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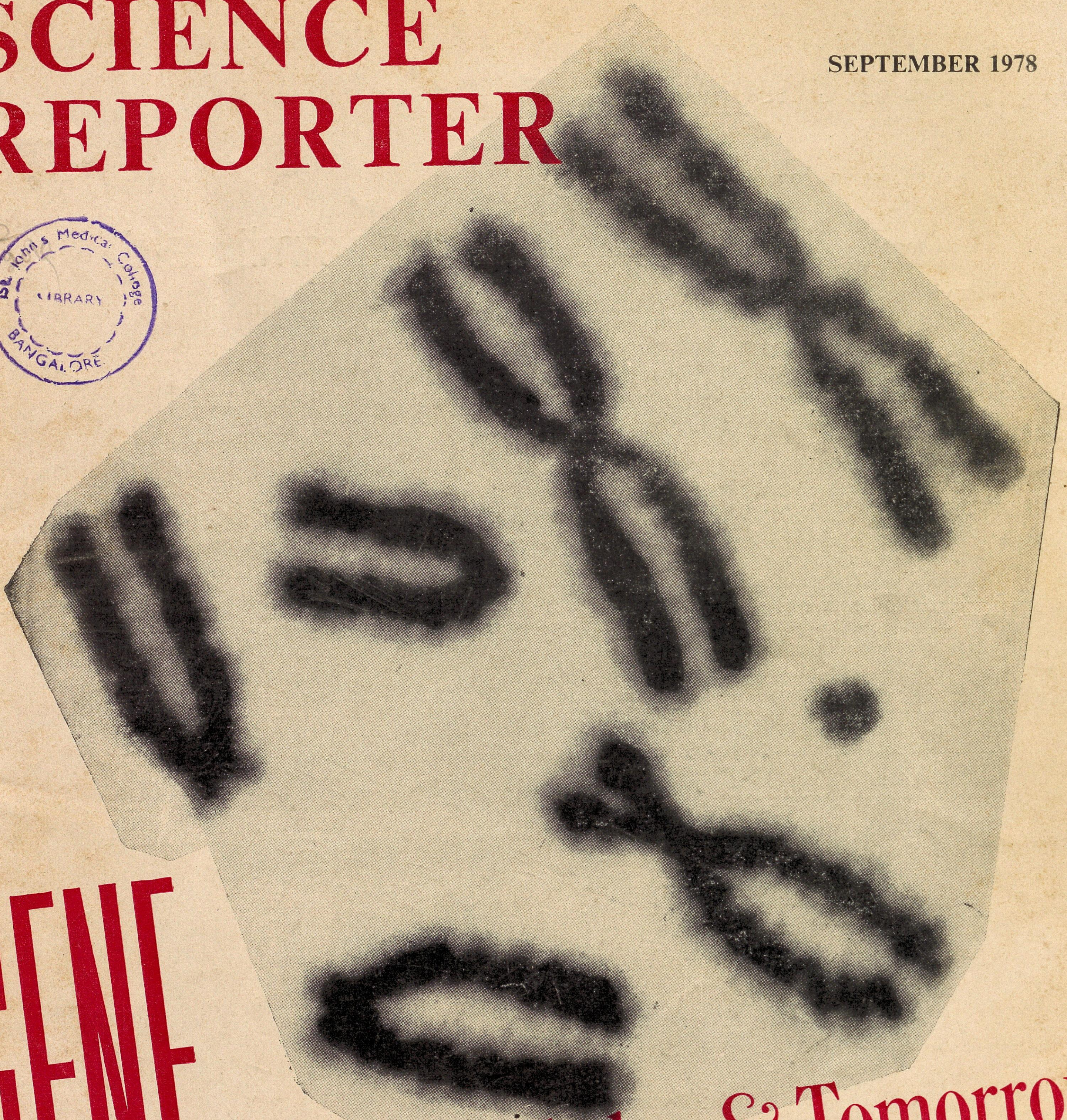
SEPTEMBER 1978



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SCIENCE REPORTER

VOL. 15 SEPTEMBER 1978 NO. 9

Cover: Giant chromosomes of the Indian muntjac

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LETTERS

Newton and the apple

Sir, This has reference to **Newton and the apple** by Girish Bhandari (*S. R.*, July 1978, Pp. 462-463). According to Bhandari, it is Voltaire who is credited with the story. It does not seem to be correct. For, Robert Green's *The Principles of the Philosophy of the Expansive and Contracting Forces* published in 1727, (six years earlier than Voltaire's *Letters Concerning the English Nation* from which Bhandari has quoted) contains the following passage:

"This well-known idea takes its origin, so it is said, from an apple. This I received from that very clever, learned and also excellent man, who was moreover my very dear friend, Martin Folkes, Knight, a very worthy fellow of the Royal Society, whom I mention here to do him honour."

No doubt, Bhandari also mentions Martin Folkes, but he has made it appear that he gave the story later than Voltaire.

Secondly, guided by the fact that the story is not vouchsafed for by either Pemberton, who received the first idea of gravitation from Newton himself or Sir David Brewster, Newton's main biographer, Bhandari throws his weight in favour of Gauss, Hegel and De Morgan who have rejected the story and have even ridiculed it.

Perhaps Bhandari will not be "inclined to believe that the fall of the apple was perhaps a fancy ...... which ultimately assumed the weight of a legend merrily carried on...... ...." if he takes into account another piece of evidence coming from Dr. Stukeley, Newton's physician, whose *Memoirs of Sir Isaac Newton's Life* remained as a manuscript unnoticed for nearly two centuries and was published only in 1936 by A.H. White. Dr. Stukeley has explicitly stated that he has written from matters of his own knowledge and "not from hearsay". This is what he has to say about the story :

"On 15th April 1726, I paid a visit to Sir Issac, dined with him and spent the whole day with him alone. After dinner, the weather being warm, we went into the garden and drank tea under the shade of some apple trees, only he and myself. Amidst other discoveries, he told me, he was just in the same situation as when formerly the notion of gravitation came into his mind. It was occasioned by the fall of an apple as he sat in a contemplative mood. Why should the apple always descend perpendicularly to the ground? thought he to himself. Why should it not go sideways or upwards, but constantly to the earth's centre? Assuredly, the reason is that the earth draws it."

That the sight of the falling apple led to the discovery of gravitation is no doubt a dramatized version of the story. Bhandari is quite right in saying that "it was a mass of available observations which Newton used to derive the laws of universal gravitation". But it is not improbable that the falling apple set him on the track to the discovery. It is very likely it did. Dr. Stukeley's testimony cannot be trifled with. Nor can Voltaire and Martin Folkes be equated with the noodle that Gauss has conjured.

J. R. Lakshmana Rao
Mysore University

No star charts please!

Sir, I am a regular reader of *S. R.* I wonder how many readers are interested in the regular column **Planets and their positions.** I conducted an opinion poll in our town. Out of 150 readers, none was interested in this column.

Why don't you seek the opinion of readers on the continuance of this column. If majority does not want it, a valuable page in *S.R.* can be saved for some more popular features.

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Near absolute zero

Sir, **In Near absolute zero—expanding applications** (*S.R.*, May 1978), I feel the author has not laid enough stress on the significance of the phenomenon of diamagnetism. As a matter of fact, materials with zero resistance do not qualify as superconductors. It is the combination of zero resistivity and diamagnetism together that forms the minimal definition of a superconductor. For example, a plasma system is known to have infinite electrical conductivity but it is not a superconductor. Diamagnetism is not only interesting but an essential feature of a superconductor. The second point is that a very important effect, called the Isotope Effect in superconductors, has not been mentioned at all. The application of this effect has been seriously considered in an endeavour to increase the transition temperature, which forms the mainstream of the present day research on superconductors. In addition to this, the various attempts to increase T_C include the treatment of the superconducting material with microwave radiation, which increases the effective interaction between electrons and atoms or phonons. An increase of 1% to 2% in T_C has been observed by many workers and the phenomenon of a maximum in T_C at a certain frequency of microwave radiation has been explained by Krishan and Sinha in *Solid State Communication* (1978). The realization of various applications of superconductivity in industry and in our day-to-day life depends on the availability of high temperature or room temperature superconductors.

VINOD KRISHAN
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II

Sir, In her article, **Near absolute zero—expanding applications** (*S.R.*, May 1978), the author has briefly explained superconductivity and superfluidity. I would like to point out a few interesting facts about superconductivity, which the author has surprisingly missed.

1. None of the alkali metals, noble metals, and ferromagnetic metals is a superconductor; but their intermetallic compounds are.

2. Copper, silver and gold, the best electrical conductors at room temperature, do not become superconducting, whereas zinc and lead, the poor conductors, exhibit superconduction.

