carbon dioxide have been studied in detail and such studies have established that nitrogen or phosphorus can be important as limiting nutrients.

Eutrophication by man's activities

The sources of the nutrients, particularly phosphate and nitrates, are detergents and artificial fertilizers. The detergents we use contain sodium tripolyphosphate, $Na_5P_3O_{10}$. The phosphate acts as a filler to lessen the cost of formulation and also to adjust the pH to alkaline. But its important function is to soften the hard water. Hard water contains calcium and magnesium ions. The sodium tripolyphosphate, by reacting with these ions, forms soluble complex ions and thereby softens hard water. When water is softened, the cleaning power of the detergent is also enhanced. Hence the manufacturers always include phosphate in detergents and the domestic wastes find their way to rivers or lakes where the concentration of phosphate is increased. Many rivers also receive nitrogen in drainage from farmlands where many of the artificial fertilizers are used.

Effects

The phosphates and nitrates with the carbon dioxide available from the air cause eutrophication of river or lake waters. The enrichment supports photosynthetic process where algae and other plant life synthesise new plant material using the energy from the solar radiation and the nutrients. This excess growth of algae and other plant life however results in the depletion of dissolved oxygen in water.

All natural waters contain fishes and micro-organisms which require oxygen for respiration dissolved in the water to an extent of 10 mg/l at 15°C. Most fishes require a minimum oxygen concentration of 3 mg/l. When oxygen concentration goes below this level due to algal bloom, it results in the death of fish. When oxygen level falls to zero (anaerobic zone), some bacteria derive their requirement of oxygen through reduction of nitrates. On complete exhaustion of nitrate, oxygen may as a last resort be obtained by reduction of sulphate, yielding hydrogen sulphide. A river in this condition will be foul-smelling with undesirable taste.

Control of eutrophication

In order to prevent aquatic life and other ill effects caused by eutrophication, it becomes necessary to

control or prevent enrichment of plant nutrients in water. Any one of the three nutrients, viz., phosphate, nitrate or carbon dioxide can set off an algal bloom assuming the other two are present in sufficient amounts.

Since carbon dioxide is available from air and nitrogen can be fixed from air by blue-green algae, the emphasis is mainly laid on phosphorus for the control of total nutrients. This was also confirmed by earlier studies that the ratio of phosphorus to nitrogen was the growth-limiting factor for algae. So, one may immediately propose that phosphate in detergents should be replaced by a suitable substance. In this context it must be noted that the object of any enrichment programme is to improve water quality (including the softening of water), and hence the removal of triphosphate from detergents may cause even larger problems because of the need of detergents for our society. The problem of eutrophication was so severe in the United States and Sweden that the pressure to replace phosphate became heavy and other alternatives were employed in detergents. The most publicised substitute for phosphate is trisodium nitrilotriacetate (NTA). NTA has several advantages as phosphate substitue. It is inexpensive, is readily biodegradable and softens water by forming soluble complexes with calcium and magnesium ions. Unfortunately, NTA can also form complexes with mercury, lead, cadmium and arsenic and this will prohibit its use as these toxic metals in the form of complexes could enter different ecosystems. This has led to the withdrawal of NTA pending further tests in the U.S.A.

It may be mentioned here that even if all phosphates were removed from household detergents, still some phosphorus reaches waters from sources such as municipal and industrial waste water and artificial fertilizers. Though in India we have not yet felt the problem of eutrophication to such an extent as in other countries, it will be better if steps are taken today to decrease phosphate content in our rivers and lakes.

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Soils that repel water

WATER repellent soils are found all over the world. These soils are a serious problem on steep slopes, but an asset in arid regions. Water repellency affects both the stability and usability of soils. Severe water repellency can alter soil moisture relationship and impair crop growth.

Water repellency is indicated when water droplets form beads on soil surface and do not penetrate for at least 5 seconds. Such soils are probably produced when soil particles mix with hydrophobic (water hating) substances. The latter cover soil particles. This covering reduces the attractive forces between soil particles and water molecules. Details of molecular bonding involved in the process are, however, not known. Several biotic and edaphic factors such as decomposing plant litter, byproducts of living plants and physical and mineralogical properties of soils, affect the production of hydrophobic substances and their subsequent attachment to soil particles. Organic substances found in some plants can induce water-repellency. It has been reported that *Penicillium nigricans* and *Aspergillus sydowi* can produce water repellency in sterile sand cultures. As these fungi are common to most soils, they play a major role in making soil water repellent. Higher plants as well as microflora may be involved in many cases.

Heat induced water repellency is a serious problem on forested water sheds. Forest fires can induce extreme repellency by concentrating the natural water repellent materials. The high temperature of wild fires plays a decisive role in the formation of water repellent soils. Chaparral brush species produce organic substances which make soil water-repellent. During the years between fires, water repellent substances in the form of leachate from the brush and decomposing plant parts tend to concentrate in the upper part of the unburned soil profile, immediately below the litter layer. Smaller amounts of these substances are transported below that layer by the infiltrating water. The most severe water repellency in this unburned soil probably results from particle-coating by partially decomposed plant parts and there mixing with the mineral soil.

So, the amount and nature of the particle surface assumes considerable importance. Clay soils have large internal surface areas and would be coated less than sandy soils. Coarse textured soil would be expected to be more susceptible to water repellency than fine textured soils. The strength of the charges on the surfaces of individual soil particles probably influences the manner in which hydrophobic substances are absorbed.

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Micro-electrophoresis

DISPERSED colloidal particles are charged either positively or negatively and migrate towards oppositely charged electrodes on application of external electric field. This motion of suspended materials (or dissolved particles) under the influence of applied electric field is termed as electrophoresis which is one of the four electrokinetic phenomena involving the relative movement between the fixed and mobile parts of an electrical double layer.

Micro-electrophoresis refers to the direct measurement of particle mobility by viewing it under the microscope. The dissolved material can also be studied in this way if the substance is adsorbed on to the surface of a carrier particle, e.g., neutral oil droplets or silica. Before the advent of this technique, the simple moving boundary method was in use where the electrophoretic mobility was determined by observing the charge in the level of boundary of the dispersion in U tube on application of electric current. The micro technique has the advantage of determining electrophoretic mobility fairly rapidly over a wide range of ionic strength. Selected particles of very dilute dispersions can be observed over a long period of time. The micro-electrophoresis apparatus is simple, inexpensive and, easy to construct and maintain. It consists mainly a glass cell which is simply the observation tube (usually glass) of either circular or rectangular cross section, with an electrode at each end and (in most cases) with inlet and outlet taps attached. A schematic diagram of microelectrophoretic apparatus is shown in Fig. 1. The cell is placed in front of a microscope so that the dispersed particles can be viewed directly. The platinum electrodes fused at the ends of cell are connected to a sensitive voltmeter which reads the potential difference across the ends of cell produced due to external electric field. Two stop-cocks attached to the side attachment of the cell are operated from outside during experiment. The one stop-cock is connected with an electrode chamber and the suction pump and the other with an electrode chamber and funnel. The dispersion is poured from the funnel and the electrode chambers are filled with equi-conducting liquid (generally, KCl). The chamber electrodes having large surface area, e.g., Ag-AgCl are used to minimize polarization. The microscope is fixed to a certain depth with respect to the cell in order to minimize electro-endosmosis. The degree of magnification should be as high as possible so as to minimize the depth of cell and permit accurate location of the particles at stationary level. Total magnification of between 200-600 is generally used.

During electrophoresis the current from a constant voltage power supply unit is passed through the circuit as a result of which the dispersed particles begin to move towards the oppositely charged electrodes. The velocity of particles is measured using a stop watch by viewing them through microscope (in the eyepiece of which is attached a calibrated gradicule). The electrophoretic velocities are determined by timing individual particles over a fixed distance on the eyepiece scale (ca 100-200 microns). The current is usually adjusted to give transit times of about 5-10 seconds. The polarity of electrodes is then reversed and the particles in alternate directions are also observed in order to eliminate drift effect due to leakage, electrode polarization, etc. These velocity data are divided by the potential gradient across the cell to result electrophoretic mobility which in turn gives the zeta potential using simple equations based on size and shape of particles and the ionic strength.

Electrophoresis has been a good tool for determining the stability or unstability of colloidal dispersions. Due to vast applications of these dispersions, probably in all spheres of life and industry where these systems are desired in stable or coagulated form, it becomes necessary to know the conditions under which the system will remain stable or not and the factors responsible for colloid stability. Microelectrophoretic determinations serve this purpose and the stabilities of dispersions can be well explained considering electrical factors. It has been observed that high values of electrophoretic mobility or zeta potential on a system give rise to stable dispersions. This stability can be ascribed to the predominating effect of electrical repulsion over attraction between two dispersed particles.

Model systems consisting of carrier particles covered with adsorbed layers of biological materials, such as proteins, lipids, polysaccharides, etc., can also be studied microelectrophoretically. Such investigations facilitate the quantitative interpretation of the electrokinetic behaviour and identification of the surface nature of more complex systems, such as living cells. The technique has proved to be most useful for characterising the surfaces of organisms such as bacteria, blood cells, viruses, etc.

The technique is employed in clay technology. Clays consist mainly of plate-like particles which in contact with water form

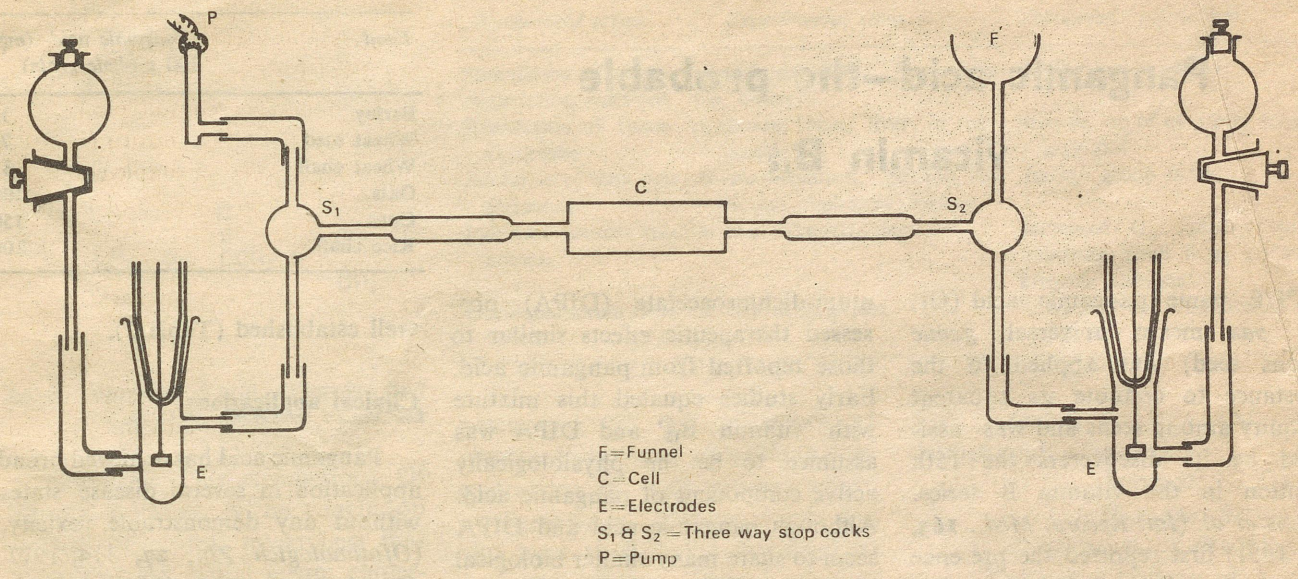

Fig. 1. Micro-electrophoresis apparatus

negatively charged faces and positively charged edges. The physical properties of clay dispersions such as sedimentation, filtration, swelling, etc., are extremely sensitive to the nature of the electrical double layers around the particles and the tendency of particles to aggregate. The control of mechanical behaviour of clay suspensions on addition of small amounts of chemicals as flocculants or stabilizer is an important feature of soil treatment, oil well drilling, ceramics and other processes involving clay materials.

The municipal water supplies are generally obtained from sources which are contaminated with mineral or organic materials derived from soil. To facilitate filtration of these contaminants, use of small quantities of flocculants, e.g., alum, polyelectrolytes, etc., has become a common practice. Effective purification of water which has been polluted with industrial wastes, domestic sewage, etc., involves an elaborate flocculation process.

In detergency, micro-electrophoresis finds applications. It has been established that a qualitative relationship exists between zeta potential of dirt suspensions with its redeposition (the prevention of which is an important factor in detergency).

The collector oils are adsorbed on the metal-rich particles (but not the siliceous material) making them more hydrophobic. The adsorption of collector oil and flotation recovery depend on the sign and magnitude of the charge on the particles. Anionic collector oils adsorb effectively on positive metal ore surfaces and vice versa. High zeta potential favours flotation recovery.

Uniform coating of paints to metal objects, manufacture of thin rubber articles, etc., through electrodeposition need the use of electrophoretic technique.

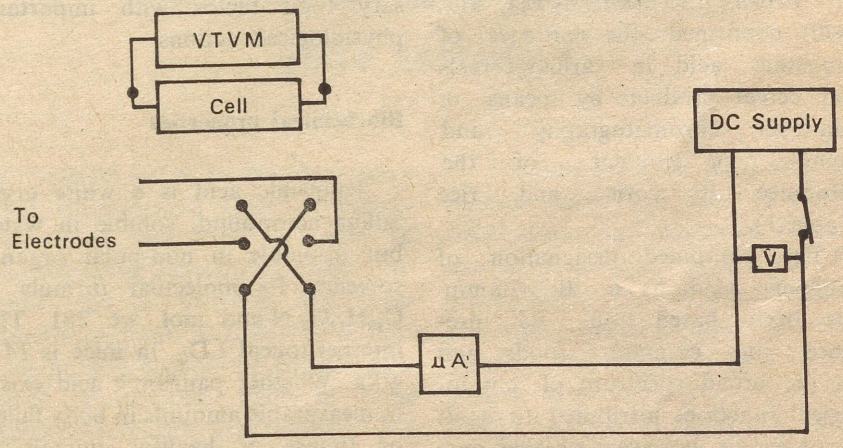

Fig. 2 The electric circuit diagram for applying the external current

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Pangamic acid—the probable vitamin B_{15}

THE name pangamic acid (Gr. *pan* means universal, *gamic* means seed) was applied to the substance to connote its apparent ubiquity among seeds and was assigned by its discoverers the 15th position in the vitamin B series. Krebs *et al.* (*Int. Record. Med.*, **163**, 18, 1951) first reported the presence of a water-soluble factor in apricot kernels and later in rice bran, brewer's yeast, ox blood and horse liver. They identified it chemically as d-gluconodimethylamino acetic acid (Fig. 1). Telegdy-Kovats *et al.* (*Z. Lebensmitt. Unters.* **143**, 411, 1970) confirmed the existence of pangamic acid in various cereals and cereal products by means of thin-layer chromatography and found high content of the substance in corn and rice (Table 1).

The continued designation of pangamic acid as a B vitamin has been based on its presence in common foods and on the broad spectrum of physiological functions attributed to it. It is not known, however, whether man or other animals have the capacity to biosynthesize pangamic acid, no specific disease can be attributed exclusively to its deficiency. Thus, the formal status of pangamic acid as true vitamin remains still unresolved.

In the course of biological evaluation of pangamic acid, it was discovered that an equimolecular mixture of gluconic acid salt (e.g., sodium gluconate), glycine (amino acetic acid) and di-isopropylammonium-dichloroacetate (DIPA) possessed therapeutic effects similar to those reported from pangamic acid. Early studies equated this mixture with 'vitamin B_{15}' and DIPA was assumed to be the physiologically active component of pangamic acid. Although pangamic acid and DIPA seem to share many similar biological properties (*J. Clin., Pharm.* 9, 282, 1969), the two are distinct chemical substances. Despite its ambiguous nutritional status, pangamic acid has been widely studied and accepted in many countries as a necessary food factor with important physiological actions.

Table 1. Distribution of pangamic acid (Vitamin B_{15}) in various foods

Food	*Pangamic acid (mg/ 100 g whole grain)*
Barley	12
Wheat seed	70
Wheat chaff	31
Oats	106
Corn	150
Rice chaff	200

Biochemical properties

Pangamic acid is a white crystalline compound, soluble in water but insoluble in non-polar organic solvents. Its molecular formula is $C_{10}H_{19}O_8N$ and mol. wt. 281. The interperitoneal LD_{50} in mice is 14.7 g/kg. Whether pangamic acid exists in measurable amounts in body fluids or tissues of healthy animals is unknown. The compound is found in blood, brain, liver, heart and kidney. After 10-15 minutes subcutaneous injections of a 430 microgram/kg dose in rats. The site of its highest concentration and the longest duration in the body is the kidney, where it persists at least for four days after subcutaneous injection. Among the different metabolic properties of pangamic acid, its effects on transmethylation reactions, cellular respiration and hepatic function have been well established (Table 2).

Clinical applications

Pangamic acid has achieved broad application in several disease states without any demonstrable toxicity. (*Oftalmologich Zh.*, **27**, 114, 1972; *Cor. Vasa.*, **15**, 20, 1973). Its widespread use in the treatment of cardiovascular diseases, disorders of lipid metabolism, liver dysfunction, exercise and in dermatoses has now been well studied.