3. Only elements or compounds having 3, 5 and 7 valence electrons per atom exhibit superconductivity.

4. The diamagnetism of a superconducting material can be explained by the existence of surface currents when an external magnetic field is present. These surface currents screen the core by creating internal fields which exactly cancel the external field throughout the body of the superconductor. That is why it appears that the magnetic field does not penetrate a superconductor.

5. M. N. Wilson of the Rutherford High Energy Laboratory and E. C. Barber of Imperial Metal Industries, United Kingdom, have found that the use of microscopically fine filaments (1/2 micron-5 micron in diameter) of Ni-Ti alloy avoids flux jumping more effectively. The finer the filament used in superconducting magnet the better is its performance.

6. A superconducting magnet, however, has a major drawback. It must always be operated at a very low temperature surrounded by cryogenic insulation.

M. MEYYAPPAN
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Nearest star

Sir, It is commonly believed that Alpha Centauri, the brightest star in the constellation of Centaurus, is the nearest star (**Science oddities**, *S.R.*, April 1978). Alpha Centauri happens to be a multiple star system consisting of the binary components (A and B) and a third faint companion (C). The latter star of about 11th magnitude has the distinction of being our nearest star and is known as Proxima Centauri.

Barring a few distracting minutia, which inadvertently creep in, it must be unhesitatingly admitted that **Science oddities** are captivating and stimulating.

S. K. GURTU
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Wrong formulae

Sir, I have noted with interest the note on Tribulus (*S.R.*, May 1978) as a new source of diosgenin, an important natural product for the preparation of a number of useful steroids, particularly cortisone and other related hormones. I was disappointed with the way the structural formula of cortisone was represented. The structure printed (Fig. 2) is that of cortisone acetate and that too wrongly given. I wish *S.R.* consults some standard text-books of biochemistry or organic chemistry before blocks are made for printing organic formulae. This is not the first time that I have observed wrong formulae given by non-chemist contributors to *S.R.* A wrong block once made becomes wasteful.

It is also better to give the scientific literature reference published by the Indian Institute of Experimental Medicine, Calcutta who have developed the method or any patent taken in this regard.

S. SANKARASUBRAMANIAN
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Steroidal compounds

Sir, This is with reference to the article **Tribulus—a new source of diosgenin** by H. K. Patra and D. Mishra (*S.R.*, May 1978, p. 324). Though the discovery of new sources of the steroidal compounds such as diosgenin, hecogenin and solasodine is welcome, unless they contain substantial amounts of these compounds, they cannot be developed as raw materials for the production of steroids. The authors have not mentioned the diosgenin content in the fruits of Gokhur. There should be an organised cultivation of the plant on a large scale before it can be developed as an alternative source of diosgenin.

The authors have stated that cortisone is a recently discovered steroid hormone of immense value. The discovery of cortisone dates back to 1943 and its first synthesis was reported by Serret in 1946. The structure of cortisone as represented in Fig. 2 is incorrect. It does not have a seven membered ring and the acetoxy group as shown in the figure.

The recent discovery by Prof. Breslow of Columbia University, New York, of the addition of functional groups at the nonactive centres of the steroid nucleus will render synthesis of steroid hormones more convenient and simpler than the methods currently followed. Then not only the plant steroids like diosgenin, hecogenin, etc, which are useful for the production of steroid hormones, but also the animal steroids like cholesterol which lack required functional groups will become important and useful as the required functionality can be introduced by the application of Breslow's method.

G. R. MALLAVARAPU
Scientist, CIMPO Regional Centre
Bangalore

Mutation

Sir, In **Mutations—its usefulness in agriculture** (*S.R.*, April 1978), the author has made a few mistakes.

He is wrong when he says that physical mutagens produce micro-mutations and chemical mutagens produce macro-mutations (Table 2). In fact, it is the other way round: physical mutagens produce macro-mutations and chemicals produce micro-mutations.

Also, when the author writes that "Unfortunately no spontaneous mutant has been isolated in case of wheat and rice," he forgets the famous "norin" dwarfing genes in wheat, which led to the green revolution in India.

In case of rice "Dee-Geo-Wu-Gen" and "I Geo-tse" genes which are also for dwarfing are nothing but spontaneous mutations. Even in India 37 spontaneous mutations for dwarfness have been isolated from North-East India rice collections. There are many other examples of spontaneous mutations in these crops.

BHARTENDU VATSYA
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The information given in Table 2 is correct in so far as it is qualified by the terms "expected effect" and "depending on the dosage". For example, repeated exposure to X-rays could give rise to micro-mutations; on the other hand, micro-mutations for major protein fractions can be induced by a low dose of EMS. Some of the alkylating substances are very powerful, and have been sometimes called "super mutagens."

In the 3rd column on page 261, the 2nd sentence from the top has been incorrectly constructed. More appropriately it should have read "This high ratio is responsible for pellagra in the populace whose staple diet is maize or sorghum".

The sentence, "Unfortunately no such spontaneous mutant as cited above has been identified in the case of wheat and rice" gives a totally wrong information.

S. R. CHATTERJEE
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Atmospheric ozone

Sir, It has been mentioned in **Supernovas can cause catastrophe** that a near supernova explosion can cause depletion of the ozone layer of the atmosphere, thereby endangering life on earth (*S.R.*, May 1978.) The ozone layer, it has been stated, absorbs ultraviolet radiations coming from the sun as well as hot infrared and light radiations. I am afraid, the latter part of the statement is not correct. Actually it is water-vapour in the atmosphere which is responsible for some extremely strong absorption in the long wavelength infrared region. Oxygen in the atmosphere also produces absorptions in the near infrared regions of the spectrum.

S. K. GURTU
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Desert living

Sir, Thanks for **Tricks of living in desert** by Samar Chakrabarti (*S.R.*, May 1978). The author has dealt with physiological aspects only but not with other facts which are also equally remarkable.

Defence. Desert animals have to protect themselves against natural enemies. They do it through colouration or spiny covering. They have grey, brown or red colour to match the colour of the sand or the rock. Warning colours are also commonly seen. Some insects and lizards have a hard or spiny covering for protection as the 'moloch' and the horned toad, Phrynosoma.

Poison. Presence of poison is a feature of desert animals. Most reptiles of the desert have poison. Spiders, scorpions and wa spsare also very poisonous.

PUSHKER SAXENA
D.A.V. College
Kanpur

II

Sir, Apropos of the article **Tricks of living in desert** by Samar Chakrabarti (*S.R.*, May 1978), I would like to add that colour of the body also plays an important role in desert vertebrates. All desert creatures possess a concealing colour which resembles the colour of the sand. The colour adaptation helps them survive in deserts.

SAMIR K. BANERJI
Calcutta

Ringworms

Sir, In the article **Ringworm—a fungal infection** by Banani Sur (*S.R.*, May 1978), the author has mentioned salicylamide containing powder for treatment of the fungal disease. Salicylamide is used as an analgesic, antipyretic and antirheumatic. Its use as a fungicide or fungistat has not been reported. Perhaps the author meant salicylanilide, which is effective in topical application for treatment of *Tinea capitis* caused by *Microsporon audouini.*

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Salicylamide containing powder for treatment of fungal disease has already been reported by R. N. Gupta and S. K. Shome. For details see *Jour. Ind. Med. Asson.*, **33** (2), 39-42, 1959.

BANANI SUR

Prostaglandins

Sir, I read the article **Cyclic AMP, prostaglandins and cancer** by U. N. Das with interest (*S.R.*, May 1978). A nice interpretation has been given by the author regarding occurrence of cancer and levels of prostaglandins and cyclic AMP or factors which affect the levels of cyclic AMP. He says that cancerous cells possess low levels of cyclic AMP whereas resting cells or normal proliferating cells contain high levels of cyclic AMP. It is quite obvious, therefore, that any factor which can lower the level of cyclic AMP either by enhancing the activity of phosphodiesterase enzyme or by inhibiting the activity of adenyl cyclase may induce cancer and vice versa. Prostaglandins E-1 and E-2 act as suppressors of carcinogenesis by elevating cyclic AMP level through adenyl cyclase enzyme.

In this context, I would like to mention two alkaloids, caffeine and theophylline which, according to R.R. Burk of Experimental Virus Research Unit, Institute of Virology, Glasgow (1968), inhibit the activity of 3′, 5′ phosphodiesterase and induce the accumulation of cyclic AMP within the cell. High levels of cyclic AMP is known to suppress carcinogenesis. It seems, therefore, that caffeine and theophylline also suppress occurrence of cancer by a mechanism almost similar to prostagladins E-1 and E-2. Caffeine is known to inhibit carcinogenesis by another mechanism also, by altering DNA repair. Boreck *et al.* (*Nature*, **243**, 450, 1973) found that theophylline inhibited the growth of hepatoma cells. It has also been reported that theophylline retards intradermal growth of Rouscher leukemia virus induced cancer.

Three years ago, a Japanese worker, Takeo Kakunaga, (*Nature*, **258**, 248, 1975) observed that caffeine inhibits tumor induction in mice *in vivo*. They assumed that caffeine inhibits post-replication repair of DNA (presumably an error prone) but not excision repair (presumably error free) in rodent cells. Similar results were obtained by Lehman (*Mutation Research*, **26**, 73, 1974). He found that caffeine reduces transformation frequency in mouse cells treated with N4QO (4-Nitroquinoline-1-oxide).

Survival of transformed cells was considerably reduced by caffeine. Similar results have been worked out at the Biology Department of Michigan Cancer Foundation. Veromica *et al.* (*Nature*, **258**, 760, 1975) found that caffeine affects survival of *Xeroderma pigmentosum* variants and not the normal human cells after exposure to UV irradiation or carcinogens which form lesions in DNA and may be repaired by the same processes as in dimers produced by ultraviolet.

Parallel to Kakinaga's work, some trials have been made at the Institute for Medical Research and at the Department of Fundamental Radiology, Osaka University, Japan, by Nomura (*Nature*, **260**, 547, 1976) who did his experiment using the same potent carcinogen 4-NQO and found that transformation of mouse cells was reduced greatly by post-treatment with caffeine. It is evident now that caffeine reduces the possibility of carcinogenesis both by elevating cyclic AMP level and by inhibiting the error prone DNA repair. As stated by Das, prostaglandins raise the cellular cyclic AMP level and thus reduce the possibility of carcinogenesis, but I would like to know whether prostaglandin has also got a dual role in cancer suppression as caffeine does, i.e., whether prostaglandins, besides raising cyclic AMP level, also influence DNA repair.

According to Nelson D. Goldberg, the ratio of two nucleotides, cyclic AMP and cyclic GMP, is important because high levels of cyclic GMP and low levels of cyclic AMP induce synthesis of DNA in fibroblasts whereas opposite is the case for resting cell. PGE-1 is known to activate adenyl cyclase whereas PGG-2 can activate gunylate cyclase (Goldberg 1976). So, besides cyclic AMP, cyclic GMP also appears to be somehow related with the prostaglandins and inhibition of cellular growth.

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It is generally believed that under normal conditions, there exists a balance between cyclic AMP and cyclic GMP in several tissues. Hence, any factor that can upset this delicate situation is supposed to adversely affect cell growth and produce malignant transformation. It has been shown that whenever cyclic AMP level falls, automatically cyclic GMP level rises. This is supported by the observation that in some tumor cells, low cyclic AMP levels were associated with high cyclic GMP levels. But this situation need not occur always. Low cyclic AMP levels were almost always found in malignant cells or cells such as foetal tissue that were rapidly growing.

It is true that prostaglandins can modulate both cyclic AMP and cyclic GMP levels in tissues. But, more studies have been done on the effects of PGs on cyclic AMP levels than on cyclic GMP levels of various tissues. One particularly interesting feature that was observed with PGE is that at supra physiological concentrations or in pharmaceutical doses, it can lower cyclic AMP level in the cells, rather than increase it (*Lancet*, Vol. 1, p. 936, 1977). But a rise in cyclic GMP levels was observed. This shows that the levels of PGE and cyclic AMP need not always be directly proportional to each other. This is further supported by the fact that in some rapidly growing tumors, the PGE levels were found to be quite high. From this data, it is evident that maintenance of PGE levels, in the cells within a narrow physiological range is very important. This is also true when one considers the effect of PGE on immune response. Our experiments have shown that at physiological concentrations, PGE enhances, whereas at higher concentrations it depresses, the immune response, akin to cyclic AMP.

Regarding the effect of PGE on DNA repair, it is now speculated that PGs can regulate gene action (*Lancet*, Vol. 2, p. 1115, 1976). This is an explanation given for PG's ability to initiate several cell processes. Because PGE can also turn a malignant cell into normal looking cell, it is possible that it is also able to enhance or initiate DNA repair in chromosomal abnormalities known to occur in malignant cells.

As Dr. Srivastava has pointed out, it is well-known that agents that can enhance intra-cellular cyclic AMP level are known to be of help in arresting or reversing a malignant process. In fact, it has been suggested that bronchial asthma patients, who use more or less continuously drugs that enhance cyclic AMP levels in cells, are less likely to suffer from cancer.

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II

Sir, Thanks for **Cyclic AMP, prostaglandins and cancer** (*S.R.*, May 1978).

Have any clinical trials been undertaken to know the beneficial effects of PGE in malignancy?

G.R. SRIDHAR,
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So far no clinical trials have been undertaken to study the possible use of PGE in malignancy. This may be due to the difficulties in delivering PGE and cyclic AMP selectively to the desired tissues in view of their varied actions and high potency even in very small quantities. But efforts are now being made to synthesize analogues of PGE which are tissue specific, so that when a particular analogue is injected, it reaches the particular tissue and brings about the desired action. U. N. DAS

Plagiarised article

Sir, The article **Paddy-cum-fish culture** by S.P. Singh and R.K. Sinha (SR June 1978) has been copied verbatim from the book *Fish and Fisheries of India* written by Dr. V.G. Jhingran (page 800-802) and the last two paragraphs from F.A.O. fisheries bulletin *Handbook of fish culture in the Indo-pacific region* by S.L. Hora and T.V.R. Pillay (page 157) word by word. The author probably could not follow c. 3 kg/ha (page 601, line 2 in Jhingran's book) and mentioned it as 0.3 kg/ha in the article. Plagiarism by contributors should not be encouraged in this august journal.

Further, for the interest of readers I would like to add here that paddy fields are found to be ideal breeding grounds for some air breathing fishes such as *Clarias batrachus*.

M.P. SINGH KOHLI
Scientist S
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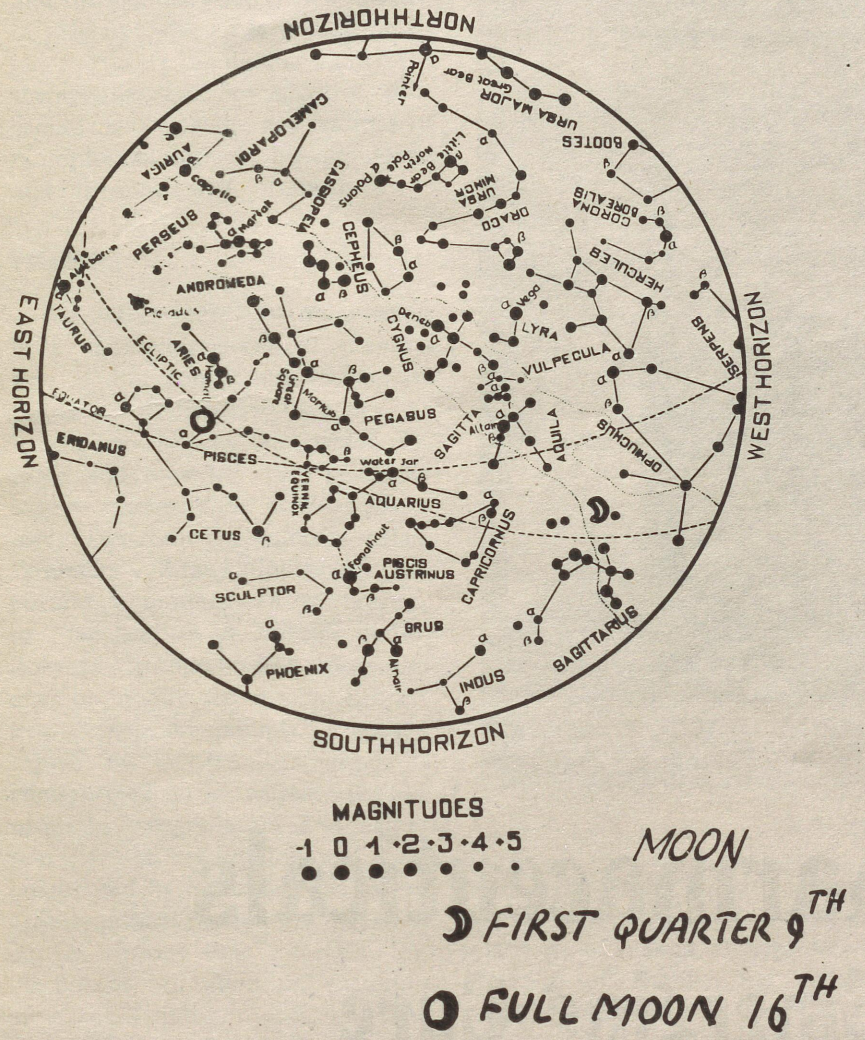
Planets and their positions

October 1978



The moon

NEW moon occurs on 2nd at 12-11 a.m. and full moon occurs on 16th at 11-40 a.m. I.S.T.