Cardiovascular diseases Pangamic acid and its di-disopropyl derivative are reported to be safe and effective in the treatment of patients with ischemic conditions associated with either cardiopulmonary insufficiency or atherosclerosis. Daily oral doses of 50 mg 300 mg diminish the frequency, intensity and duration of anginal or dyspenic attacks and increase exercise tolerance among patients suffering from coronary insufficiency and myocardial infarction. Diuresis is stimulated, and hypertension and peripheral edema are reduced in subjects with congestive heart failure when treated with calcium pangamate. Skin temperature increases and pain and circulatory time decrease in the affected areas after oral pangamic acid therapy. Apanasenko, A.A. (*Cor. Vasa.*, **15**, 20, 1973) showed in a study of 80 patients with arteriosclerotic heart disease that daily doses of 150 mg of calcium pangamate for 20-30 days significantly improved myocardial contractility

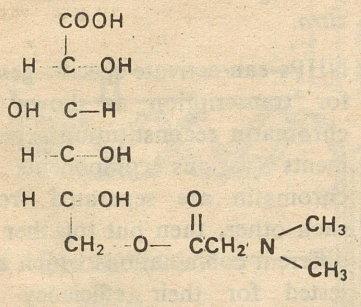

Fig. 1. Pangamic acid (Vitamin B_{15}) $C_{10}H_{19}O_8N$, molecular weight 281

Table 2. Biochemical action of pangamic acid

Biochemical effect	*Experimental state*	*Postulated mechanism*
Stimulation of trans-methylation reactions	*in vitro* mammalian liver, muscle, bacteria	Methyl group donar
Stimulation of tissue O_2 uptake	*in vitro* rat brain, liver; *in vivo* cyanide	Stimulation of oxidative enzyme activities
Inhibition of fatty liver formation	*in vivo* starvation, protein restriction, cholesterol feeding	methyl group donar
Increased exercise tolerance	*in vivo* swimming rats	Increased O_2 uptake; energy substrate levels (e.g., glycogen, creatine phosphate)
Decreased serum cholesterol	*in vivo* normal rats	Inhibition of cholesterol biosynthesis

Diseases of lipid metabolism. Of interest, however, is the conclusion reached by several researchers that the higher the initial serum cholesterol value, the greater is the reduction in cholesterol afforded by pangamic acid therapy with most hyperlipoproteinemia patients treated daily with 120 mg-300 mg pangamic acid for 10-30 days. Some patients also show concomitant reductions in elevated serum total lipids and β-lipoproteins and a rise in serum albumin.

Liver disease. In cases of infective hepatitis of children upto 15 years of age, daily oral administration of pangamic acid for 10-20 days led to a rapid decline in fever, liver size, jaundice and finally brought the liver function to normal.

Exercise. In man, pangamic acid is claimed to foster a greater adaptation to muscular activity if administered orally to highly trained atheletes for three days prior to moderate or intense exercise at a dose ranging between 100-300 mg/kg. Plasma glucose, lactate and oxidised/reduced glutathione ratio were recorded as indices of response to physical exertion. Pangamic acid treatment had no effect on prestress levels of these parameters. It significantly inhibited the rise in lactate and the fall in both glucose and oxidised/reduced glutathione ratio immediately after exercise. It accelerated the rate of return of glucose, lactate and glutathione concentrations to their pre-test levels.

Dermatoses. Pangamic acid has also been used in the treatment of patients suffering from various dermatoses, e.g., scleroderma, psoriasis, eczema, urticaria and other dermatologic disorders.

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Can RNA also regulate gene activity?

CHROMATIN is the deoxyribonucleic acid (DNA) usually complexed with one or more of the following substances: basic proteins such as histones and protamines; chromosomal ribonucleic acid (RNA) and nonhistone (acidic) proteins or histones. Each of these substances occurs in chromatin in a proportion that is significant with respect to the DNA component and makes the chromatin less active (Table. 1). For example, the number of sites available for the action of calf thymus transcription enzyme (RNA polymerase), is 1 per 40,000 nucleotides in "naked" DNA and 1 per 50,000 in chromatin. This suggests that most of the nuclear DNA is normally not available for template usage in transcription in the cell because it is complexed with the components of chromatin.

Histones are basic proteins which contain large amounts of amino acids lysine and arginine. Histones are of five major types, i.e., H1, H2A, H2B, H3 and H4. All these five types can be divided into three classes depending upon their amino acid contents; lysine-rich (H1), moderately lysine-rich (H2A and H2B) and arginine-rich (H3 and H4). They are not much different from each other as indicated by the fact that the amino acid sequence of H3 of cow is nearly identical to carp, and amino acid sequence of H4 of cow is nearly identical to pea seedlings, irrespective of the fact that these organisms are very diverse on evolutionary basis. For that matter, histones of any part of any cell or of any organism can be replaced by any other cell or organism without altering the pro-

Table 1. Relative mass of various components of chromatin

Chromaton source	*DNA*	*Histone*	*Non-histone protein (NHP)*	*Chromosomal RNA*	*Chromatin activity (% of naked DNA)*
Pea					
Embryonic axis	1.00	1.03	0.29	0.26	12
Vegetative bud	1.00	1.30	0.10	0.11	6
Growing cotyledon	1.00	0.76	0.36	0.13	32
Rat					
Liver	1.00	1.00	0.67	0.043	20
Ascites tumor	1.00	1.16	1.00	0.13	10
Human					
Hela cells	1.00	1.02	0.71	0.09	10
Cow					
Thymus	1.00	1.14	0.33	0.007	15
Sea urchin					
Bastula	1.00	1.04	0.48	0.039	10
Pluteus stage	1.00	0.86	1.04	0.078	20

perties of chromatin.

The histone and DNA content of chromatin are approximately equal in mass (Table. 1), that is, the ratio of histone to DNA in different cells is constant. In calf thymus, the addition of histone to incubation mixture inhibited DNA synthesis, whereas removal allowed three-to-four fold increase. Further, when histones are added to a histone-deficient system, RNA synthesis is immediately suppressed. This suggests that histones, in general, strongly suppress transcription. Histones are also nonspecific repressors of transcription because all histones are approximately alike.

What role does chromosomal RNA play in gene expression is not very clear. However, certain species of chromosomal RNA can select specific base sequences on one strand (called Crick strand) of DNA helix and make it separated from the opposite strand (called Watson strand) which is then made available for transcription (Fig. 1). This mechanism is however speculative.

Nonhistone proteins (NHPs) probably have heterogeneous functions. Some NHPs are enzymes which are used for DNA replication, repair, transcription, modification and also for the degradation of histones. Specifically the NHPs are suitable candidates for the role of specific activators of transcription. In other words, acidic proteins function as specific activators of histone-repressed DNA sequences so that they could be available for transcription. Such regulatory role has been assigned to NHPs because:

1. The amount of NHPs is different in different nuclei. It is high in highly active cells.
2. NHPs are tissue specific, their types differ in different tissues.
3. Active sites of chromosomes contain greater amounts of NHPs than inactive ones.
4. NHPs partially reverse the repressing effect of histones *in vitro*.
5. NHPs can activate specific genes for transcription as shown by chromatin reconstitution experiments (various components of chromatin are separated from each other, then put together in different combinations which are tested for their efficiency as templates for transcription).

It is, however, not yet clear how NHPs act at molecular level to effect transcription. Some NHPs which get phosphorylated in the nucleus may combine with histones to displace them from DNA to make it available for transcription. Still other NHPs may form a complex with chromosomal RNA to pull it off the chromosome so that template could be reused.

But the most important point forgotten in assigning regulatory role to NHPs is, that they always have RNA associated in small amounts, called small nuclear RNA (snRNA). Has the snRNA any role to play in gene activity other than structural? Recent experiments have now proved that snRNA has a definite role in gene expression of higher organisms (eukaryotes)—as suggested nine years ago by James Bonner of California Institute of Technology, California. Margarida Krause and Maurice Ringuette of the University of New Brunswick recently separated snRNA from the protein fraction of NHPs from human cells that were either normal or transformed by a virus (the transformed cells produce large quantities of RNA than the normal ones as they are very active). Then they added separately the protein and snRNA fractions to the normal human cell nuclei. They observed that it was only the snRNA fraction, and not the protein fraction, of transformed human cells which could

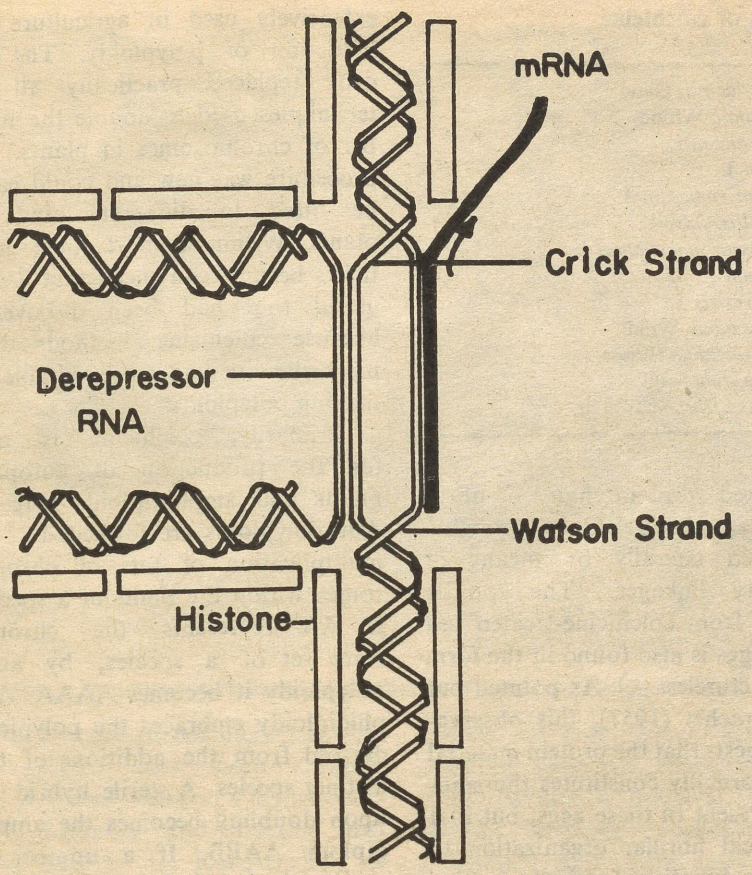

Fig. 1. Model for the role of chromosomal RNA

stimulate RNA synthesis activity of normal human nuclei to the same high levels as that of transformed ones, clearly proving that it is snRNA which has a definite role in gene expression. The same has been supported by Man-Chiang Niu of the Temple University, Philadelphia.

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Colchicine—the alkaloid that doubles chromosome number

COLCHICINE, an alkaloid extracted from seeds or corms of the autumn Crocus, *Colchicum autumnale* L., is used extensively to double the chromosome number. It induces of polyploidy—a condition where a plant or an animal cell contains more than the diploid number of chromosomes. It arrests development of the spindle fibres and cell walls, but it does not prevent division of chromosomes. As a result, chromosome number is increased from diploid to tetraploid, yet all the chromosomes remain within a single cell. Besides polyploidy breeding, colchicine is used in biology and medicine.

Sources of colchicine

The species *C. autumnale* belonging to the family Liliaceae is well-known and is mentioned in every pharmacy book for the production of colchicine. But there are many other species that produce the compound. All species under the genus *Colchicum* analyzed to date yield colchicine. An extensive list of them has been drawn (Table I). Species of two genera, *Merendera* and *Colchicum*, are found in the Northwestern Himalayas. Isolated substances from *C. autumnale* and related species have been studied extensively by Professor F. Santavy and his colleagues at the Medical-Chemical Institute of the Polacky University of Olomoue, Czechoslovakia. Generally, colchicine is present in all parts of the plant, but is mainly obtained from seeds and corms. The maximum percentage obtained is 0.5 per cent in *C. autumnale* and 0.3 per cent in *Gloriosa superba.*

Modern research

Colchicine in its present role as a mitotic poison and as a tool for biological research, was discovered in 1934 at Brussels, Belgium, in the laboratory of Professor A. P. Dustin, Sr., who for a long time had been investigating means of altering mitosis. In 1937 botanical research began in several countries using *Allium* root tips for their tests. Other botanists also chose *Allium* root tips to illustrate the action of colchicine. In the same year, the role of colchicine as an agent for the induction of polyploidy was conclusively demonstrated.

The horizons of colchicine research widened quickly when botanists learned how effectively the drug

Table 1. Principal plant sources of colchicine

Colchicum autumnale L.	*Tofieldia glacialis* Gaud.
C. montanum L.	T. *Calyculata* Whlnd.
C. neapolitanum Ten.	*Veratrum album* L.
C. araenarjum Waldst. and K.	*V. nigrum* L.
C. alpinum D.C.	*Anthericum ramosum* L.
C. luteum Baker.	*Hemerocallis fulva* L.
C. multiflorum Brot.	*Orinthogalum umbellatum* L.
Merendera bulbocodium Ram.	*O. comosum* L.
M. caucasica Biel.	*Tulipa sylvestris* L.
M. persica Bois and Kotsch.	*Asphodelus albus* Willd.
M. sobolifera Fisch.	*Fritillaria montana* Hoppe.
Gloriosa superba L.	*Lloydia cerotina* Salib.
Bulbocodium rathenicum Bung.	*Muscari tenuiflorium* Tausch.

could be used in their work. Laymen became interested in the drug as references to cancer entered the discussions and the creation of new varieties of plants stimulated new programmes in agriculture. Scope of research was widened by this single substance.

Mechanism of action

Every mitotic cycle builds anew the spindle fibres, substances that are responsible for chromosome movement. Colchicine prevents formation of a spindle at prophase, delays chromosomal separation, inhibits formation of daughter nuclei, and effectively blocks division process. Although the inhibition of spindle fibre formation of colchicine was known, the mechanism remained a problem for a long time. In 1952, D. Mazia and K. Dan, University of California, Berkeley, developed a method of isolating the mitotic apparatus from sea urchin eggs which permitted extensive studies to be made on the chemical composition of its component parts. D. Mazia showed that the spindle fibres were composed essentially of small protein molecules associated end-to-end by—SS—(disulfide) linkages to form elongate protein chains. He interpreted this finding as indicating that secondary bonds (presumably hydrogen bonds) had been disrupted and that the—SS—linked protein chains or fibrils of the spindle gel were probably condensed laterally by means of secondary linkages. The spindle isolated from colchicine-treated sea urchin eggs is also found in the form of a structureless gel. As pointed out by J. Brachet (1957), this observation suggests that the protein material which normally constitutes the spindle is present in these eggs, but that the typical fibrillar organization to form the functional spindle is prevented by colchicine. D. Mazia (1955) concluded that colchicine might produce its effect by interfering with the establishment of secondary bonding which he regarded as responsible for the orientation and geometry of the fully formed spindle.

Chemistry

Pure colchicine, $C_{22}H_{25}O_6N$, forms fine and practically colourless needles. It is readily soluble in alcohol, chloroform or in cold water, but is less soluble in hot water or in cold benzene and is almost insoluble in ether. The structure of colchicine is problematical. By X-ray crystallographic analysis, it has been confirmed that it has a tricyclic structure with its two fused 7-membered rings.

Applications

Agricultural uses. Colchicine is extensively used in agriculture for induction of polyploidy. The new drug replaced practically all the techniques used to double the number of chromosomes in plants. The procedure was new and could easily be fitted to different kinds of plants. Within a short time, geneticists became convinced that a very useful tool had been discovered, because colchicine methods were more effective and more suitable for making polyploids.

Primarily, colchicine is used for the production of autopolyploids and amphidiploids (Fig. 1). Autopolyploids are formed by the multiplication of sets of chromosomes within the limits of a species. If AA represents the chromosome set of a species, by autopolyploidy it becomes AAAA. Amphidiploidy embraces the polyploids derived from the additions of two distinct species. A sterile hybrid AB upon doubling becomes the amphidiploid AABB. If a number of species included increases beyond two, a polyploid—amphiploid condition obtains.

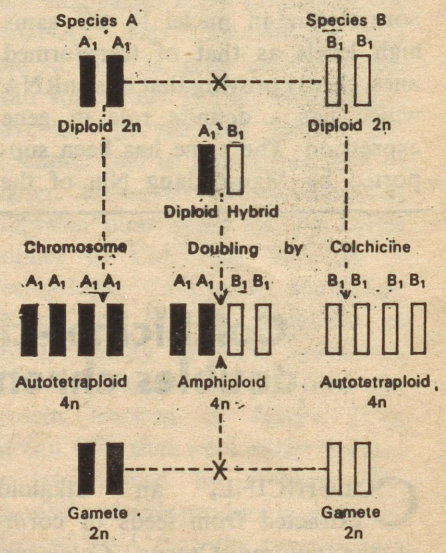

Fig. 1. Use of colchicine to make autotetraploids, doubling the chromosomes of interspecific diploid hybrid, amphiploids made by hybridizing two autotetraploid species

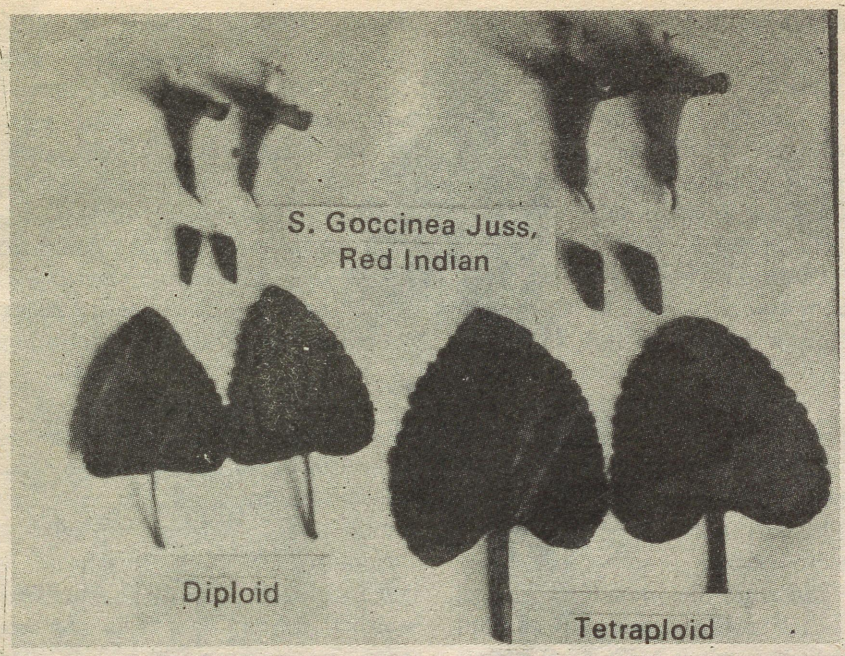

Fig. 2. Size of leaves, flower buds and flowers of diploid and tetraploid individuals

By the use of colchicine, several new species have been created, e.g., *Raphano brassica*, a hybrid between *Raphanus* and *Brassica* produced first by G. Karpechenko of Russia in 1926. *Raphanus* has 2n=18 and *Brassica* has 2n=18 chromosomes. In the hybrid there will be 9 *Raphanus* and 9 *Brassica* chromosomes. The chromosomes are non-homologous (not similar), so they do not pair and the hybrid is sterile. To overcome this, colchicine is used to double the chromosome number and in the hybrid 18 *Raphanus* chromosomes pair among themselves and so the 18 *Brassica* chromosomes to restore the fertility of the hybrid. Other synthetic hybrids are *Galeopsis tetraphid*, *Primula kewensis*, etc.