The moon passes about four degrees north of Mars on 4th, ten and a half degrees north of Venus on 5th, about four and a half degrees south of Jupiter on 24th and three degrees south of Saturn on 27th.

The lunar crescent becomes first visible after the new moon day in the evening of 3rd. The moon is at perigee or nearest to the earth on 11th and at apogee or farthest from it on 24th.

There will be a partial eclipse of the sun on the 2nd but it will not be visible in India.

The planets

Mercury (Budha) is too near the sun to be visible during the first three quarters of the month. Thereafter, it reappears as an evening star and rises about an hour after sunset. It passes about 5 degrees north of Venus on 27th. It moves from Virgo (*Kanya*) to Scorpio (*Vrischika*) through Libra (*Tula*). Its visual magnitude is about – 0.2.

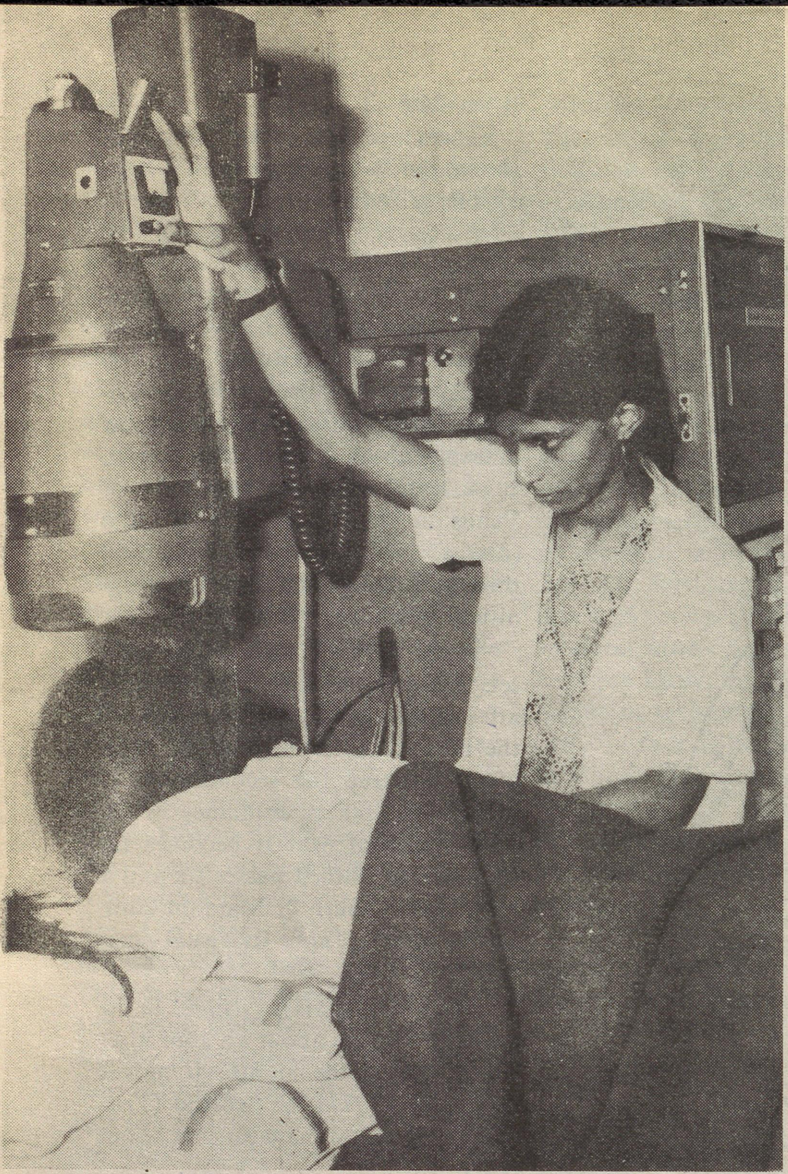
Venus (Sukra), an evening star, sets about one and a half hours after sunset during the first half of the month and about half an hour after it during the second half. It attains the greatest brilliancy in the early hours of 4th. It becomes retrograde on 18th. It passes six and a half degrees south of Mars on 20th. It is in Libra (*Tula*). Its visual magnitude is about —4.3.

Mars (Mangala), visible in the evening sky, sets about an hour after sunset during the month. It moves from Libra (*Tula*) to Scorpio (*Vrischika*). Its visual magnitude is about +1.7.

Jupiter (Brihaspati) rises about an hour after local midnight during the first half of the month and at about local midnight during the second half. It is in quadrature with sun on 1st Nov. It is in Cancer (*Karkata*). Its visual magnitude is about —1.7.

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

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



B. A. R. C. has placed India among the few advanced countries of the world in the very sophisticated technology of radiopharmaceuticals

Radiopharmaceuticals
The Emerging Cure

R. S. MANI

Dr. Mani is Head, Radiopharmaceuticals Section, Bhabha Atomic Research Centre, Trombay, Bombay-400085

RADIOPHARMACEUTICALS are a special class of drugs which have been developed during the last three decades, thanks to the research work carried out for the peaceful harnessing of atomic energy. The large scale production of radiopharmaceuticals is now a well established industry in many advanced countries, and to some extent in India. These products are now employed in medicine for a wide variety of diagnostic and therapeutic uses. A new branch of medicine, known as nuclear medicine, covering the unique diagnostic, therapeutic and investigative procedure involving the applications of radiopharmaceuticals, has developed and is now well established.

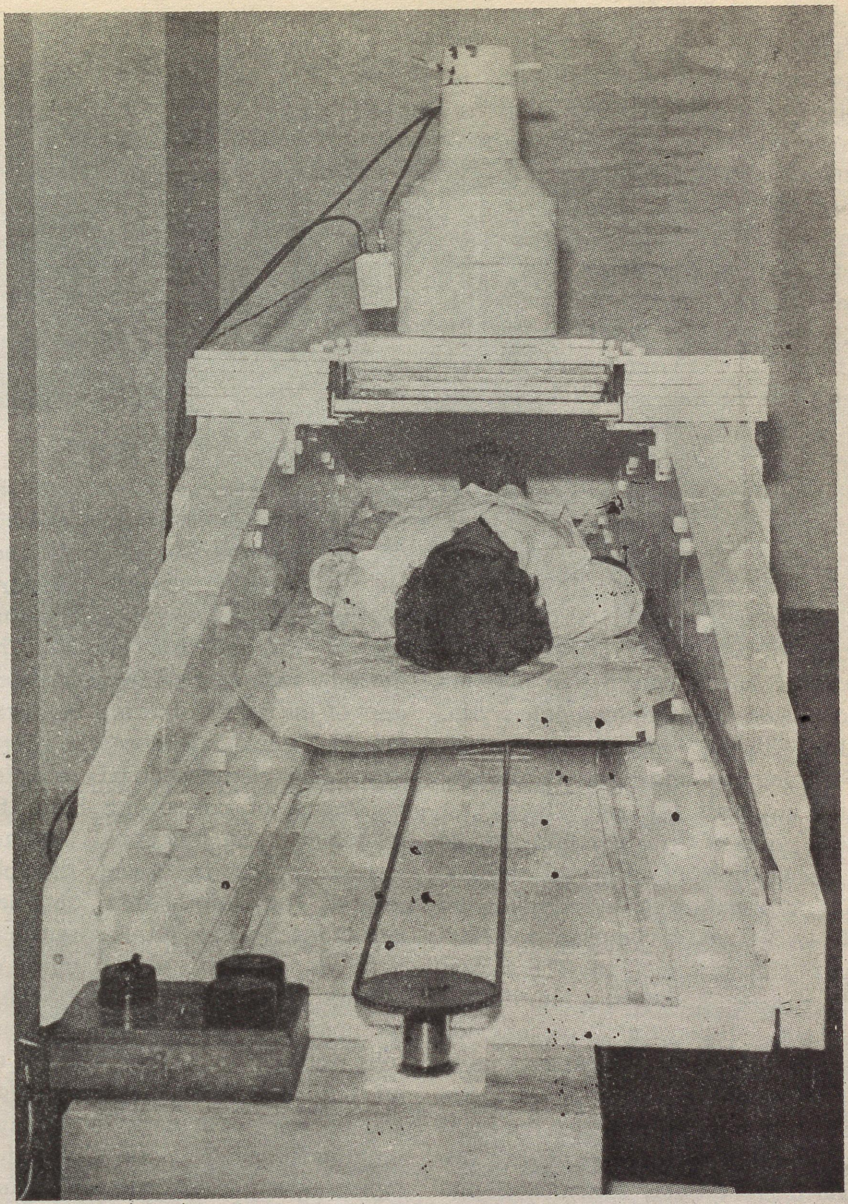


Fig. 1. Whole body counter

Principles

The active ingredient or principle in a radiopharmaceutical preparation is the constituent radioactive isotope. Radioactive isotopes, as is well known, can be detected, located and quantitatively measured even at extremely low concentrations using electronic instruments called "counters". Many biologically important compounds can be "tagged" or "labelled" with suitable radioisotopes. Isotope-tagging does not alter or modify the specific properties of these compounds. If such a tagged or labelled compound is administered to a patient, its absorption, degradation and excretion can be readily followed and quantitated by estimating the radioactivity present in blood, urine, stool etc. at various time intervals. So, the uptake, utilisation and excretion of essential nutrient salts, proteins, carbohydrates, fats, vitamins and drugs can be studied in health and disease.

To give one example, cyanocobalamin or vitamin B_{12} is an essential nutrient required for maintenance of good health. Dietary deficiency of this vitamin or its improper absorption by the body gives rise to the disease anemia. In a patient suspected to have early symptoms of anemia, absorption and excretion of vitamin B_{12} can be readily evaluated by administering a tracer dose of cyanocobalamin tagged with a radioactive isotope of cobalt, followed by measurements of the radioactivity retained in the body using an instrument called the "whole-body counter". By this method, B_{12} deficiency anemia can be readily diagnosed. Malabsorption of other important nutrients such as iron salts, fats, carbohydrates, etc. can be similarly evaluated and several other tropical diseases diagnosed. The response of individual patients to different therapeutic treatments can also be carefully monitored by these diagnostic investigations thereby optimising the therapy.

Imaging

Another important application of radiopharmaceuticals is known as scintiscanning or imaging. This procedure enables evaluation of size, shape and location of important organ systems and parts of the body and delineation of structural lesions such as cysts, abscesses, nodules and cancerous growths. For this purpose, a radiopharmaceutical preparation which has specificity for the organ under study and which incorporates a radioactive isotope emitting gamma radiations is administered to the patient. Radiations emitted from each tiny segments of the organ due to the radioactive preparation concentrated therein are recorded by using an electronic instrument known as the scanner gamma camera to obtain a scan or picture of the organ. The scanner has a scintillation detector consisting of a sodium iodide crystal alongwith a collimator arrangement. The detector moves systematically and automatically and "looks" at each point of the organ and records concentration of the radioactivity. The information is displayed on an X-ray film as a complete point-by-point map of the organ. The gamma camera, also known as a scintillation camera , displays electronically the amount of radioactivity at each point of the whole organ at a time. So, the camera is quicker than the scanner. In both cases, the display obtained gives a two dimensional picture of the organ under observation. Radiopharmaceutical preparations have recently been developed which enable doctors to obtain high quality pictures of all important organ systems and parts of the body including thyroid, liver, kidney, spleen, heart, lung, brain, gall-bladder, stomach and skeleton. Precise localisation and delineation of tumours, cysts and other lesions is of great help in their treatment by surgery or radiation therapy.

The selective uptake and clearance of the radiopharmaceutical from its favoured organ can also be made use of to study the dynamic functioning of the organ. Diseases of the thyroid gland such as thyrotoxicosis and hypothyroidism and functional disorders of the kidney, heart, liver etc. can be diagnosed by using specific radiopharmaceuticals. The dynamic recording of sequential images of the heart following an intravenous "bolus" injection of a short-lived radiopharmaceutical provides a means of visualising both the anatomical and functional characteristics of the heart and the big vessels. The information obtained pertaining to important parameters such as cardiac output, ejection fraction, pulmonary transit time, pulmonary blood volume and diastolic ventricular volume, etc., is of great interest to cardiologists. Such studies are particularly useful for monitoring shunt closure or valve replacement and patients of angina with equivocal ECG stress test. Radioisotope "renography", i.e., study of kidney function, is very useful in screening patients with high blood pressure to detect surgically correctable renovascular disorders, and in monitoring kidney transplants for an early detection of complications. It may be emphasised that these investigations are essentially non-traumatic and non-invasive, and involve the minimum of discomfort to a patient.

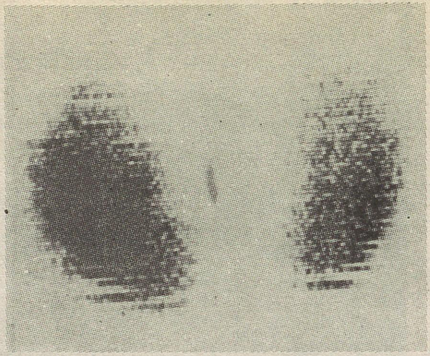


Fig. 2. Normal kidney scan

The high energy radiations emitted by a radioactive isotope can be advantageously used for selective irradiation of certain tissues and for destruction of cancer cells. To give two examples, sodium radioiodide is successfully employed for the therapy of thyrotoxicosis and thyroid cancer, while sodium radiophosphate is administered for the treatment of a rare type of blood cancer known as Polycythemia Vera.

Production

The production of radiopharmaceuticals is a highly specialised and intricate job requiring expertise in

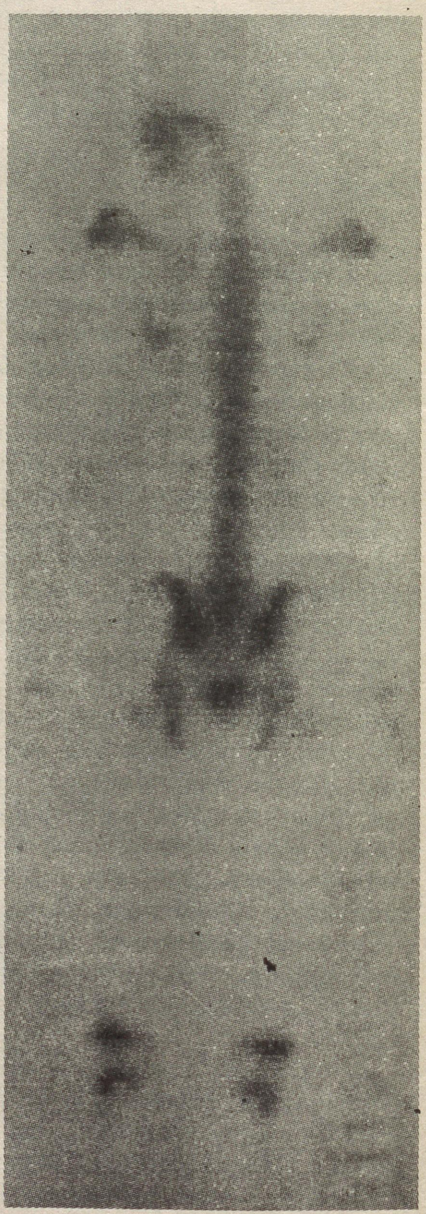


Fig. 3. Normal bone scan

various fields, including radiochemistry and radioanalytical chemistry, radiopharmacy, health physics, pharmacology and microbiology. The first step in their production is the preparation and purification of the raw materials which include special chemicals and biochemicals, and the primary radioisotopes. The requirements of purity of these raw materials are stringent and special procedures and techniques are required to obtain the requisite specifications.

The primary radioisotopes are prepared by irradiating suitable materials, known as targets, in a nuclear reactor or a cyclotron, followed by chemical processing. For example, for the production of radioiodine (iodine-131), pure tellurium metal is used as the target. After tellurium metal is irradiated in a nuclear reactor for a period of two weeks, oxidative acid dissolution followed by controlled reduction releases radioiodine from the irradiated target. Radioiodine is first obtained in the primary chemical form of sodium iodide. From this, labelled compounds such as tagged organic iodocompounds and iodinated proteins, hormones, steroids and drugs can be prepared by taking advantage of synthetic and exchange reactions. Specially designed facilities, known as "hot cells", are required for carrying out such chemical processing.

Synthesis and purification of radiopharmaceutical formulations involve intricate radiochemical manipulations which have necessarily to be carried out by remote control to avoid radiation hazards. All radiopharmaceutical preparations require to be subjected to rigorous quality controls which involve specialised chemical and radiochemical analyses and biological evaluations in experimental animals.