Aneuploids and colchicine

Aneuploidy is a condition in which chromosomes are added to or lost from the diploid set of chromosomes. The loss or addition may be found at polyploid levels. For example, the nullisomic (2n=2) is essentially aneuploid.

Aneuploids can be created by colchicine in two ways. One procedure involves direct action on dividing cells in meristems. The other method is indirect, following specific breeding procedures after polyploids have been made. Until colchicine was discovered, the first type was rarely seen, particularly the diploid deficient plants, 2n=1. The scope for indirect method has been expanded to more species because colchicine has stimulated production of tetraploids. It is well-known that tetraploids crossed with diploids create triploids. These in turn, when crossed back to diploids, become a rich source of off type plants, those with extra-chromosomes. Among the higher levels, pentaploids are an excellent source of aneuploids. Propagating autotetraploids regularly throw plants with deviating chromosome numbers.

Effects on individuals due to chromosome doubling

Due to chromosome doubling tetraploids show generally vigorous growth. This can be easily seen by observing the leaf size, stomatal size, flower size as well as the size of the pollen grains (Fig. 2). Later on, tetraploids are confirmed by counting the chromosome numbers, which are exactly double the diploids. However, it has been found that in some cases, due to tetraploidy, seed setting decreases. For this, production of tetraploid plants has been exploited fully in horticultural plants, where seeds are not essential and reproduction takes place vegetatively. Triploid plants with seedless fruits have been obtained in many cases by crossing tetraploids with diploids.

Other uses

From second century to seventeenth century A.D., many physicians recommended *Colchicum* for the treatment of gout. During the latter eighteenth and beginning of nineteenth centuries, many English and French physicians wrote extensively about gout recommending *Colchicum* for relief. An application of colchicine reported in modern medical practice is the Hodgkin's disease in which remissions were obtained. Colchicine had also been tried for the treatment of cancer but no positive result was found.

It has been tried in higher plants, lower plants, bacteria, higher animals, lower animals, etc., to study cellular growth, morphological changes, growth inhibition, growth enhancement, etc. Nowadays, the main biological use is the study of metaphase chromosomes of both plants and animals with a low concentration of colchicine.

There remain unexplored problems which appear to promise more discoveries. Future progress in agriculture, medicine, pharmacy, biology and chemistry will be facilitated by further research on colchicine.

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Food habits of mountain gorilla

IN 1975-76 and 1978, I had the opportunity of visiting Kahuzi-Biega—the National Park for Mountain Gorillas, in the Kivu area of Zaire (former Belgian Congo). Mountain Gorillas, Pygmy Chimpanzees (Bonobo), and Okapi are the three most important mammals of Zaire and the Government has tried special measures for protecting and studying these species. All the three live in dense woodland and therefore, unlike the plains game of African Savanna, are very difficult to observe.

Till recently the Gorilla was considered to be a demonaic breast-slapping creature who would tear the hunter into pieces. The recent work of Schaller, Donisthorpe, Fossey, etc., has exploded this myth. The Gorilla is a mild and gentle creature who slaps his breast or a branch of a tree and emits a barking roar, but then calms down if you also wait calmly and make no movements that might be construed as aggressive gestures. Schaller and Fossey became almost close companions of Gorillas of Kabara and neighbouring regions of Zaire and Rwanda. I myself could approach to within about 7.5 m of the largest male Gorilla of the troop most often seen in Kahuzi-Biega.

Gorillas are pure vegetarians except that in Rwanda they eat grubs, i.e., insect larva. This aspect needs a comment because in recent times it has been proved that chimpanzees and baboons are occasionally meat eaters. Again, even the chimpanzees are very noisy and excited while rushing to the fruiting wild fig trees, probably because there is a certain degree of competition for food. The Gorillas, by contrast, are slow eaters, unhurriedly feeding on the endless supply of leaves, barks of small branches and grass (including bamboos).

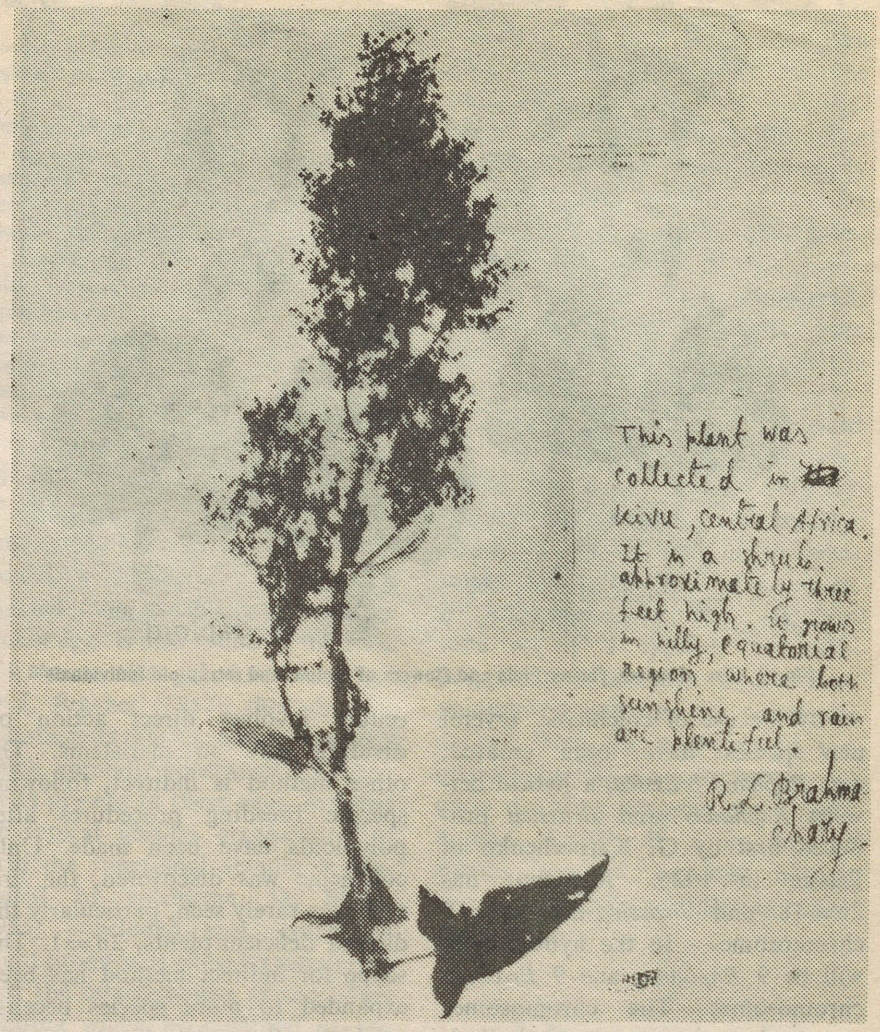

Fig. 1 Mufumba

At Kahuzi-Biega, there was practically no fruit during my period of stay but I saw the Gorillas eating a lot of leaves and bark. Like other investigators I found only vegetal remains (including grass) in the dung of Gorillas. Apart from numerous fly larva mentioned by Schaller, I saw two species of beetles in the Gorilla dung. I had also obsered these beetles (together with other dung beetles), in the dung of elephants in Parc National de Virunga. I tried to confirm the report of Mckinnon (*Mimes report to IUCN on Gorillas and Bonobo*) that wasp grubs are eaten by Gorillas but failed to do so. Wasp nests can be seen frequently, if at all in Kahuzi.

Schaller and others have listed a hundred species of plants which serve as food for Gorillas in various regions. Goodall observed 104 species of plants in Kahuzi.

The French speaking guide, Bizimana and the Pygmoid trackers Mushebere and Matene, have frequently observed about 27 species of plants being eaten at Kahuzi. I observed some of these myself. Of the 14 species I tested only, two exuded acidic sap. Schaller and Grzimek reported that most of the leaves eaten by Gorillas have a

rather bitter taste. These two acidic plants, *Mufumba* and *Gakomanjorero* (sap pH ≃ 3 and ≃ 3.5, respectively), are therefore interesting items. In 1975 Casimir listed the food plants of Kahuzi. His list does not include these two plants. I, therefore, decided to investigate these two plants, especially *Mufumba*, which has very lucious, fleshy leaves and stalks, and seems to grow easily everywhere.

In 1978 I performed a field experiment for making a rough estimate of ascorbic acid content of Mufumba sap. On the basis of the colour reaction of the dye 2–6–dichlorophenol–indophenol, the ascorbic acid content seems to be high (2 mg/ml), but as is well-known, because of the possible presence of other reducing agents, this test is not confirmatory. This field experiment warrants a rigorous laboratory experiment.

Ascorbic acid in Gorilla food was discussed by Pauling in his advocacy for consuming large quantities of vitamin C. He quoted Bourne's comments on Gorillas. In the wild a Gorilla will have to eat at least 10 kg of leaves to gain 4000 calories (based on the estimated weight of a gorilla). "This amount of leaves is likely to contain about 4.5 g of ascorbic acid"—argues Pauling. But this estimate remains to be verified after estimating the vitamin C content of the leaves of all the species (which is quite feasible) and observing the average relative quantities of all the plant species eaten (which is very difficult in that dense vegetation but has been attempted by Goodall).

In 1978 I could collect Mufumba with inflorescence. This was identified by Dr. Panigrahi of Botanical Garden, Calcutta as *Rumex abyssinicus*. Samples preserved in this herbarium library were collected by Schimper, Zenker and Whyte between 1837-1894. There is an earlier sample of 1815 which is anonymous. In 1974 Goodall had noted the plant as a food species of Gorilla in the course of his Ph.D. work.

As this plant grows very easily in Kahuzi, it can become a source of economic value if cultivated outside the National Park. I would like to dwell on this point. Formerly, in some parts of Congo, it was indeed cultivated for extracting a colour from the roots which used to be mixed with butter. In India, the roots of *Rumex dentatus* (aptly named Lalbibi in Hindi) are a source of red dye, while in Mexico the Navajo Indians use the yellow dye of *R. hymenosepalus* on woollen clothings. A relative of Mufumba in India is *R. vesicarius* (Hindi: *Khatta Palak*; Beng: *Chukapalang*), the name of which indicates the acidic nature. Apart from serving as a minor item of food, it also enjoys the reputation of having medicinal properties in its juice, seeds and roots which are believed to contain diuretic, purgative and antidysenteric properties and also to serve as medicine for scorpion stings. Gorillas in Kisoro are known to eat the stalks of leaves of *Rumex nepalensis*, the roots of which contain a purgative principle. In India this was prescribed as a substitute for rhubarb and was being sold in the markets of Bengal as *rewandchini*. The purgative principle in rhubarb is known to be emodin. This and other anthraquinone-like substances may be available in Mufumba also.

This plant, therefore, deserves a thorough investigation for possible exploitation in Zaire. Like rhubarb, also known as pie-plant, the stalks of Mufumba may be edible. The rather pleasant sour taste of the sap is also like that of rhubarb. A vitamin-rich cold drink may perhaps be prepared from the juice of Mufumba.

In East African native medicinal lore, the sap of leaves and stems of *R. abyssinicus* is used in treatment of cold, cough, pneumonia, etc., This may have a scientific basis if the sap is rich in vitamin C. The extract of roots was also used for application on wounds. This may have a scientific basis if, as in rhubarb, bacteriostatic anthraquinones exist in the roots.

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Micoplasma rickettsiae—the new group of plant pathogens

THE history of living cells is a long one, starting in 1865 when it was recognized that cell is the basic unit of life processes. The most primitive mollicutes have very thin membranes permeable to some molecules and ions. In 1967 Japanese scientist Professor Y. Doi discovered the large group of prokaryotes that infects plants and insects. These microorganisms were carefully studied and their morphological resemblance to mycoplasma as well as PLT (Psittacosis - Lyphogranuloma - Trachoma) agents was pointed out. Earlier, this group of pathogens had been classified as viruses because scientists failed to isolate and characterize them properly. The name "mycoplasma" was coined by plant pathologists as the organisms were devoid of cell wall and belonged to the class mollicutes and order mycoplasmatales.

In 1974 Professor Karl Maramorosch of U.S.A. described the new group of plant pathogens as RLO (Rickettsiae-Like-Organism) or walled

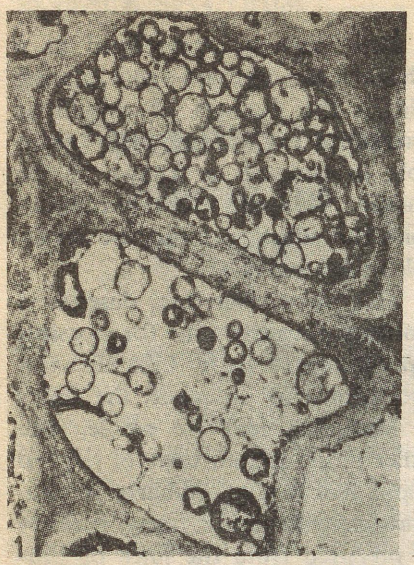

Fig 1 Mycoplasma like bodies in sieve tube elements of mid-vein from witches broom *Salix rigida* leaues (*Courtesy*: Prof. K. Maramorosch)

acteria. They are membrane bound disease agents. The mollicutes were isoiated from sieve elements of the plants suffering from yellow type diseases. The tempoiary remission from yellow type diseases was conferred when tetracyclines but not penicillin) were applied. Electron microscopy of recovering plants showed the gradual disappearance of recovering plants. But after several weeks, the effect of tetracycline ceased and plant succumbed to the disease indicating that the cure was temporary and incomplete.

During the past eleven years, over 70 distinct plant diseases affecting some 300 genera of plants were found to be caused by mollicutes-like organism (MLO).

These prokaryotes associated with yellow type plant diseases are characterized and defined as follows by Professor Karl Maramorosch of U.S.A in 1974. The term is applied to the pleomorphic organisms, bounded by unit spiroplasma is membranes, 8-10 nm in thickness, with RNA granules (ribosomes) and DNA strands in nuclear region (Fig. 1). Many MLO's are susceptible to tetracycline application *in vivo*. These microorganisms can be visualized by electron microscopy of thin sections of phloem cells. The common diseases are rice yellow dwarf, sandal spike, little leaf of brinjal and sesamum phyllody (Fig. 2). Known vectors of MLO include leaf hoppers, plant hoppers and psyllids.

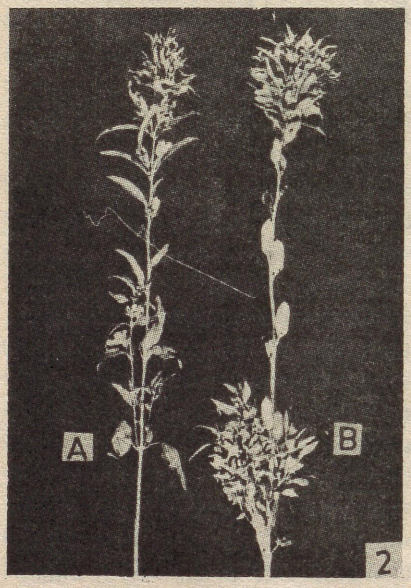

Fig 2 *Sesomum indicum* plant showing phyllody syndrome. (A) Healthy plant (B) Diseased plant

Spiroplasma. Spiroplasma is a vernacular name given to some MLOs that are characterized by a spiral form. The spiral form is discernible in dark field and phase contrast microscopy (Fig. 3). The first and so far the only cultured *Spiroplasma citvi*, the causative agent of citrus stubborn disease.

Rickettsiae-like organism(RLO). This term is applied to pleomorphic microorganisms possessing a definite cell. 20nm-25 nm in thickness, often rippled (Fig. 4). The RKOs are susceptible to periocillin *in vivo*. The internal structure resembles that of rickettsial and they do not belong to mollicutes. They have been found in phloem or xylem in diseased plants. The important diseases are citrus greening, Witche's broom of willow, clover club leaf and title leaf of *Sida cordifoiia*.

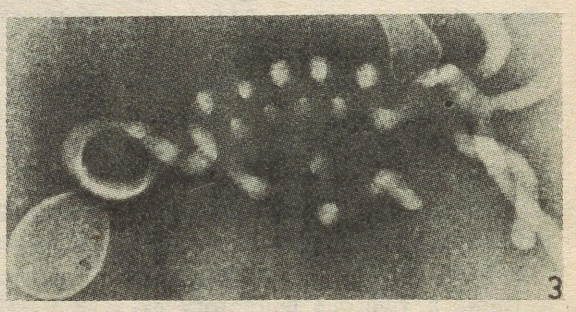

Fig. 3. Cultured spiroplasma, isolated from witches-broom diseased cactus (*Courtesy* :Prof. K. Maramorosch)

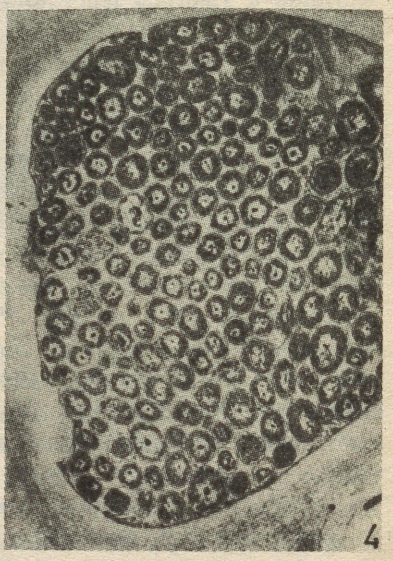

Fig. 4 Cross section of a sieve tube element fully packed with numerous rickettsia-like organisms in *Sida cordifolia* leaves (*Courtesy*:Prof. K. Maramorosch)

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Don't kill useful snakes

WE consider all snakes as a menance though only some of them are deadly. Rarely it occurs to us that some snakes are also helpful animals, because they are effective rat killers

Rats are delicious

The two harmless sand boas (1 m), the Common Sand Boa (*Eryx conicus*) and the Red Sand Boa (*Eryx johnii*), are miniature pythons. They are also closely related to pythons and are widely found in plains, hills, and sandy soils of India. Like their giant cousins, the boas constrict their prey before swallowing. For this reason, they are called constrictors. The common sand boa is fairly found in dikes between rice fields and heaps of agricultural produce, probably, because of the assured supply of their delicacy—rats and other rodents which damage crops. Though it superficially resembles a python, it is more commonly mistaken as a deadly viper because of its small scaled head and thick-set body which bring the snake nearer to death at the hands of the innocent people. It hunts for food at night. The red sand boa, whose tail is so blunt that it looks almost like another head, has become a favourite with our snake charmers who exhibit it as a 'double-headed snake' to the delight of their gullible audience. This sanke is credited with the exceptional power of penetrating the blocked burrows of the rice-destroying mole rat.

It is not well-known that diet of the largest of Indian sankes, python (6m), includes rats and other destructive mammals. It is deployed in rice fields for the eradication of rats, pythons are welcome pets in grain stores of Burma and Thailand.

The harmless trinket snake (*Elaphe helena*) reaching a maximum length of 1.5 m is one of the beautiful snakes which relishes rats. It is found in farm lands and forests of India and its presence in agricultural areas should be a major factor in controlling rodents and other rodent pests.

The Indian rat snake or *Dhaman* (*Ptyas mucosus*) occupies a place of pride for its service to Indian farmers. It is considered a deadly enemy of rats on which it preys voraciously. Found throughout India, this non-venomous snake is commonly seen in rat holes, rice fields and large godowns of food grain. Next only to the king cobra

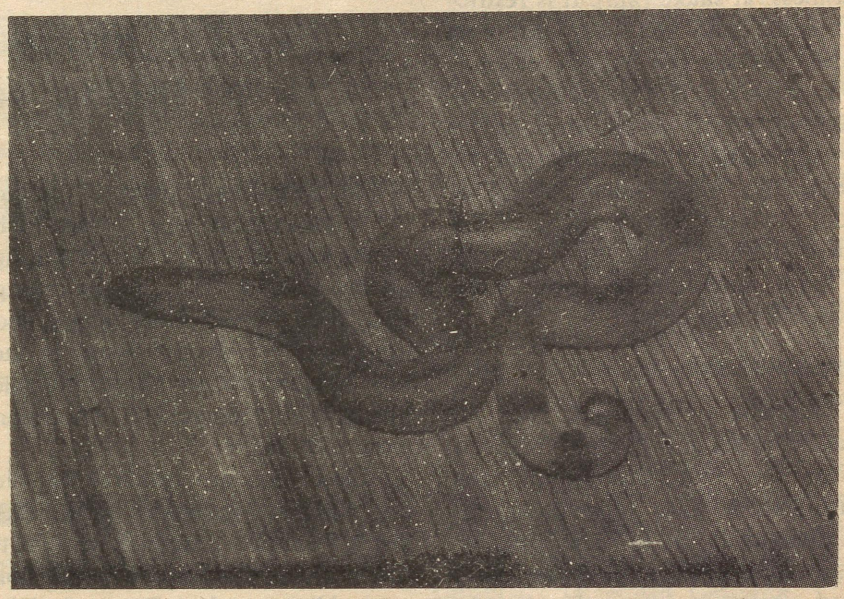
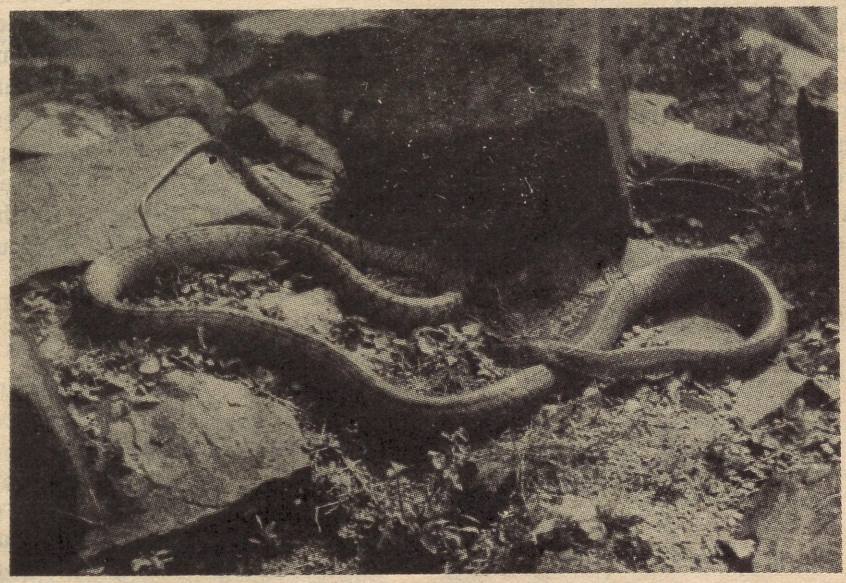


Fig. 1. The red sand boa



3. The Indian rat snake

and Indian Python, it is 3.5 meter in length and is considered a male cobra simply because it is big and rather aggressive. Also, because of their similar feeding habits, the cobra and dhaman sometimes appear together. The purely accidental assembling of these two totally different kinds of snakes has given rise to several myths. The simple fact that these snakes enter our homes in search of rats is not realised.

The Royal Snake or Diadem Snake (*Spalerosphis diadema*) is another harmless rat snake (2m). It is restricted to the arid zone of Northwest India. Though this rodent eater is non-venomous, it is still regarded by the local people as another variety of cobra and is killed with. Besides cobra, the other killer snakes of India, namely, the Krait and the Russell's Viper, prey upon rodents, a habit that makes them enter homes in quest of rats.

Ornamental skin

The boas, pythons and the rat snakes are sought for their precious skins. Lured by its ornamental skin, skin traders have nick-named the common sand boa as 'Baby python', whose ornamental skin commands a good market in international trade. With incerasing demand for their skin, ruthless killing of these harmless snakes continued unabated until the entire population of some of the abundant species were wiped out and have become a rare or endangered snake. To prevent their extinction, the Government of India has enforced laws regulating the export trade and has protected some species like pythons under more rigid laws.

Snakes and green revolution

The bitter truth is that despite all the rodenticides and rattraps, rats are merrily multiplying. Though it may seem a bit eccentric to suggest that we should allow the existence of deadly varieties of snakes around us, at least the harmless species like the boas, rat snake and the trinket snakes should be allowed to thrive on our farmlands so that they can play a helpful role in our economy.

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Earliest marine pelecypods from Indian sub-continent

THE sedimentary rocks of Indian sub-continent have yielded rich assemblages of marine fossils during last few decades. These fossils belong to different invertebrate phyla and are generally well distributed in the Early Palaeozoic to Early Cenozoic (about 500 million years to 55 million years old) strata.

A few years ago, while engaged in the systematic collection of marine fossils from the Cambrian sediments (about 500 million years to 425 million years old) exposed at Baramula District in Jammu and Kashmir (India), we discovered two completely fossilized valves of marine pelecypods (Phylum: Mollusca). These valves constitute the oldest pelecypod remains recovered so far from Indian sub-continent. Earlier the only true Cambrian pelecypod fossils (belonging to the genus *Fordilla*) were known to occur in Denmark, England, Portugal, etc. *Stenothecoides*, a doubtful Cambrian pelecypod, has been reported from North America. Morphologically, the fossil valves from Jammu and Kashmir State are assined to *Fordilla* though the Indian material is comparatively younger in age.

I strongly believe that the ecological conditions of the cambrian time quite suited the marine pelecypods in Northern India. Further, the systematic exploration of the Cambrian successions exposed in different parts of the Himalayas can yield rare and well preserved pelecypod material in future.

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INDIAN OCEAN (*Continued from page 670*)

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NEWS & NOTES

Dr. Keldysh passes away

DR. MSTISLAV Vsevolodovich Keldysh, a mathematician who headed the Soviet Academy of Sciences for 14 years, died on June 17 at the age of 67 years. Dr. Keldysh was a leading specialist in mathematics, mechanical engineering, electronics and aerodynamics. He was honoured in the Soviet Union for his theory of aerodynamic vibrations, which became widely used in designing aircraft and long-range guided missiles. From 1961 to 1975, as President of the Academy he dominated the Soviet Union's almost every major area of science, including space programmes. A most outstanding contemporary scientist, he played a fundamental role in developing computer and nuclear technology. Throughout his life Keldysh was showered with honours, including three times the title of Hero of Socialist Labour, the Soviet Union's top civilian honour. He was also a honorary member of the American Academy of Arts and Sciences.

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16-36 million year old leaves found intact

PLANT tissues, when somehow trapped, undergo usually some degree of alterations, such as mineralization and/or decomposition. Mineralization is a process in which molecules of minerals surrounding the trapped tissues replace molecules of organic chemicals, as generally observed in petrified wood. Under other conditions, there may not be mineral substitution but a compression of the tissues, and a form of decomposition occurs converting the plant tissues into oil or coal. Under dry conditions that destroy any decaying microorganisms, plant leaves may simply be trapped and merely desiccated, and if sealed off, may remain undisturbed for thousands of years. Last year, some leaves were recovered from volcanic ash deposits in eastern Oregon, U.S.A. that remained green for millions of years. Recently, a team of botanists from the New York Botanical Garden and the University of North Carolina reported that it has discovered the most perfectly preserved specimens of leaves from the distant past (*Proc. Natl. Acad. Sci.* U.S., July 1978). The specimens were tree leaves that were 16 million to 36 million years old, that had remained green and intact down to the membranes, organelles and other microscopic structures inside the cells. The leaves of Chinese elm, called Zelkova, which is extinct in North America, appeared to have been trapped during an ashfall from a volcano in North Carolina. The cool, dry ash apparently rapidly dehydrated the leaves without distorting them much. From the heaps of the now hardened ash it was possible to gently loose, the leaves, which appeared almost as if they had been pressed in the pages of a book only a few weeks back, say the investigators, Karl J. Niklas of the New York Botanical Garden and electron microscopist Dr. R. Malcolm Brown of the University of North Carolina.

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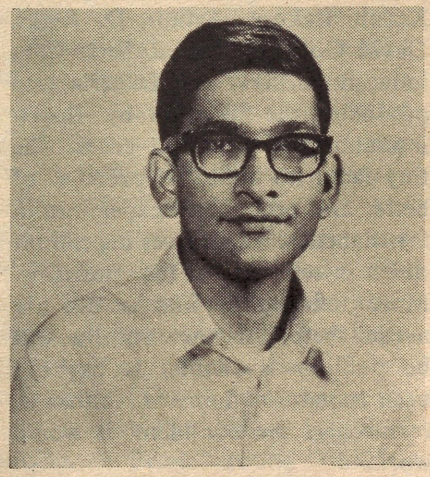
An Interview

Dr. P. Balram

"MANY prestigious Indian institutions such as I.I.T.s and central universities have adopted research and teaching methods similar to those abroad, for instance in the U.S.A. But in many cases," says Dr. Padmanabhan Balaram, Assistant Professor at the Indian Institute of Science, Bangalore, and, 1977 INSA medal winner, "more irrelevant aspects have been bor-



Dr. P. Balram

St. John's Medical College LIBRARY

rowed, while essential ones, such as rigorous and objective evaluation of scientific and teaching performance, have been ignored. Moreover, research funds are not often tied to "performance!"

Dr. Balaram has worked at Carnegie-Mellon University, Pittsburgh, where he did his Ph.D., and was also at Harvard University—in all for four years in the U.S.A. Earlier, he did B.Sc. from Fergusson College, Pune, and M.Sc. from I.I.T., Kanpur. He says he was fortunate that he studied at the Chemistry Department of I.I.T., Kanpur, where his interest in research was encouraged by his teachers.

Dr. Balram's researches concern the study of complex molecular systems like cell membranes. Using techniques such as fluorescence and nuclear magnetic resonance spectroscopy, he has probed into the structures and interactions of biologically important molecules. His work has undoubtedly important implications in understanding the details of life process.

What seems to irk him is that "politics has entered in our temples of learning". He says, "Unless our universities take imparting education as their primary objective, there is no point in devising methods for improving education".

DILIP M. SALWI

(*Next month*: S. S. Bhatnagar Award winner)

Bacteria made to synthesise human insulin

IN a development that could affect millions of diabetics, a team of researchers in genetic engineering in Duarte, California announced in the first week of September the creation of artificially-produced human insulin for diabetics in laboratory bacteria serving as hormone factories. The research team consisting of Keiichi Itakura, Arthur D. Riggs, David Goeddel, and Roberto Crea induced *Escheria coli* bacteria into producing the hormone by inserting laboratory-produced genes. The tiny factories hold the promise of better and probably cheaper insulin for diabetics, whose lives depend on daily injections of the hormone. More refinements and testing are needed before the new insulin will be publicly available. It has not been tested on humans, although researchers are confident it would work.

The research team that worked at the City of Hope National Medical Center at Duarte collaborated with scientists from Genetech Inc., a private San Francisco laboratory that funded the project. Genetech Inc. has applied for prtents on the process and the pharmaceutical concern Eli Lilly Co. of Indianapolis plans to manufacture and market human insulin made with the bacterial process.

The insulin work was built on a foundation laid last year when the City of Hope National Medical Center and the University of California at San Francisco announced that they had built an artificial gene that ordered bacteria to synthesize a much simpler, less valuable human hormone called somatostatin. The research team created artificial genes that carry the chemical blueprint for human insulin. The genes were inserted into *E. coli*, a favourite organism of researchers working with deoxyribonucleic acid (DNA). When chemical on-off switches, were added to the genes and switched on, the bacteria assembled the components of insulin from their own supply of chemicals. The product, when extracted and purified, was chemically identical to the insulin produced by the human pancreas.

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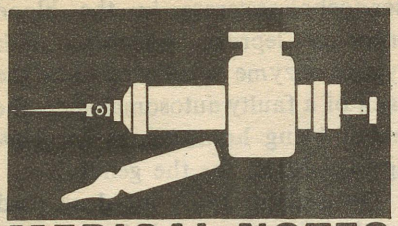
Chromatography of polymers, petroleum and petrochemicals symposium

A three-day Symposium on Chromatography of Polymers Petroleum and Petrochemicals will be organized from Dec. 26-28, 1978 at the Indian Association for the Cultivation of Science, Calcutta, for professionals in industry and research workers of R&D organisations and academic institutions. The Symposium aims at improving the application of chromatography in various industries. Besides lectures and discussions, it will also organize a workshop for technicians. The symposium and workshop will be conducted jointly by Sukumar Maiti of the IIT, Kharagpur and Prof. C. V. N. Rao of the Indian Association for the Cultivation of Science, Calcutta. Additional information can be obtained from Prof. Sukumar Maiti, Materials Science Centre, Indian Institute of Technology, Kharagpur-721302.



MEDICAL NOTES

The ignored anti-malarial plant

SOME of the recent scientific reports have confirmed that, we in India, are fast losing our battle against malaria. This is because in case of both, mosquitoes and malarial parasite, certain strains have become resistant to the synthetic chemicals commonly used against them. Cinchona bark and its alkaloid quinine still have an important role in malariology, but the various *Cinchona* spp. yielding this drug have been cultivated to a limited extent in Mangpho (Darjeeling) and Neduvatam (Ootacamund) in India. For our present needs, if we use quinine, much of it has to be imported.