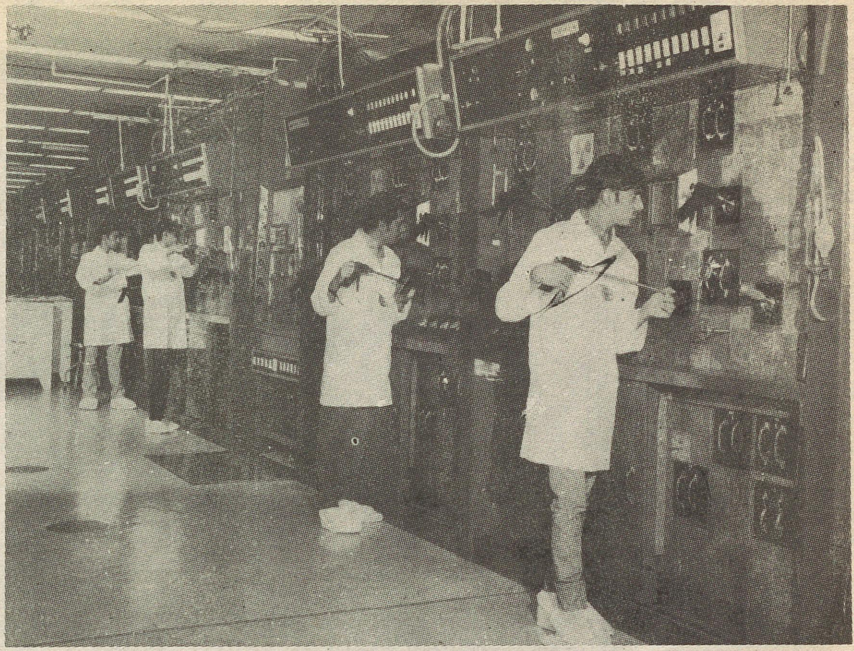


Fig. 4. Isotope laboratory at Bombay

Indian work

In the Indian atomic energy programme, high priority has been given to the indigenous development and utilisation of radiopharmaceuticals. Research and development work was initiated at the Isotope Group of Bhabha Atomic Research Centre as early as 1958 for the development of many important radiopharmaceuticals. Sodium radioiodide, radiochromate, radiophosphate, radioiodine labelled and thyroid hormones and labelled human serum albumin and vitamin B_{12} preparations were developed at the Isotope Laboratories at Trombay by early 1960's. The Radiopharmaceuticals Section of B.A.R.C has so far developed the know-how for over 120 radiopharmaceutical products which include very sophisticated preparations known as "radioisotopic cows" or "generators" and "radioimmunoassay kits".

The radioisotopic cows make possible ready preparation of several pharmaceutical formulations of versatile short-lived isotopes of technetium, indium and strontium in any hospital. The short-lived radioisotopes are derived from their long-lived parent radioisotopes (namely molybdenum-99, tin-113 and yttrium-87 respectively); the latter are firmly retained in the generator or cow. The short-lived, daughter isotopes can be 'milked' from these generators by using simple radiochemical procedures such as chromatographic elution or solvent extraction. Pharmaceutical formulations of these short-lived isotopes find extensive applications in a wide variety of valuable diagnostic procedures including specialised investigations on children and pregnant women. In view of their short half-lives and high photon output, investigations using these short-lived radiopharmaceuticals involve the minimum of radiation exposure to patients and the scan pictures obtained with their help are of high quality. Serial studies can also be carried out to follow the progress of therapy.

Radioimmunoassay

Radioimmunoassay is a novel radioanalytical procedure which can be employed for the estimation of minute concentrations of important biological ingredients such as hormones, vitamins, drugs and viral proteins in body fluids.

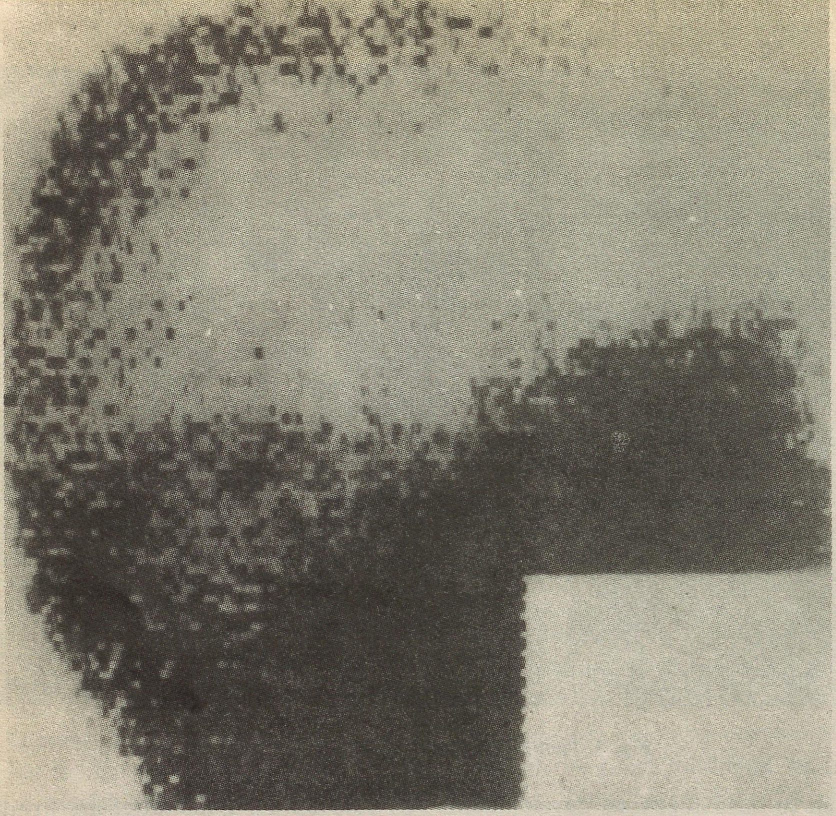


Fig. 5. Normal brain scan

In radioimmunoassay, the extreme detection sensitivity of the radiotracer and the highly specific reaction of an "antigen" with its "antibody" are made use of to attain a high degree of detection sensitivity and specificity in the estimation. For example, estimation of insulin levels in blood serum under various conditions including fasting and after glucose stimulation is of considerable importance in the management of some forms of diabetes and detection of certain tumours of the pancreas called insulinomas. Radioimmunoassay offers an easy and reliable means of carrying out such an estimation. For this assay, a small measured volume of the patient's blood (usually a few drops) is withdrawn and the serum is separated by centrifugation. To this serum are added known quantities of anti-insulin serum and isotopically tagged insulin (tagged with radioiodine, I-125). The anti-insulin serum is prepared by immunising guinea pigs with increasing doses of porcine insulin, injected over a period of 4-6 months; the guinea pigs are then bled and the serum rich in insulin antibodies is separated. The avidity or potency of the anti-insulin serum can be determined by direct titration with isotopically labelled porcine insulin. The latter can be tagged or labelled with radioiodine by a simple chemical process involving controlled iodination of the tyrosyl groups of insulin.

For the actual assay, the mixture containing patient's serum, anti-insulin serum and I-125-tagged insulin is incubated for a few hours. The insulin antibody molecules specifically bind insulin molecules to form a complex and the insulin present in patient's serum as well as the isotopically labelled insulin molecules added extraneously react with the antibody molecules. As the total quantity of antibody molecules added is not sufficient to complex all the insulin molecules present in the mixture, some fraction of the insulin remains unbound. The unbound insulin molecules can be readily separated from the antibody-complexed-insulin by a simple procedure such as direct absorption of the former on specially prepared dextran-coated charcoal. The radioactivity associated with the bound and free or unbound insulin fractions is measured accurately, and their ratio (denoted as B/F i.e. Bound to Free) is determined. B/F ratios are also determined under identical conditions for standard sera samples containing known quantities of pure insulin, and a standard curve relating to the observed B/F values with the levels of added standard insulin is constructed. From a typical standard curve, the content of insulin in the patient's serum can be readily read off, since the value of B/F for the patient's serum is known.

The great potentialities of radioimmunoassay procedures in the field of medicine can be readily appreciated from the following typical applications.

Radioimmunoassay of thyroid hormones can be used for the early

"With so many of them being advertised on the radio every day, these radiopharmaceuticals have become a household word now."