Keeping the above facts in view, a literature and field survey of Indian plants was carried out to find out if any other drug can be used as a substitute of *Cinchona*. The tree *Dichroa febrituga* of family Saxifragaceae (Fig. 1) appears to be quite promising in this regard. It is found growing in Nepal, Sikkim, Assam and Khasi Hills at an altitude of 1,200 m to 2,500 m. The dried root and flower tops of this plant have been extensively used as a drug of choice for malaria in Chinese system of medicine for many centuries. The dried root with a small portion of the stem attached to it is known as 'Chang Shan' and dried leaf tops as



Fig 1. The plant Dichroa febrifuga

'Shuchi'. In the treatment of malaria 'Chang Shan' may be used alone, but usually both the 'Chang Shan' and 'Shuchi' are administered along with betel nut, turtle shell and ginger. A report in 1958 mentioned the cultivation of this tree in Soviet Union, as a source of effective remedy against malaria.

In India, the therapeutic efficacy of this plant for malaria is well-known in the areas where the tree grows. In Sikkim, it is called 'Basak' and the vapours obtained after boiling the drug in water are inhaled. In Nepal, it is called 'Aseru' and decoction of root and bark is taken. The root bark is available in the market also (Nadkarni, 1954). It is soft corky, almost tasteless with a faint aromatic odour. It causes nausea and vomitting when used as a drug. But there is a common belief that its beneficial effect is due to its emetic action.

Some earlier chemical reports on the chemistry of the drug are quite conflicting and the isolated alkaloids were given different names by the different authors. Openshaw (1953, 1960) confirmed that the alkaloids of the plant, febrifugine and iso-febrifugine, are of quinazolin type. Anti-pyretic and anti-parasitic effects of these alkaloids have been confirmed by various trials. Febrifugine has 64 to 100 times greater activity against *Plasmodium* spp. than quinine. From roots, 0.05% alkaloid was isolated of which 63%

was febrifugine. Leaves contained 0.0%1-0.2% alkaloid of which 50% was febrifugine, but the interesting point to note is that leaves have more anti-malarial activity than roots. This shows that some compound other than febrifugine may also be responsible for the anti-malarial effect of *D. febrifuga.*

After some preliminary experiments about two decades back, further researches on the drug were abandoned, probably because western researchers could not get the authentic material. In that era, encouraging results were obtained from the synthetic anti-malarial drugs. Then, the side effects of this drug might have been a discouraging factor. Chopra *et al.* (1958) fully realised the potentialities of this plant and also the lack of interest of western workers in this drug and remarked "Further work on this plant by Indian workers may prove beneficial."

For an Indian worker, the availability of this plant should not be a problem now. The only point to be considered is its mode of administration. The main objection against the use of this drug is, its emetic effect, but it should not be ignored that the effectiveness of this plant in traditional systems of medicine is said to be due to its power to cause vomit.

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Chandigarh 160014

Leprosy cure

LEPROSY is caused by *Mycobacterium leprae*, which was identified by Hansen in early 1873 and the infection is confined to the skin and nerves. In the nodular or lepromatous type of leprosy, most of the skin and peripheral nerves are involved. Brownish spots, followed by nodular thickenings, appear on the limbs and face; the face shows a "leonine" appearance due to the thickening of the skin in the region of the forehead, eyes, lobes of ears and around the nose and mouth. The maculo-anaesthetic or tuberculoid form of leprosy involves peripheral nerves and patchy areas of the skin and is marked by flat, red to brown lesions on the skin, distributed symmetrically. These lesions gradually become insensitive to touch and pain. Ulceration of the feet occurs due to loss of sensation and paralysis of motor nerves produces deformities.

An unsolved problem in leprosy research is that the bacilli have not yet been cultivated in the test-tube. Its multiplication is generally done in the footpads of mice, particularly for testing the activity of new drugs against it. It was only in 1960 that infection was produced in experimental animals. In 1968 scientists at the National Institute of Medical Research, London produced leprosy infection in mice which closely resembled the human disease.

Of current research interest, mention may be made of the genetic basis for susceptibility to leprosy. It was found that identical twins have a greater incidence of leprosy than non-identical twins. Persons with 'O' blood group have a higher incidence than those of 'B' blood group Some. observed the presence of an atypical variety of the enzyme pseudocholinesterase in the blood serum of leprosy patients. This atypical enzyme is believed to be the result of a faulty autosomal gene, the patient being homozygous (or having two doses) for the gene.

Until about 1947, the drug used for the disease was chalmoogra oil which was not very effective. However, until recently the most effective drug for leprosy cure is a sulpha drug—Dapsone (4, 4^1-diaminodiphenyl sulphone, DDS). This is generally given orally in doses of 6mg-10 mg/ kg body weight/week for a period of 2-5 years or even longer. However, the drawback with this is that the leprosy bacilli often develop resistance to it.

Most current research studies have shown that Dapsone is converted in man into monoacetyl dapsone (MADDS) by the same enzyme systems responsible for acetylating isoniazid, a drug used for tuberculosis treatment. But unlike acetylisoniazid, MADDS is rapidly deacetylated in man, with the consequence that the half-life of DDS in the body, unlike that of isoniazid, seems to be unrelated to the speed at which it is acetylated. Scientists of MRC, England and National Leprosy Control Centre, Malaysia concluded from their interesting experiments on mice and man that the rate of acetylation of DDS is likely to be without prognostic effect in the treatment of leprosy. Whether or not MADDS has antileprotic activity cannot be established at present, since it is rapidly deacetylated to dapsone, in both man and mouse, in which its therapeutic efficiency might be investigated.

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Distillates . . . . Sublimates

E. NARAYANAN

THE death of E. Narayanan, Editor of the *Patriot* in the first week of September, made the *Science Reporter* family sad. Few know that Narayanan had much to do in nursing *S.R.* when it was born in 1964.

I had no personal knowledge of Narayanan nor had I ever met him before 1964. He had then just established the United India Press and we were looking for a reliable and good printer for India's first popular science magazine, *S. R.* We chose the United India Press and that is how I came to know Narayanan.

My first impression of the man was not a very pleasant one. He was a highly introverted person and refused to be provoked into conversation. We had a lot of questions to ask him about the printing of *S.R.*, especially the first issue that was to be brought out on the New Year's day of 1964. I found it extremely difficult to extract anything but briefly worded answers to my anxious questions. I was wondering whether I will really be able to work with him.

Later, I was to discover that Narayanan was pleasantly humane. Concealed behind the exterior arrogance was a warm heart.

I doubt he had any special interest in science, but, nonetheless, willingly accepted to print *S. R.* Whenever I had any difficulty about the publication deadline of the magazine, I used to complain to him, at times against his own workers. I found him accommodating and helpful.

S.R. was printed for nearly 10 years at Narayanan's United India Press. Inspite of the heavy demands on his time by the weekly *Link* and the daily *Patriot* which he edited, Narayanan took personal interest in the timely publication of *S.R.* He contributed a good deal to the success of the magazine in its initial years. The death of this quiet, unassuming and pungent journalist will be mourned by all who knew him.

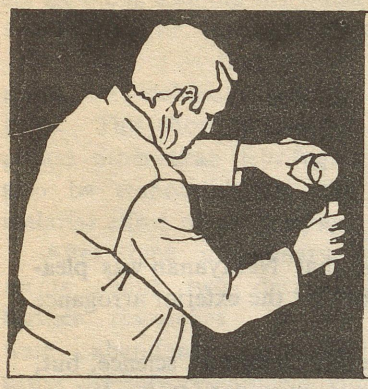
CRIME DETECTION—STILL PRIMITIVE

THE murder of Sanjay Chopra and Geeta Chopra in the last week of August and the subsequent manifestation of the ineptness of the police in apprehending the ciminals has generated a national debate on various aspects of crime detection in the country. Apart from the police apathy in this case, what has amazed one is the inadequacy and primitiveness of the forensic outfit in the capital. The murderers left clues almost at every stage of the crime. In fact, there were quite a few eye witnesses to the struggle for survival put up by the two children, Sanjay and Geeta, on some of the busiest streets of New Delhi in the twilight hours of the fateful day. The post mortem report said that the murder took place around 10 PM, but the alleged culprits, since arrested, have given out that it was at 7 PM, right in the car. How could the forensic expert be so wide of the mark in regard to the timing of the death of the children—an extremely vital aspect in solution of the crime mystery? Needless to say that such a grave error misled the detectives and confused the police and others in apprehending the criminals. Then, it took the forensic experts nearly three days to compare the fingerprints and shreds of hair found in the abandoned car in Majlis Park. The delay kept detection from narrowing down to only a few suspects. The criminals got the much needed time to plan their escape.

The two alleged criminals, Billa and Ranga, have been arrested, but the police, the forensic experts and the detectives have little to boast of—their capture was more accidental than the result of a planned investigation of the police. None of the clues was detected or discovered by the police. Everything, from the dead bodies of the murdered children to the arrest of the criminals, was made over to the police by others.

It is time to take a hard look at our forensic and detective outfit—to see how modern they are. Which, in essence, means how scientifically equipped they are. A suspicion is widely shared in the scientific community of Delhi that our forensic and detection outfit is outmoded, and miserably wanting in modern, scientific tools and appliances of crime detection. Nothing illustrates this deficiency better than the police failure to prevent the criminals from murdering the two innocent childern inspite of timely tip to them and then, to apprehend them soon, after a neat, carefully planned investigation.

SHRAVAN



SCIENCE FOR THE YOUNG

The first encounter

PRACTICALLY each one of us has seen a new born baby at some time or other. When gazing at the little miniature, an exact scaled down replica of an adult human, have you stopped to wonder where it came from? From its mother's womb? Yes, but how did it get in there in the first place? The story goes back a long way to an 'egg' and a 'sperm' which got together to make a baby, complete in all details, down to the tiny fingernails on its little pink toes.

The human body consists of two types of cells, the somatic cells of which all tissues are made, and the germ cells or gametes which are produced in the reproductive organs on maturity. The woman has ovaries which produce ova or eggs and the man has testes which produce sperms or spermatozoa. Someone has calculated that all the ova required for the present world population could be contained in a top hat and the sperms to fertilise these three billion ova would fit into a thimble. One would deduce from this that the ovum is much bigger than the sperm, and so it is. It is, in fact, the largest cell in the body (apart from some nerve and muscle cells which are very long), having a diameter of about 0.00916 cm, just barely visible to the naked eye, while the sperm is a miniscule, nearly ·000091 cm. So you see that the human egg is a pretty insignificant little thing, compared to the egg you eat for breakfast or the ostrich egg which is about 170 mm × 135 mm, just a little smaller than a football (Fig. 1).

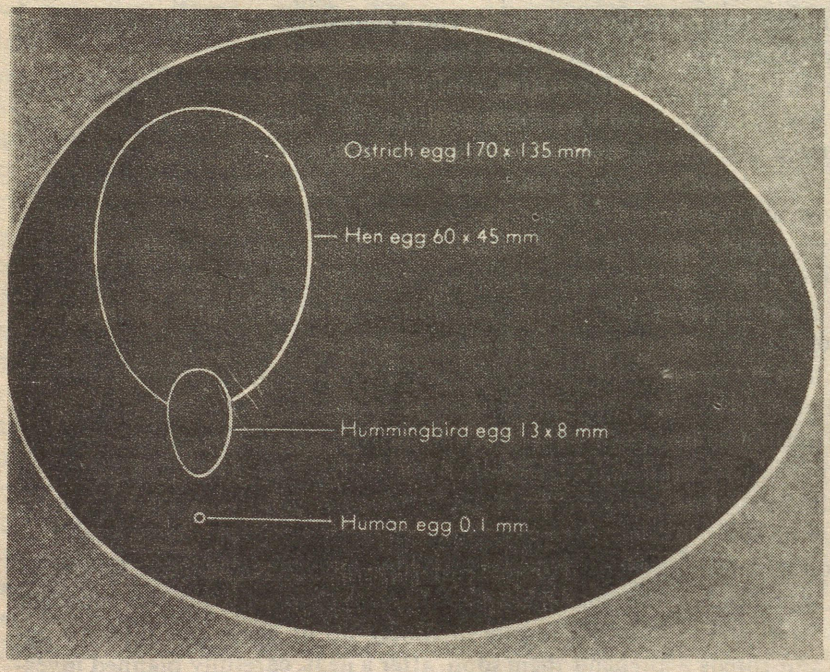


Fig. 1. A comparison of sizes of different kinds of eggs ranging from the tiny human egg to the enormous egg of an ostrich

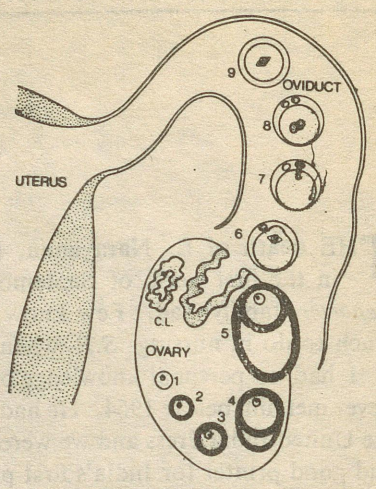
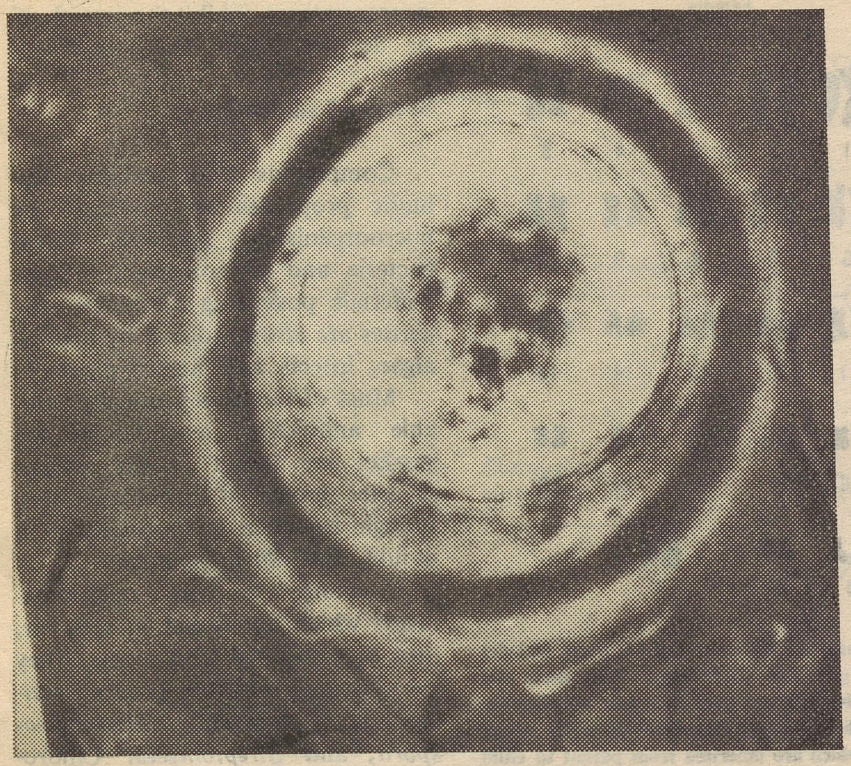


Fig. 2. After the sperms get deposited in the vagina, they move through the uterus and oviduct and meet the egg which is ready to 'receive' them (7). This egg comes from the ovary after maturing through various developmental stages (1-6). A scar in corpus luteum (CL) is formed in the ovary at the site from where the egg left it. Corpus luteum secretes certain hormones which are responsible for maintaining pregnancy

Each ovum matures within a small sac in the ovary known as follicle, and is surrounded by an envelope of cells which form what is called the 'radiate crown' around the ovum. Once mature, the ovum is released from the follicle and enters the funnel-shaped opening of the



Fis. 3. A mature ovum surrounded by sperms as seen under microscope

oviduct which hovers over the ovary. The sperm or spermatozoon consists of two parts, a head which contains all the genetic material (that is, information about all the characters a baby would inherit from its daddy) and a tail, which is used for swimming upto the oviduct, where the mature ovum lies waiting (Figs. 2, 3).

The sperms are suspended in a thick, whitish fluid (semen) which is rich in sugar, carbohydrate and protein to provide them energy during their long arduous journey to reach the ovum. Among other things, semen also contains an alkaline lubricant to neutralise any acid in the form of urine, present in the path of the sperm, as they are very sensitive to acid.

Whereas sperms are produced all the time by a healthy adult male, the female produces only one mature ovum once every four weeks. This seems like an absurd state of affairs, but nature has got to do something about the population (exploding the way it is). After all, one cannot run the risk of having sixteplets each time one gets pregnant, that is what would happen if six ova, for instance, were mature at the same time and got fertilised. Any way, for the great majority of sperms, the way up through the vagina and uterus and the oviduct is the proverbial road to destruction. Millions succumb in the acid secretion of the vagina. Presumably, half of those which reach the uterine cavity enter the wrong oviduct (i.e., not the one in which the mature ovum lies for fertilization), the rest run the risk of swimming astray in the labyrinth of folds and recesses in the widest part of the oviduct (Fig. 4). Finally, not more than a hundred sperms arrive in the neighbourhood of the ovum, of these only one reaches its destination and fertilises the ovum—if it is there. Since it looks like a contest of survival of the fittest, one assumes that it is the fittest sperms that get to the right place to participate in the final race for the ovum.

As for those sperms which appear at the wrong time, that is, when the ovum is not mature, things do not go well at all. They have difficulty in penetrating the viscid mass of mucus in the vagina which constitutes an effective barrier during the greater part of the menstrual cycle.



Fig. 4. A scanning electron microscope picture showing sperms getting caught in the microvilli of the linings of the uterus while passing through it

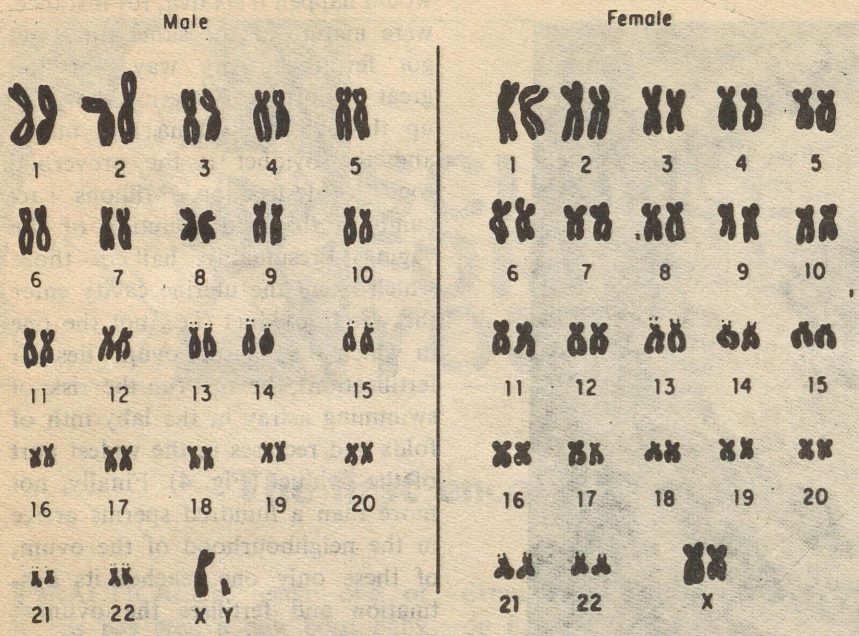


Fig. 5. Each human cell has 23 pairs of chromosomes, making a total of 46, which includes two sex chromosomes—XX in the case of girls and XY in boys. The sperm and egg contain only 23 chromosomes each, taking just one from each pair of chromosomes, so that when they fuse to form the zygote, there are 23 pairs again. These chromosomes carry the characters which are inherited from parent to child

So we see that the successful initiation of pregnancy requires that the ovum descending the umbrella-shaped mouth of the oviduct meets the ascending sperm at the right time, in the right place, and under the right circumstances.

Once the ovum and the sperm have met and the egg has been fertilised, it becomes impervious to all other sperms and the rejected suitors have no choice but to wither away and die. The fertilised egg is now called the zygote and the zygote is where the new baby begins, one cell each from the mother and the father (that is why you have Daddy's curly hair and Mummy's lovely brown colour). As to why you have yourown stubborn chin which is like none other in the whole world—that's another matter (Fig. 5). When the mother's characters and the father's characters come together in the zygote, there is a sort of mixup and then, a little like scrabble where you can make lots of new words from the same alphabets, new characters emerge, which are totally individual and that is why no two people look identical (except perhaps, monozygotic twins, and that is because the zygote splits into two and each part makes a new baby).

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Chloromycetin, the powerful antibiotic

IF you have ever suffered from typhoid fever you must have been given chloromycetin capsules by the doctor. Chloromycetin, also known as Chloramphenicol, is a potent antibiotic which kills bacteria that cause typhoid and many other diseases. Antibiotics are substances produced by microorganisms (i.e., metabolic products) which, in low concentrations, inhibit the growth of, or destroy other microorganisms.

Source of antibiotics

Compounds which exhibit antibiotic properties are produced by microorganisms, primarily fungi, bacteria and actinomycetes. Some materials possessing antibiotic properties are also produced by lichens, algae, insects and higher plants.

Most of the therapeutically valuable antibiotics available in the market are found in the Actinomycetes group of microorganisms, though penicillin is produced by a mould, *Penicillium notatum*.

Actinomycetes are microorganisms which are found in soil, air, dust or associated with plants. They are classified into four genera: *Actinomyces*, *Nocardia*, *Micromonospora*, and *Streptomyces*. Chloromycetin or chloramphenicol is a *Streptomyces* antibiotics. It is produced by the actinomycete, *Streptomyces venezuelae*.

Cultures of *Streptomyces venezuelae* are grown in a suitable medium. After fermentation is complete, the culture is filtered, the filtrate acidified and extracted with ethyl acetate. The extract is then concentrated and diluted with light petroleum. Then it is washed a few times with acid, a few times with alkali and finally with water. The resulting solution on concentration produces colourless crystals of chloromycetin. The ethyl extract of the acidified culture filtrate can also be distilled under reduced pressure and the residue extracted with ether. But then it is necessary to purify

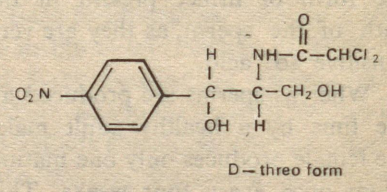

Fig. 1. Chloromycetin

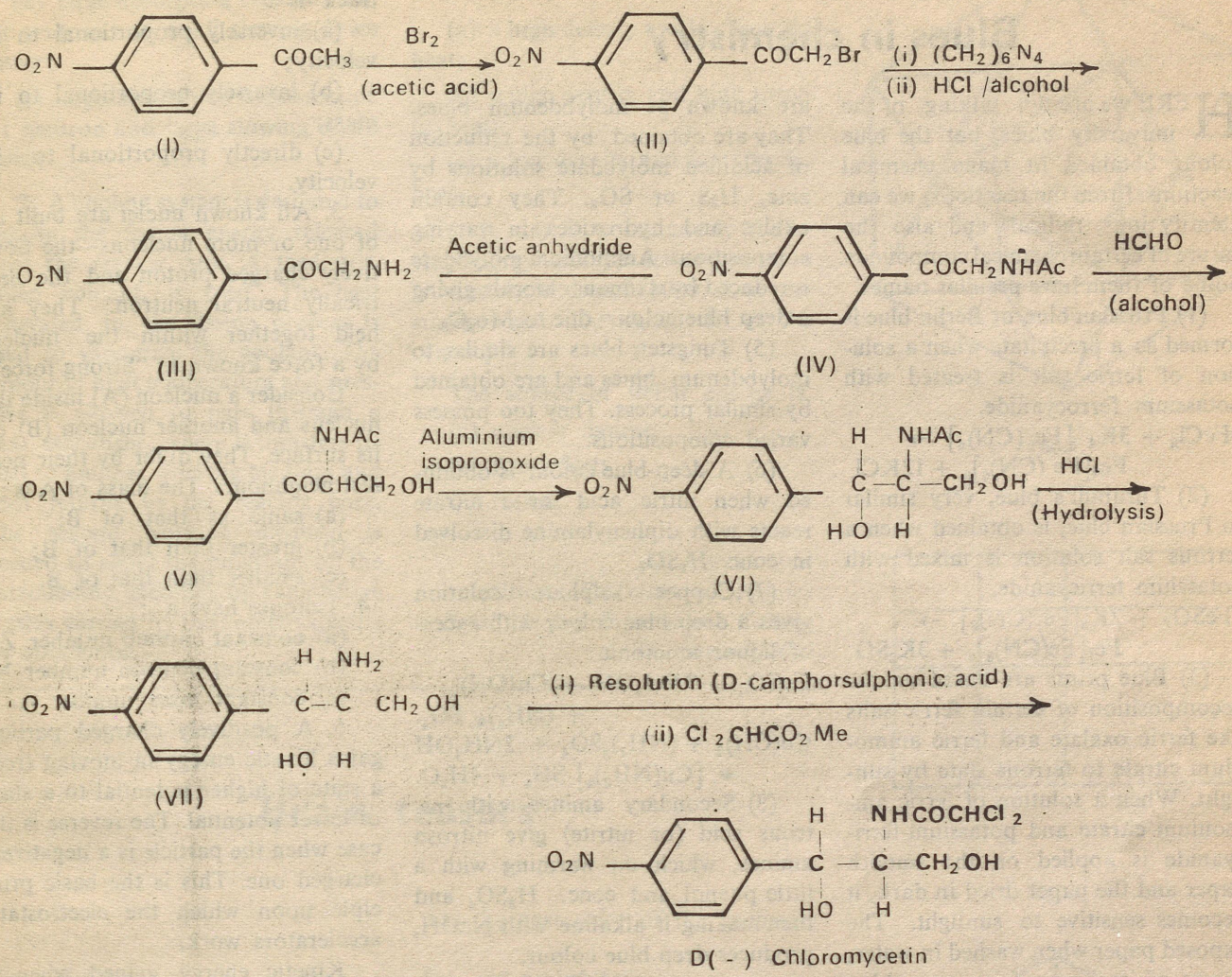

Fig. 2

the crude ethereal extract by chromatography which is a tedious process. For this reason, the former method is normally used.

Synthesis of chloromycetin

Chloromycetin is an optically active substance, i.e., it rotates the plane of polarised light. Only the D-(-)-threo-form of the antibiotic is biologically active, and therefore, during its synthesis in the laboratory, care is needed to prepare only the D-(-)-threo-form. (Fig. 1).

Quite a few methods are known for the synthesis of chloromycetin. The most efficient of them is the one starting with nitro acetophenone (Fig. 2).

Chloromycetin is active against both gram-positive and gram-negative bacteria. In other words, it is a broad-spectrum antibiotic. It is active against bacteria responsible for typhoid, typhus and dysentery. Chloromycetin along with streptomycin gives Chlorostrep which is used against bacillary dysentery.

Chloromycetin has a low general toxicity, but prolonged administration causes blood disorders leading to anaemia (e.g., aplastic anaemia).

As it has a very bitter taste, it is usually marketed in the form of capsules or as its palmitic ester. Esterfying the primary hydroxyl group ($-CH_2OH$) in chloromycetin gives a more palatable form.

CHITRA DATTAGUPTA

Blues in chemistry

HERE we are not talking of the university blues, but the blue colour obtained in many chemical reactions. From the reactions, we can identify ions, radicals and also the nature of certain chemical compounds. Some of them have peculiar names.

(1) Prussian blue or Berlin blue is formed as a precipitate when a solution of ferric salt is treated with potassium ferrocyanide.

$$4FeCl_3 + 3K_4[Fe(CN)_6] \rightarrow Fe_4[Fe(CN)_6]_3 + 12KCl$$

(2) Turnbull's blue, very similar to Prussian blue, is obtained when a ferrous salt solution is mixed with potassium ferricyanide.

$$3FeSO_4 + 2K_3[Fe(CN)_6] \rightarrow Fe_3[Fe(CN)_6]_2 + 3K_2SO$$

(3) Blue prints are based on the decomposition of certain ferric salts like ferric oxalate and ferric ammonium citrate to ferrous state by sunlight. When a solution of ferric ammonium citrate and potassium-ferricyanide is applied on the smooth paper and the paper dried in dark, it becomes sensitive to sunlight. The exposed paper when washed in water, shows white impressions on a blue background formed by the reaction of ferrous ions with ferricyanide.

(4) Blue oxides of molybdenum are known as molybdenum blues. They are obtained by the reduction of acidified molybdate solutions by zinc, H_2S or SO_2. They contain oxides and hydroxides in varying compositions. Ammonium molybdate is reduced by stannous chloride giving a deep blue colour due to Mo_3O_8

(5) Tungsten blues are similar to molybdenum blues and are obtained by similar process. They too possess varied compositions.

(6) A deep-blue colour is obtained when nitric acid or a nitrate reacts with diphenylamine dissolved in conc. H_2SO_4.

(7) Copper sulphate solution gives a deep blue colour with excess of liquor ammonia:

$$CuSO_4 + 2NH_4OH \rightarrow Cu(OH)_2 + (NH_4)_2SO_4.$$

$$Cu(OH)_2 + (NH_4)_2SO_4 + 2NH_4OH \rightarrow [Cu(NH_3)_4]SO_4 + 4H_2O.$$

(8) Secondary amines with nitrous acid (or nitrite) give nitroso amines, which on warming with a little phenol and conc. H_2SO_4 and then making it alkaline with NaOH, produces deep blue colour.

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Quizzes

1. When a charged particle moves in a circle or spins, it behaves like a closed current circuit. It can be considered an equivalent magnetic shell, the magnetic moment of which is directed among its spin vector axis. The magnetic moment associated with an electron is usually expressed in terms of Bohr magneton. One Bohr magneton is equal to 9.273×10^{-24} joule/tesla.

One Bohr magneton is :

(a) magnetic orbital moment associated with an s-electron;

(b) magnetic orbital moment associated with an *p*-electron;

(c) magnetic orbital moment associated with an *d*-electron.

2. A moving charged particle ionizes the medium through which it travels. The process of ionization continues until the ionizing radiation loses almost all of its energy.

The ionization produced by an ionizing particle at a point in its track is :

(a) inversely proportional to its velocity;

(b) inversely proportional to its mass;

(c) directly proportional to its velocity.

3. All known nuclei are built up of one or more nucleons—the positively charged proton and the electrically neutral neutron. They are held together within the nucleus by a force known as "Strong force".

Consider a nucleon (A) inside the nucleus and another nucleon (B) on its surface. They differ by their nearest neighbours. The mass of A is :

(a) same as that of B;

(b) greater than that of B;

(c) smaller than that of B.

4. Isotones have a :

(a) constant atomic number Z;

(b) constant neutron number N;

(c) constant mass number A.

5. A positively charged particle gains kinetic energy in moving from a state of higher potential to a state of lower potential. The reverse is the case when the particle is a negatively charged one. This is the basic principle upon which the electrostatic accelerators work.

Kinetic energy gained when a particle of mass m and charge q falls through a potential difference V is :

(a) $\frac{1}{2}mV^2$; (b) $(q/m)V$; (c) qV

6. Nuclear fission can be further induced and made self-generating if neutrons are released during fission. This chain reaction is appreciably hindered by the fast neutron capture by Uranium-238 and Uranium-235. For effective chain reaction, usually two methods are adopted. They are: (i) enrichment of Uranium-235 in the nuclear fuel; and (ii) moderation. The materials like graphite, heavy water, water and beryllium or beryllium oxide are used as effective moderators.

A good moderator should have:

(a) small absorption cross-section for neutron and large slowing down

power;

(b) large absorption cross-section for neutron and small slowing-down power;

(c) large absorption cross-section for neutron and large slowing down power.

7. A cooling system is designed to remove the fission energy released from the reactor core. A mediator, called coolant, is used. The heat generated in the fission process is used to vapourize the coolant. The vapour at high temperature and pressure is allowed to pass through a heat exchanger, where it transfers its heat to another working medium and then returns to the reactor core. The second working medium is needed to avoid the pollution of the surrounding medium by radioactive wastes carried by the coolant during its circulation.

An effective and good coolant should have;

(a) a high density and low specific heat;

(b) a high density and high specific heat;

(c) a low density and low specific heat.

8. A star is continuously radiating energy and yet its temperature is sensibly constant (6000 K at the surface and 20,000,000 K at the centre.)

The source of stellar energy is.

(a) nuclear fission;

(b) fossil fuel;

(c) fusion.

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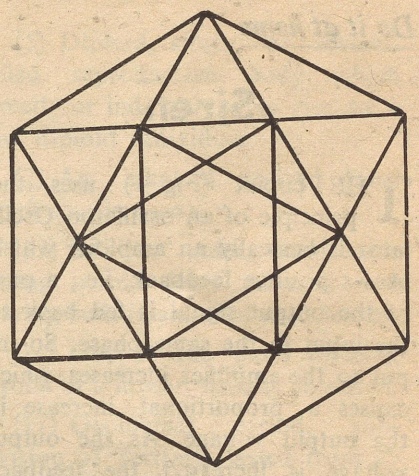

Fig. 1

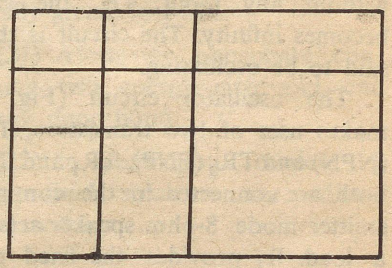

Fig. 2

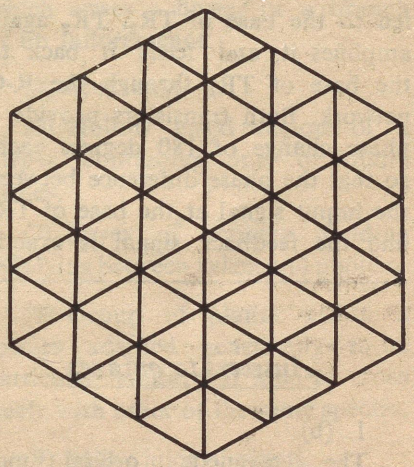

Fig. 3

Brain teasers

I

Tank and taps

A water tank has two taps and a waste pipe. One of the taps fills the tank in 10 minutes, the other takes 15 minutes. The waste pipe can empty a full tank in 7½ minutes. Now, if we start with an empty tank with both the taps full on, when will the tank be full if the waste pipe be left open?

II

Garment and profit

A shopkeeper sold a certain garment and made profit, the per cent profit was equal to the cost price. If the selling price was Rs. 24, what was the cost price of the garment?

Boy and probability

One of the two children in a family is a boy. What is the probability that there are two boys in the family?

III

Are you good at counting?

Look at the geometrical figures given below (Fig. 1, 2 and 3). Can you tell: (i) How many triangles are in Fig. 1? (ii) How many rectangles are in Fig. 2? and (iii) How many regular hexagons are in Fig. 3?