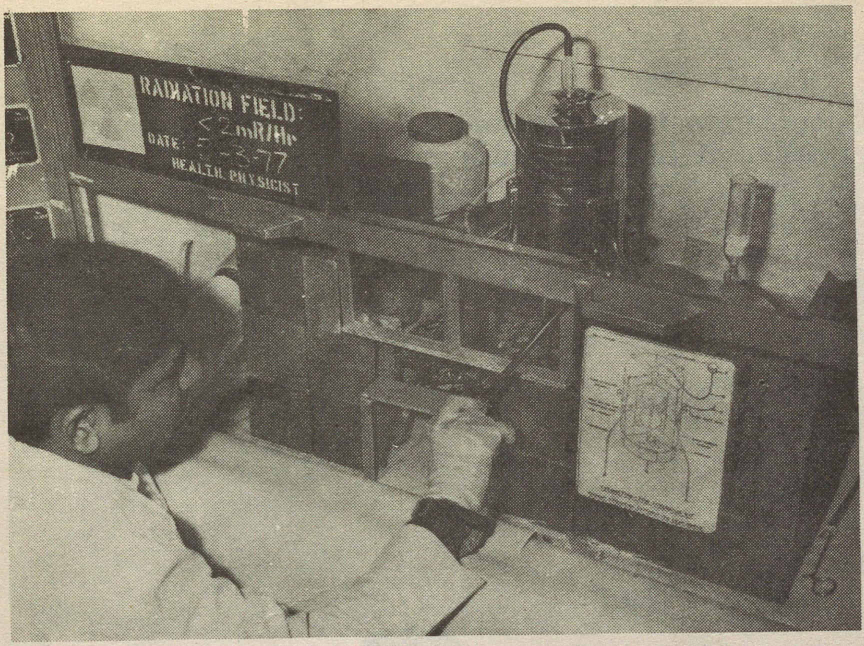


Fig. 6 Technitium -99m radioisotopic cow

diagnosis of thyroid diseases including hypothyroidism in infants. The diagnosis of hypothyroidism in newborns has to be established as early as possible after birth, because irreversible brain damage sets in soon. The incidence of neo-natal hypothyroidism is high in many developing countries and there is a very large scope for a low cost reliable technique such as radioimmunoassay for mass screening of infant population. Where the tests are positive, hormone treatment can be started within days of birth and a life-long disability can be prevented. Assay of another hormone called human placental lactogen in blood serum of pregnant women enables early diagnosis of possible complications in pregnancy such as abortion and foetal distress. Radioimmunoassay of digoxin is important for the careful monitoring and optimisation of digitalis therapy for heart patients. Another elegant and important radioimmunoassay with great potential for tropical countries is radioimmunoassay of Australia antigen which enables mass screening of donor blood for the possible occurrence of dangerous hepatitis virus.

BARC-produced radiopharmaceuticals are now in regular use in more than 50 major hospitals and medical research institutions, and over 2,00,000 patient investigations have been carried out in this country in 1977. Trombay-produced radiopharmaceuticals are also exported to several countries including advanced countries such as Australia, Denmark and France. Considering the range and quality of the radiopharmaceuticals for which know-how has been developed at the Isotope Group of BARC, it can be legitimately claimed that India today ranks among the few advanced countries in the world in this very sophisticated field of technology.

Further reading

1. *Radioisotope Production and Quality Control*, Technical Reports Series 128 (International Atomic Energy Agency, Vienna) (1971).
2i *Radiopharmacy* Edited by W. Wolf and M. Tubis. John Wiley and Sons (1976).
3. *Isotopes in Day to Day Life*, International Atomic Energy Agency Publication (Nov. 1977).
4. *Radioimmunoassay and Related Procedures in Medicine*, International Atomic Energy Agency Publication Vols. I, II, Proceedings of a Symposium, Berlin (November 1977).

Corrigenda

1. The title of the main article on page 454 (*S.R.*, July 1978) by Y.K. Gupta is *How do Chemical Reactions Occur*? and not as printed.

2. The author of the article *Electrochemical Polymerization* (*S.R.*, July 1978) is S. N. Bhadani and not as printed.

Because the bulk of Indian population is vegetarian, plant proteins are extremely important in our country

H. K. PATRA

D. MISHRA

Proteins from

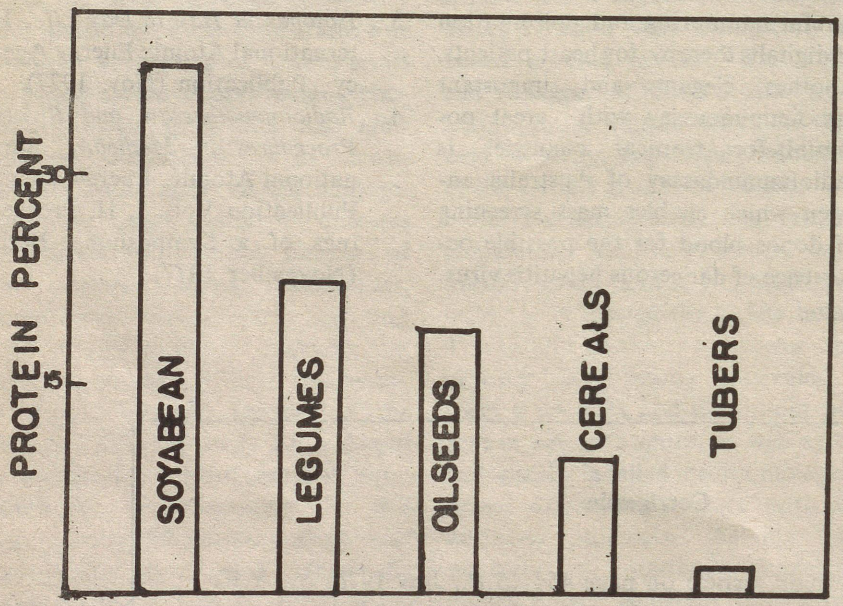


Fig. 1

PROTEINS are ubiquitous components of all living tissues—plants, animals and bacteria. They have indispensable functions in cellular architecture, catalysis, metabolic regulation and are an important weapon in the defense arsenal of many higher organisms. Indeed, proteins are intimately concerned with virtually all physiological events.

Food proteins in the body undergo a continual process of breaking down and building up. As protein molecules break down, fresh sources are provided from the food supply in order to keep up and repair body tissues and to provide a supply to new tissues. They are required in large quantities for tissue formation due to rapid growth in childhood

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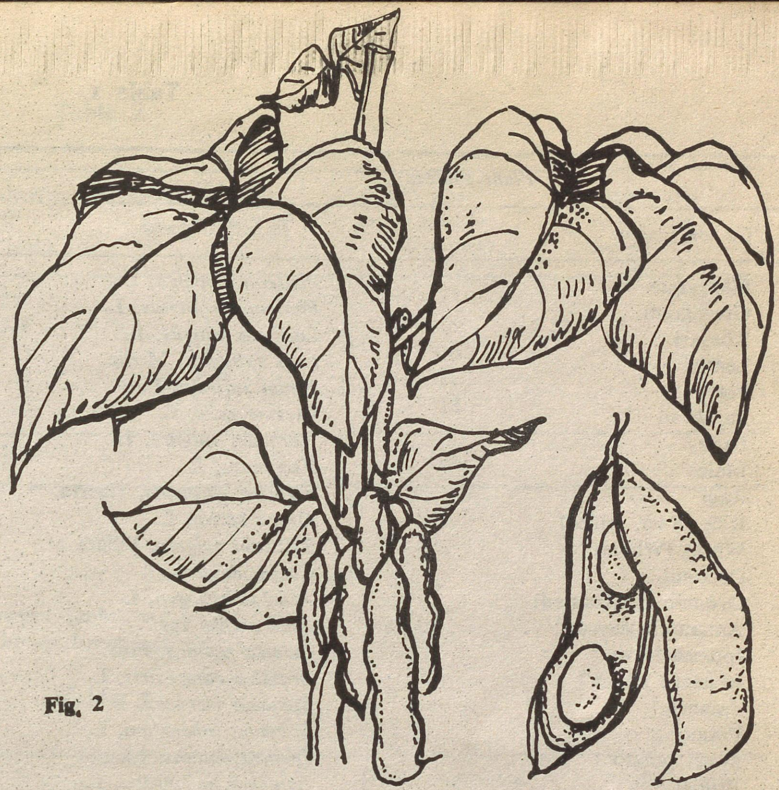


Fig. 2

Indian plants

and during adolescence. Proteins furnish every cell with fundamental building materials upon which life depends.

Dietary requirement

The requirement of a good diet is not the intake of a particular protein, but the one that is well balanced in essential amino acids and has a higher biological value and protein efficiency ratio. Out of twentytwo different amino acids, eight have been shown to be indispensable for proper nitrogen balance in human body. Animal protein is, however, superior to plant protein, as the latter generally contains insufficient quantities of essential amino acids, i.e., lysine, methionine, tryptophan, threonine, valine, isoleucine and phenylalanine (J.H. Macgillivary and J.B. Bosley, *Econ. Botany*, 16; pp. 25-30, 1962). The low lysine content of most varieties of maize and low methionine content of beans are examples. The fault can be evened out by using a combination of different foods. A diet that consists of 1/3 beans and 2/3 maize provides a biological value of 100, if we take the biolgoical value of the protein in hen's egg as a standard (100) (M.S. Kaldy, *Econ. Botany*, 26; pp. 142-144, 1972.)