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Do it at home

Siren

THE circuit (Fig. 1) uses the principle of an oscillator. Oscillator is basically an amplifier which uses a positive feedback, i.e., a part of the output signal is fed back to the input in the same phase. So input to the amplifier increases which causes a proportional increase in the output voltage. As the output voltage is increased, the feedback voltage also increases which, in turn, causes further increase in the output. The process continues and finally a stage is reached when we get output without any input, i.e., the gain becomes infinity. The circuit is then said to be oscillating.

The oscillator circuit (Fig. 1) makes uses of two transistors, TR_1 (NPN) and TR_2 (PNP). TR_1 and TR_2 both are connected in the common emitter mode. 8-ohm speaker acts as a load. R_1 provides the fixed d.c. bias for TR_1.

When the key S is pressed, the circuit is completed and a pulse is produced at the base of TR_1, which is amplified by the transistor and is fed to the base of TR_2. TR_2 again amplifies it and feeds it back to the base of TR_1 through the R-C network. Both transistors provide a phase change of 180 degrees each, so that the phase difference between the imput signal at the base of TR_1 and the feedback signal is exactly

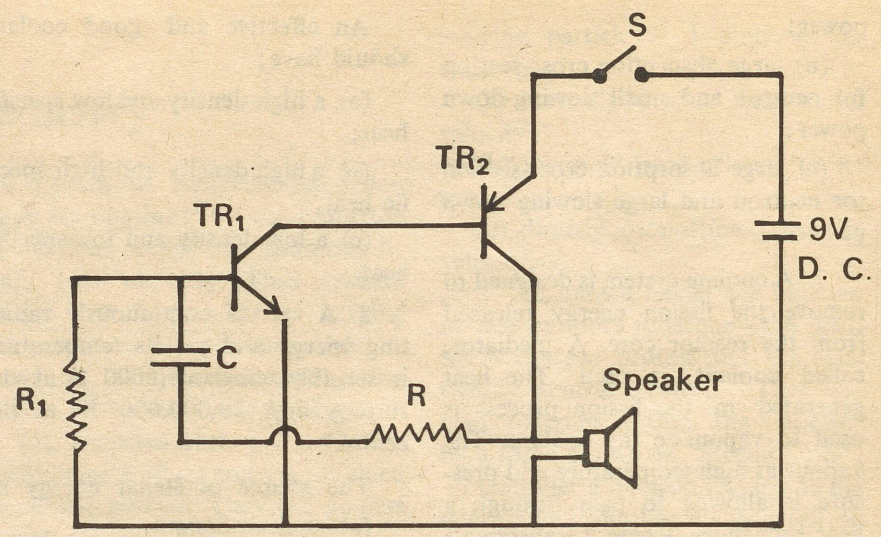


Fig. 1

360 degrees. In other words, feedback signal is in the phase with input signal. The circuit thus starts oscillating and an audio tone is heard.

The circuit may be used as a siren in cases of emergency or as a door bell, or even to practice the Morse code.

Components

TR_1 : AC 187
TR_2 : AC 188
C : 0.05 mfd., Disc ceramic
R : 68 Ohm, 1/2 W
R_1 : 82 K ohm, 1/2 W
Speaker : 8 ohm.

Switch, battery, suitable enclosure, etc.

P. G. SARANG

Answers to quizzes

1. (b)

The magnetic orbital moment associated with s-electron is zero, as its orbital angular momentum is zero. The magnetic orbital moment associated with *d*-electron is two Bohr magneton.

2.(a)

Slower the velocity of an ionizing particle, greater will be the time taken by it to traverse a given path. Hence the efficiency of ionization gradually increases as it is slowed down until it attains the energy less than 33 eV, the minimum energy required for ionisation. The efficiency of ionization is directly proportional to the mass of the particle and inversely proportional to its velocity.

3. A nucleon on the surface of a nucleus would not have all the 12 nucleons as nearest neighbours as in the case of nucleons inside (Fig. 1).

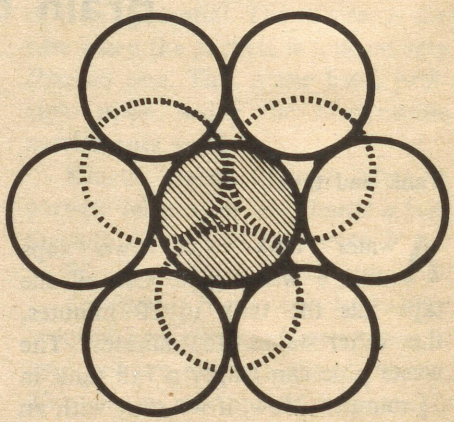


Fig.1 A nucleon and its 12 nearest neighbours

So the surface nucleons are loosely bound as compared to the nucleons inside. As binding energy comes only from their masses, the nucleons on the surface of a nucleus are more massive than those inside.

4. (b)

$_6{}^{14}C$, $_7{}^{14}N$ and $_8{}^{14}O$ are isotones of neutron number 8.

5. (c)

The work done on a charged particle by the electric force appears in the form of increase in kinetic energy. The gain in the kinetic energy by the particle is the product of its charge and the potential difference through which it falls.

6. (a)

The capture of neutrons by moderators will reduce the available neutrons for fission. To avoid the non-fission capture by moderators and to increase the probability of U-235 fission, the effective moderator should have small absorption cross-section for neutron and large slowing down power.

7. (b)

The higher the density and the specific heat, the greater the amount of heat that accumulates in a unit volume of the heat transfer agent. Metals have the highest density but low specific heat, while gases have high specific heat but low density. So usually liquids or high pressure gases are used as coolants in reactor system. Water, heavy water, liquid sodium and certain specific organic liquids are used as reactor coolants.

8. (c)

The nature of fusion reaction depends upon the temperature of the star. In general, the energy released during the fusion of four hydrogen atoms into one helium atom is the main source of stellar energy.

Solutions to brain teasers

I

The two, in 1 minute, will fill 1/10 and 1/15 of the tank respectively. During the same time 2/15 will flow away. So the total gain in 1 minute is 1/10 +1/15—2/15-1/30. The water tank will therefore be a thirtieth full in 1 minute and will fill completely in 30 minutes.

II

(i) Let the cost price of the garment be P. As there is P% profit, the selling price of the garment is $P+P^2/100$, which must equal 24. From this, we obtain a quadratic in P whose solution will give two values, 20 and —120. The latter obviously makes no sense. So, the cost price of the garment is Rs. 20.

(ii) Consider the ways in which it is possible for a family to have two children. Using B for boy and G for girl, the first and second children can be BB, BG, GB, or GG. The fact that there is one boy in the family obviously eliminates the fourth possibility. Of the remaining three possibilities, only one satisfies the condition that there are two boys in the family. So the probability is 1/3,

III

(i) Fig. 1 contains seventysix triangles; (ii) Fig. 2 contains thirty six rectangles; and (iii) Fig. 3 contains twentyseven regular hexagons.

Crossword puzzle (Botany)

Clues

Across

(1) Many-seeded, succulent fruit in which pericarp consists of outer skin (epicarp), fleshy mesocarp and inner membranous endocarp.

(2) Genetic material found in nucleus.

(3) Disease of cereals and wild grasses caused by the fungus *Cleviceps purpurea.*

(5) Diploid, single, or several-celled reproductive body which directly or indirectly gives rise to a new diploid individual.

(7) An alkaloid derived from *Erythroxylon coca.*

(13) Swollen underground stem having stored food material and bearing buds in axiles of scaly leaves.

(14) One of the parts forming corolla of a flower, usually coloured.

(17) Geological period, subdivision of Tertiary, lasted from 25 million to 10 million years ago.

(19) A class of mosses.

(20) One of the parts forming calyx of dicotyledonous flowers, usually green, leaf-like.

(21) Adenosine phosphate containing two energy rich and one energy poor bond.

(22) In anatropous ovules, a longitudinal structure for adherence to funicle.

Down

(1) A small leaf with relatively undevelopedb lade, in the axile of which arises a flower or a branch of an inflorescence.

(4) Seed coat.

(6) Hollow basal region of a carpel, containing one or more ovules.

(7) Layer of actively dividing cells lying between xylem and pholem.

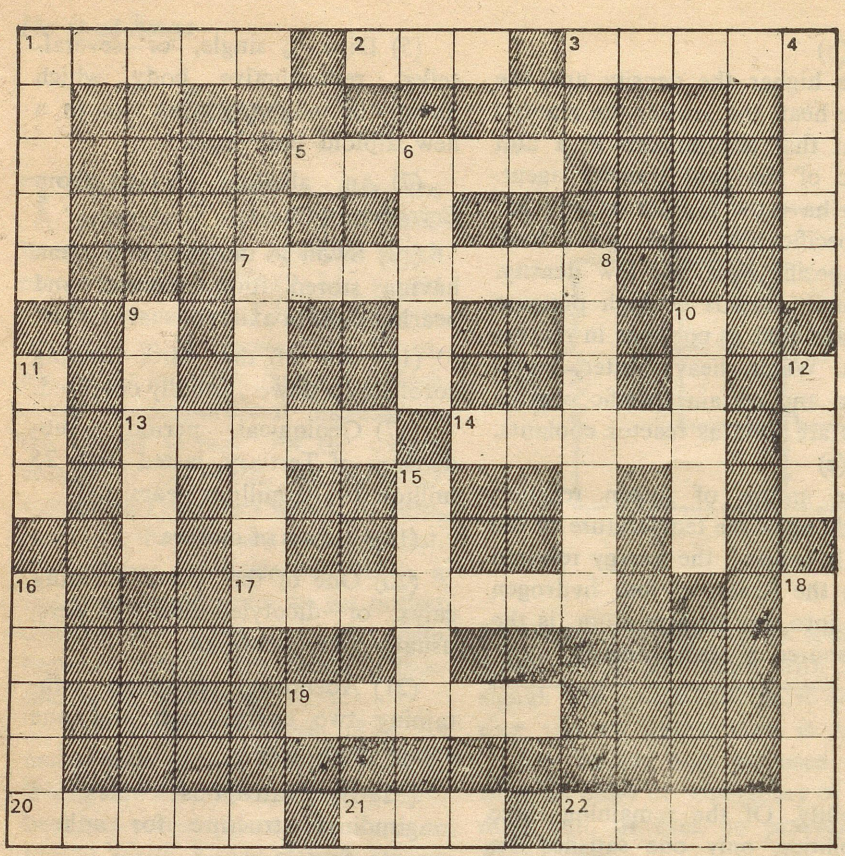
(8) Group of plants within a species adapted genetically to a particular habitat but able to cross freely with other of the same species.

(9) Milky juice of plants.

(10) Scar on seed coat, marking former point of attachment of seed to funicle.

(11) Coenzyme-2.

(12) Dry, indehiscent, one



seeded fruit with woody wall, produced by more than one carpel.

(15) Fruiting body of Ascomycetes.

(16) Disease producing protein particles, intermediate between living and non-living.

(18) Succulent fruit in which wall consists of outer skin (epicarp), thick fleshy mesocarp and hard stony endocarp enclosing a single seed.

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Readers' comments

Sir, Re: **Brain teaser** by P. K. Mukherjee (*S.R.*, July 1978), I have found a very simple solution to this question which can be further generalized.

Mark points on the circumference as 0, 1, 2 , 3, 4, 5, 6, 7 (on the inside of the circle). Then start from 0, count 6, any direction, and mark that point 1(0) (on the outside). Starting from point 1(0) again count 6, mark it 2(0) and so on till you reach 7(0). Now start in the other way, i.e., starting from 6(0) put a coin on 7(0), starting from 5(0), put a coin on 6(0) and so on till you put a coin on 1(0) starting from 0. In this way, 7 of the eight points can be occupied leaving one point blank (Fig. 1).

The above method can be generalized for larger number of points except a few cases. It holds good for all even natural numbers that are not multiples of 3.

In the generalized method, all one has to do is to mark the points starting from 0 to (n-1), in case of n. Then starting from (n-2), mark (n-1), from (n-3) mark (n-2), from (n-4) mark (n-3) and so on till you mark 3 from 2, 2 from 1 and 1 from 0, leaving 0 unmarked. Thus this method holds good for questions with n equal to 4, 8,1 0, 14, 16, 20, 22..... with the exception of the numbers 6, 12, 18, 24, etc., which are even multiples of 3.

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II

Sir, I have received many reactions on my **brain teaser** (*S.R.*, July 1978). While some of the readers have found the puzzle interesting and amazing, others maintain that alternative solutions are also possible. While agreeing with them, I give below a more general method of solution to the problem.

You can start counting from whichever point you like. Move either in clockwise or anticlockwise direction; occupy the point when you count six. In the second move, you occupy the starting point of your

(*Contd. on page 708*)

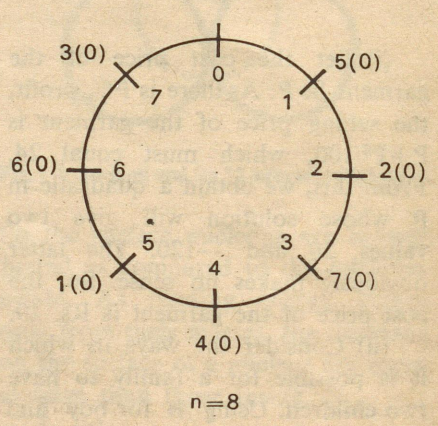

Fig. 1



FOR HER

Face powder

THE feminine face has been known to 'Launch a thousand ships'. She knows it, and so she has always cared to find out 'cosmetics' to beautify her face. Probably, the earliest preparations were clayey muds. They consisted of simple substances such as chalk and white lead. Slowly, the more complicated blends of different materials were evolved leading to modern face powders.

A face powder should be harmless to a normally sensitive skin. It should apply easily, spread evenly, remove shine from the face and cover minor infections of the latter without showing itself. It must look natural, be discreet and invisible, and yet give suitable glow to the face. It should be pleasant to wear, should stay on well and be lightly perfumed, Modern face powders are sold in two different forms—loose and compact.

Loose powders

The raw materials for face powder should be selected with great care because the final outcome of the formulation depends primarily on their quality and characteristics, i.e., colour, odour, apparent density, feel, fineness, oil absorption and perfume retention.

Talc. It is the most important component because the ultimate product greatly depends on it, rather than on any other raw material. Theoretically, it is the softest material available. Chemically, talc is magnesium silicate ($3\ MgO.\ 4SiO_2.\ H_2O$). Its colour may vary from pure white to dark grey. A talc suitable for face powder should be white, odourless and somewhat greasy. It should be free from iron, for its presence may cause both odour and colour deterioration.

Kaolin. Like talc, it is also a natural product. Native aluminium silicate is generally accepted as having the formula $2SiO_2.Al_2O_3.2H_2O$. Its colour is never completely white but shows varying degrees of cream shades. When dry, it is odourless. It should be light in colour and free from iron and water-soluble acids and alkalies. It removes shine of the talc by its absorbent qualities and softening properties.

Calcium carbonate is widely used in face powders in varying amounts. It possesses absorbent quality derived from porosity of its particles. It should be used only when such qualities are needed and not as a basic constituent of powders. Magnesium carbonate is another absorbent. If it is present in good measure, it will make the face dry. One should not use more than 15 per cent by weight of magnesium carbonate in the finished product.

Some metallic salts of stearic acid, which are insoluble in water, are used in face powders to make them adhere to the skin. The salts should be unctuous, should possess greasy feel and cover the skin with an even film. Their amount should vary roughly between 5% to 15%. Most common stearates used are zinc and magnesium salts. Use of calcium and aluminium stearates is also mentioned but, is less common.

Zinc oxide is a necessary adjunct to a face powder. It provides covering capacity to a powder. (The more opaque a powder, the more it covers the skin). A powder which covers too much gives a mask-like effect. Zinc oxide is mildly antiseptic and has a slightly drying effect on the skin. If more covering is desired, titanium oxide may be used in conjunction with zinc oxide. However, titanium oxide has the undesirable property of not blending well with other ingredients of a face powder.

Shades. Different shades of face powders are obtained from two types of colours: organic lakes, and inorganic pigments. Theoretically, any shade can be obtained by blending primary colours (red, yellow and blue) with various amounts of black and white. Colour should be reasonably lightfast, i.e., should not fade easily when exposed to light. Inorganic pigments do not undergo this type of degradation, while all organic pigments degrade to some extent.

The composition of a basic face powder is :

Kaolin	15 per cent
Calcium carbonate	10 „
Zinc oxide	15 „
Zinc stearate	5 „
Magnesium carbonate	5 „
Talc	50 „
Perfume	q.s.

Depending upon the quality of the powder required, the percentage of ingredients may be changed. The climate where the product is used might have some influence on the composition of a powder. For example, in cold and windy climates, the skin has a tendency to dry, but in hot, humid areas the opposite is true.

Compact powder

They are dry, pressed in a cake form, and applied to the face by a powder puff. They should come off easily when rubbed with

powder puff and not break easily under normal conditions.

In compact powders, rice starch is used in small proportions alongwith other ingredients. Composition of a compact face powder is :

Talc	50 per cent
Zinc oxide	10 ,,
Kaolin	15 per cent
Titanium oxide	5 ,,
Calcium carbonate	15 ,,
Rice starch	5 ,,
Perfume	q.s.

A binder solution to an extent of 5% is added. Most commonly used binders are natural or synthetic water-soluble gums, such as gum Arabic, carboxymethyl cellulose alongwith hygroscopic chemicals such as glycerol, glycol, sorbitol, etc.

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HIGH TEMPERATURES (*Continued from page* 659)

tures. When the two match, the instrument filament tends to 'disappear' against the unknown radiation in the background. The filament temperature then gives the source temperature after suitable corrections.

For control of temperature, it is necessary to have an arrangement for switching off power when the temperature exceeds a predetermined value. This is "on-off" control. A more accurate control is achieved when the power is merely reduced slightly below the actual requirement (using a bypass) to be fully restored again when the temperature begins to drop. This is known as high-low control. Fig. 4 schematically shows two control schemes.

Table 4. Some common resistor materials and maximum temperature of use*

Material	*Maximum Temperature °C*			*Remarks*
	Oxidizing atmosphere	*Reducing atmosphere*	*Vacuum*	
80Ni-20Cr	1200	1000	1100	Sulphur compounds, hydrocarbons, etc., to be avoided
Kanthal (A-1)	1350	1000	1200	
SiC	1650	—	1400	—do— also moisture
90 Pt-10Rh	1600	1600	No	Metals begin to evaporate above 1600°C.
Mo		2100	2400	—
Graphite	No	2200	2800	Some reaction with H_2, N_2

*Of these elements, SiC and graphite cannot be wound as wires and must be used as rods or specially machined forms as shown in Fig. 3.

Table 5. Some common thermocouple materials

Wire materials		*Maxm. temp. of use °C*	*Suitable atmosphere*
Wire 1	*Wire 2*		
Chromel (90Ni-10Cr)	Alumel (95 Ni, 5Al, Si, Mn)	1200	Mildly oxidizing, neutral or vacuum
Pt	90Pt-10Rh	1500	,,
Cu	Constantan	300	Any atmosphere
Fe	,,	800	Neutral, reducing or vacuum
Re	W	2000	Reducing, neutral
Mo	W	2300	Vacuum

Further reading

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Science in Industry

Silver impregnated contacts

VARIOUS types of contacts are used in electrical gears, circuit breakers and relays to make or break electrical circuit or transfer contact from one element to another. The contact forms a sensitive part of the relay, and its satisfactory operation depends upon the materials of the contact. The common contact materials are copper, silver and metals of high melting point. Excessive wear and deterioration owing to welding, overheating, formation of high resistance filter and material transfer are some of the disadvantages associated with these contacts.

The National Physical Laboratory (NPL), New Delhi, has developed silver-impregnated contacts for relays which combine the conducting properties of silver and refractory graphite and overcome the defects mentioned above. Such contacts are widely used in railway signalling relays. The special advantages of silver-impregnated graphite (SIG) are its hard fusing characteristics, better conduction of heat and electricity, and easy brazing. Another feature of the process developed at NPL is that silver can be incorporated in any desired shape and in controlled quantity. The distribution of silver in graphite is uniform.

In the process of manufacture, graphite is shaped and its dimensions are checked. The cut pieces are washed, weighed and impregnated under vacuum. The pieces are finally washed and baked. After the samples are tested for mechanical and electrical properties they are ready for use.

Presently, these contacts are imported and cost Rs. 60 lakh in foreign exchange.

After vigorous tests and field trials, the Railways have found the material acceptable for their use.

Tetradifon

TETRADIFON is a modern acaricide and miticide, and is active on all stages of mite. The demand for Tetradifon together with other acaricides, viz., Dicofol and Ethion, is estimated at 150 tonnes by 1978-79. Tetradifon and Ethion are preferred for use on tea plantation. Tetradifon is not manufactured in the country and the entire demand being met through imports.

The National Chemical Laboratory (NCL), Pune, has developed a process for the manufacture of Tetradifon with a view to make the country selfsufficient. The process consists in treating trichlorobenzene (containing minimum 88% 1:2:4 isomer) with chlorosulphonic acid to obtain trichlorobenzene sulphonyl chloride which is then reacted with monochlorobenzene and aluminium chloride. The crude Tetradifon so produced is purified by crystallization. The process has been standardized on 1 kg per batch scale. The product obtained by this process matches, in respect of melting point, microanalysis and UV spectra, with the commercial sample.

Trichlorobenzene (containing minimum 88% 1:2:4 isomer), chlorosulphonic acid, sulphuric acid, aluminium chloride, chlorobenzene, ethylalcohol and butyl acetate are the major raw materials required, and all these (of technical grade) are available indigenously. Mild steel (MS) reactor with cooling coil, rubberlined tank (MS), crystallizer (MS), centrifuge, drying oven, hydrochloric acid absorption and generating system, solvent recovery unit, sparkler filter and refrigeration system are the main items of plant and equipment. These are either indigenously available or can be fabricated in the country.

The capacity of an economically viable unit, according to NCL, is 30 tonnes per annum. The total capital outlay for a plant of this size is estimated at Rs. 16.45 lakh (Rs. 11.50 lakh on land, building, plant and equipment, and Rs. 4.95 lakh as working capital). The ex-factory cost is estimated at Rs. 54 per kg against C.I.F. price of Rs. 70-Rs. 90 per kg for technical quality product.

Luminescent transfer paper

LUMINESCENT transfer paper finds application in confidential communication systems and in invisible signature verification systems. It is also used for confidential storage of information. Once the paper is made available indigenously and its uses become known, a good demand

for this paper could be created in the country.

The Central Electrochemical Research Institute (CECRI), Karaikudi, has developed a process for manufacturing luminescent transfer paper. The process consists in coating the paper with a solution containing wax in a suitable solvent. It is further coated with a suspension of phosphors in a suitable organic liquid vehicle to which a small quantity of a suspension agent has been added. The paper is again coated first with a solution containing a grease. The coated paper is dried and subjected to a mild pressure to ensure smoothness.

The process has been studied on a laboratory scale. About 100 sheets of paper (30×20 cm^2) have been prepared in the laboratory.

Paper sheet, grease, parafin wax, phosphor and solvents are the main raw materials required, and all these are available indigenously.

Sprayer with compressor, drier, roller (calendering machine), cutter, glass apparatus, and UV lamps are the main items of plant and equipment. Except UV lamps, all are available indigenously.

The estimated total investment for setting up a plant capable of producing 100 sheets (30×20 cm^2) per day is Rs. 1.85 lakh (fixed capital on building and plant, Rs. 0.815 lakh, and working capital, Rs. 1.040 lakh). The cost of production is estimated at Rs. 3.38 per sheet (30×20 cm^2).

Ethephon

ETHEPHON is an important plant growth regulator. By its application, rubber latex yields can be increased by 200% to 300%. Ethephon changes the female-male flower ratio and this eventually yields more fruits in many plants. It is also used for maturing and ripening of fruits in a number of plants, and it is reported to increase yields of certain cereals. Ethephon is not known to be produced in India. Also, its requirements in the country are not known precisely. Formulations of Ethephon, imported from Amchem of USA, are marketed under the brand name 'Ethrel' by Agromore Ltd., Bangalore. The requirements for latex stimulant formulations have been estimated at about 1.5 tonnes/annum by the Rubber Research Institute (RRI), Kottayam. The requirements of various plant growth regulators, as estimated by the Directorate of Plant Protection, Quarantine and Storage, is 100 tonnes for 1978-79.

The National Chemical Laboratory (NCL), Poona, has developed a process for the manufacture of Ethephon, with a view to make the country self-sufficient. The process consists in (i) preparing tris-(2-chloroethyl) phosphite from phosphorus trichloride and ethylene oxide; (ii) isomerization of the phosphite to the diester of phosphonic acid; and (iii) de-esterification of the diester of phosphonic acid by dry hydrochloric acid gas to yield Ethephon.

The process has been standardized on 5 litres per batch scale. Yield of Ethephon is about 90% based on phosphorus trichloride. The product has been tested in the laboratory as latex stimulant by RRI, Kottayam, and has been found to be satisfactory. The Nimbkar Agricultural Research Institute, Phaltan, has also tested the product successfully for cucumbers and is carrying out experiments on some more plants.

Phosphorus trichloride, ethylene oxide, hydrochloric acid and sulphuric acid are the main raw materials required, and these are available indigenously.

Flasks, stirrers, distillation condensers, bubblers (all-glass), electrically heated oil-baths or heating mantles with controls, and chilling unit are the major items of plant and equipment. These are either available indigenously or can be fabricated.

The capital outlay for a plant of 6 tonnes/annum capacity (considered economical by NCL) has been estimated at Rs. 2.46 lakh (Rs. 1.00 lakh on all-glass equipment, Rs. 0.50 lakh on land, and Rs. 0.96 lakh as working capital). The cost of production is estimated at Rs. 51.5 per kg against the C.I.F. price of Rs. 200 per kg for the imported material. The selling price of 10% solution of Ethrel, used as latex stimulant, is Rs. 105 per litre while that of 40% solution of Ethrel, used as plant growth regulator, is Rs. 350 per litre.

SCIENCE FOR THE YOUNG (*Continued from page* 704)

previous move. Next time you occupy the starting point of this move and so on. In this way, you can easily occupy all the seven points, leaving one point vacant.

For example, if you start counting clockwise from A and stop at F then your next move must be such that the point A is occupied by the coin (e.g., DEFGHA). Then continue with GHABCD, BCDEFG, EFGHAB, HABCDE and CDEFGH. You will see finally that the point C remains unoccupied. The same method is true for anticlockwise moves.

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BOOK REVIEWS

SPINOFFS FROM SPACE RESEARCH, selected and arranged by S. Gopinathan, *Federal Publications* (Available as a set from Affiliated East-West Press Pvt. Ltd., G-1/16, Ansari Rd., New Delhi-110002 Rs. 197 per set)

"IN a sense," said Arnold J. Toynbee, the British historian sarcastically, "going to the moon is like building the pyramids or Louis XIV's palace at Versailles. It's scandalous, when human beings are going short of necessities, to do this. If we're clever enough to reach the moon, don't we feel rather foolish in our mismanagement of human affairs?" The masses, and even a large section of intellectuals, air similar views whenever opportunity arises. The book under review, packed with evidences and arguments, tries to correct this "misleading" impression. How much it has succeeded in this task is open to question.

Critics of space research may have second thoughts after reading the book. The picture painted is so rosy that one feels secure that his tax-money that is being spent on space research will pay dividends in the long run as well as in the near future. The book, which is a sequel to *The Challenge of Space*, tells how space research has affected various spheres of human activity (particularly in the U.S.A.) namely, science, technology, industries and management.

The success of a spacecraft depends upon the functioning of thousands of components it is built of. Even if one of them fails, the space mission may meet its doom. Technology had therefore to be "polished up" to achieve perfection—zero-flaw in every component. This has apparently affected industries that manufacture the components. Likewise, new management techniques have been developed for building spacecraft. A spacecraft, its internal environment and astronauts are studied as a single unit. The vast conglomeration of diverse activities of industries, universities and institutes, each studying, or manufacturing, a particular problem or component, is coordinated to achieve a set goal. All this has resulted in the development of a new management technique called "Systems approach". This has now found varied applications in big industrial houses in the U.S.A.

In scientific research, the spinoffs are mostly confined to "bio-astronautics". According to the author, the gadgets and systems used to study how spacemen react to space environment have now found use in hospitals. The knowledge obtained has particularly helped in understanding the functioning of heart. To read how gadgets especially fabricated for spacecraft missions have today been put to terrestrial uses is indeed amazing. For instance, a spaceman's helmet is now being used to give a child medication.

But so had the World War II given an impetus to the development of science and technology. Radar, jet planes and operational research are the most conspicuous spinoffs of the last war. Does it mean that we should have wars time and again to give stimulii to our development, in line with Orwellian "War is peace" sarcasm in his classic *1984*. Compared to the colossal amount of money spent on landing on moon and other space missions, are the spinoffs justifiable?

Another point one has to consider: invention is one thing, its commercialisation is another. In this respect, thanks to the NASA management people and planners, the commercialisation of spinoffs from space was but very rapid. But will this be possible to achieve in any other developing country which is trying to gain a foothold in space?

The book is interesting, both for admirers and critics of space research.

DILIP M. SALWI

ORGANIC REACTION MECHANISMS *by* Raj K Bansal, *Tata McGraw-Hill Publishing Co. Ltd.* 12/4, Asaf Ali Road, 3rd Floor, New Delhi 110002, Pp. 504, Rs 40.50.

DURING an organic reaction, molecules come in proximity of one another; atoms change their positions, and electron shift takes place. The result is that new compounds are formed. A detailed description of these changes during a reaction is termed as reaction mechanism. Dr. Raj K. Bansal has lucidly and palpably explained mechanisms of almost all important organic reactions.

The book consists of 13 chapters dealing with various reaction mechanisms. First three chapters vividly describe the basic concept and logic of reaction mechanisms. In these chapters the author simplifies the concepts of bond energies, electronegativity, dipole moment, hydrogen bonding, steric effects, etc., which form the basis of reaction mechanisms. The book gives a comprehensive view of hyperconjugation, inductive and field effects, Dradt's rule, aromaticity and Taft-Ingold equation. The author has also given a broad, simplified view of molarity and order of organic reactions to explain various reaction mechanisms. Modern concept of acids and bases is another important feature of this book.

Nucleophilic displacement S_N1 and S_N2 reactions have been mentioned in detail. Apart from substitution at the carbon atom, substitution at the silicon atom, too, has been discussed. Another significant feature of the book is that effects of isotopes, solvents and salts on the substitution reactions have been dealt with. Mechanism of 21 important organic preparatory reactions, used in organic synthesis, is discussed in chapter 5th. The author gave a broad view of free radicals, electrophilic and nucleophilic addition reactions, molecular rearrangements, mechanism of formation of olefins, neighbouring group participations and photochemical and thermal reactions. Chapter on aromatic substitution is very useful for those pursuing the study of aromatic chemistry. The author has discussed three aspects of aromatic substitution, viz., electrophilic, nucleophilic and homolytic substitutions. The book ends with the study of mechanism of carboxylic acid and their derivatives, especially ester hydrolysis, hydrolysis of acid anhydride, amides and chlorides.

Some new reactions have also been included in the book, e.g., Grovenstein-Zimmerman reaction, Kochi reaction, Hyashi rearrangement, Lewis acid catalyzed Diels-Alder reaction, mechanism of ester hydrolysis. Each chapter is provided with an impressive and exhaustive list of additional references which are useful for research workers. In the end of every chapter review problems are also given. This book is useful for organic chemists and technologists.

ASHOK K. GOSWAMI

KINETIC APPLICATIONS OF NMR SPECTROSCOPY *by* S. F. Lincoln, *Pergamon Press*, Headington Hill Hall, Oxford OX3 OBW, England, Pp, 91 $ 9.50.

THE book was originally published as an article in the International Review Journal, *Progress in Reaction Kinetics* vol. 9 Number 1, 1977, edited by K. R. Jennings and R. B. Cundall. The author has mainly tried to help non-physicists to analyse and interpret the NMR spectrograph relevant to the kinetics of chemical processes, and thus has accordingly developed the subject. In fact, this is one of the rare books on the application of NMR spectroscopy and for the study of kinetics of fast reaction in liquid state. In such a book the main problem facing the author was to present the mathematics of the process in a simple, self-explanatory way. He has been, in the view of the reviewer, successful in doing so.

The author has adequately dealt with the basic NMR theory under the sub-headings: The NMR phenomenon, The Chemical Relaxation and Line Shape Model, and Nuclear Spin Relaxation Process. In the third and the main chapter, he has explained the various factors that affect the NMR line shapes. The effect of chemical equilibrium processes on the shape of spectral line is considered using, (i) Classical mechanical model based on Block Equation and (ii) Quantum mechanical model. It is well illustrated by examples which represent the specific type of exchange process used in specific type of NMR application.

In the fourth and the final chapter, the author discusses the recently developed specialized NMR techniques such as Pulsed NMR, Fourier Transform NMR, etc., which are a tool to understand the chemical exchange process.

On the whole, the book is a success as far as the applications of NMR spectroscopy to chemical processes are concerned. But as the book will be mainly used by chemists and biologists, it would have become more useful if a list of the terms, symbols and units were also included for easy reference.

JAISHREE SHARMA

SOIL SCIENCE: GENESIS, SURVEY, CLASSIFICATION *by* A. Shankram, *The Bangalore Printing and Publishing Co. Ltd.*, Bangalore, Pp. 158, 1975, Rs. 15.00.

THE book is number 4 in the Textbook series in Agricultural Chemistry by the author. As the title of the book indicates, the emphasis is on the parent material and the pedogenic processes which lead to soil formation. The book is divided into nine chapters: Introduction; Earth Atmosphere and the Biosphere; Geological Formations and Rock Systems of India; Rocks and Minerals; Geochemistry of Weathering; Factors of Soil Formation; Soil Development and Pedogenic Processes; Soil Surveys; Soil and Land Classification. It also includes five appendices.

The book is written for graduate students who join agricultural universities. The author may be complimented for the information he has given on minerals and rock. This will remove some difficulties of soil science students, as many agricultural universities do not have geologists on their faculty. Because all the chapters have a geological bias, there is some repetition which can be overlooked. Tables of determinative mineralogy is yet another good feature of the book.

The book has some deficiencies too. Some important references have been omitted and some are incomplete. For instance, while dealing with weathering of minerals and stability, the work of Goldich is not even mentioned! Likewise, the work of Brewer on soil micromorphology is not referred. Some mineralogical compositions need to be checked. There are, in addition, several avoidable printing errors.

G. S. ROONWAL



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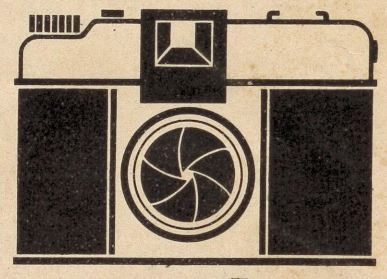

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