Biological value and protein efficiency ratio

The most common methods, generally used for evaluating the nutritive value of proteins, are protein efficiency ratio (PER) and biological value (BV). PER is defined as the gain in weight per gram of protein consumed and is determined by growth studies. The percentage of absorbed nitrogen retained in the body (BV) is then determined from the formula :

$$BV = \frac{100 \times \text{N retained}}{\text{N absorbed}}$$

$$= \frac{\text{N absorbed} - \text{N not retained}}{\text{N absorbed}} \times 100$$

The higher the biological value the better is the quality of protein. Some

Table 1

Plant sources		BV*	PER**
Common name	*Botanical name*		
Blackgram	*Phaseolus mungo*, L.	63	1.0
Greengram	*Phaseolus radiatus*, L.	54	0.8
Khesari	*Lathyrus sativus*, L.	47	0.3
Lentils	*Lens culinaris*, Medic.	49	0.5
Peas	*Pisum sativum*, L.	59	1.1
Soyabean	*Glycine max*, L.	60	0.9
Barley	*Hordeum vulgare*, L.	71	—
Maize	*Zea mays*, L.	60	1.0
Ragi	*Eleusine coracana*, Gaertn.	89	0.7
Rice (Raw, milled)	*Oryza sativa*, L.	80	1.7
Wheat (Whole)	*Triticum vulgare*, Villars.	66	1.3
Coconut	*Cocos nucifera*, L.	77	1.0
Groundnut (Roasted)	*Arachis hypogea*, L.	56	—
Amaranth leaves	*Amaranthus* sps.	72	—
Ipomea leaves	*Ipomea reptans*, Poir.	67	—
Mustard leaves	*Brassica campestris*, L.	84	—
Spinach	*Spinacia oleracea*, L.	87	—
Potato	*Solanum tuberosum*, L.	68	1.9
Sweet potato	*Ipomea batatas*, Lamk.	72	1.5
Brinjal	*Solanum melongena*, L.	71	—
Lady's finger	*Hibiscus esculentus*, L.	82	—

*BV**—Biological value
*PER***—Protein efficiency ratio

of the plant protein sources and biological values of the proteins are given in Table 1.

Protein utilisation in India

Because the bulk of population in India is vegetarian, plant proteins are of greater importance than animal proteins. Even otherwise, cost of animal protein in nutritionally significant quantities is beyond the purchasing power of an average Indian. Production of animal protein cannot keep pace with the rate of population increase.

88 per cent of the protein consumed in India is of vegetable origin. The situation in advanced western countries is entirely different as 51% of proteins consumed are of vegetable origin and 49% of animal origin. Interest in recent years has centred round proteins from unconventional sources. Among them the highest priority is given to oilseeds, some legumes, and particularily soyabean.

Exploitation of some plant protein sources

The annual world production of crude proteins by plants is 784 million tons and the protein requirement of the world's population is about 75 million tons (4 thousand million people with an average protein requirement of 50 gm per unit per day) (FAO, 1973). Grassland protein is only made available from animal production in the course of which 80% -95% of the feed protein is lost (G. Lossener, *Beitr. Trop. Landw. Vetarinarmed*, 12; pp. 101-110, 1974). The products of plant cultivation alone, however, provide more protein than man needs (Table 2) (Anon, *World Agric.* 22(3); pp. 18-21, 1973), even if only 50% of the crude protein is digestible protein. It is evident that grain crops make largest contribution to protein supplies (S. H. Wittwer, *Science*, 188; pp. 579—584, 1975). Oilseeds, particularly soyabean, play a very important part and the actual "protein plant", i.e., the grain legumes, only make a small contribution. Although the grain legumes occupy the third place as suppliers of protein, they do help significantly in many countries in filling the protein gap in human and animal nutrition. Thus, interest in recent years is focussed on various groups of food plants, especially some selective legumes, cereals and oilseed plants for substantial improvement in the nutritional levels of protein. Fig. 1 provides the data of average crude protein content (%) of various plant groups.

Legume proteins

India has achieved a good position as the main producer of grain

Table 2

Plant group	World production 1972[1] (Million tons)	Average crude protein content[2] (%)	Quantity of crude protein (Million tons)	Contribution to total crude protein (%)
Cereal grains[3]	1,273	10.4	133	72.4
Tubers[4]	534	1.7	9	4.9
Soyabean	53	38.0	20	10.8
Grain legumes[5]	44	23.0	10	5.4
Other oilseeds[6]	63	19.7	12	6.5
Total crude protein			184	

1. FAO Production Year Book, 1973.
2. Weighed average from all types.
3. Wheat, rice, maize, barley, millets, oat, etc.
4. Potatoes, sweet potatoes, yams, cassava, taro, etc.
5. Beans, Peas, horsebean, vetch, pigeon pea, lentils, cowpea, lupins, etc.
6. Peanuts, cottonseeds, sunflower, linseed, sesame, palm kernel, hemp seed, etc.

Table 3

Species or groups		World production (Million tons)	Production in India (Million tons)
Common name	Botanical name		
Beans[1]	*Phaseolus* sps. and *Vigna* sps.	10.9	1.5
Pea	*Pisum sativum*, L.	10.2	0.69
Chickpea	*Cicer arietinum*, L.	6.7	5.1
Pigeon pea	*Cajanus cajan*, Mill.	1.7	1.6
Lentils	*Lens culinaris*, Mdeic.	1.2	0.42
Other[2]—unspecified kinds		3.6	1.4

1. *P. vulgaris* (French bean), *P. lunatus* (Lima bean), *P. radiatus* (greengram), *P. mungo* (blackgram), etc.
2. *Lablab purpureus* (hyacynth bean), *Lathyrus* sps., *Voandzeia subterranea* (Bambera groundnut), *Trigonella foenugraceum* (fenugreek) etc.

legumes. Table 3 gives production figures for the types included in the FAO Production Year Book (1973).

Table 4. Amino acid contents in soyabean

Amino acids	Content (%)
Lysine	6.8
Tryptophan	1.4
Phenylalanine	5.3
Methionine	1.7
Threonine	3.9
Leucine	8.0
Isoleucine	6.0
Valine	5.3
Arginine	7.2
Cystine	3.1
Histidine	2.4

Though the production level of soyabean (*Glycine max*) (Fig. 2) is comparatively low, it may still be included in the grain legumes beca use

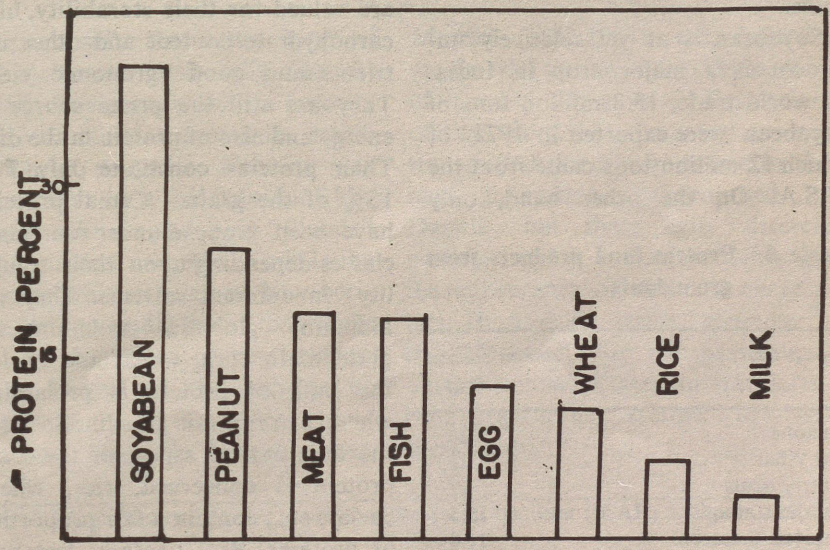


Fig. 3

Table 5

Plant sources		Protein content (%)	Annual production in India (Metric tons)
Common name	Botanical name		
Soyabean	*Clycine max*, L.	32-42	—
Castor pomace*	*Ricinus communis*, L.	36	110
Mustard	*Brassica campestris*, L.	35	1,500
Sesame	*Sesamum indicum*, L.	33	500
Sunflower	*Helianthus anus*, L.	33	—
Safflower	*Carthamus tinctorius*, L.	30	—
Linseed	*Linum usitatissimum*, L.	25-35	400
Groundnut	*Arachis hypogea*, L.	26-28	6,000
Coconut	*Cocos nucifera*, L.	20	280
Cottonseed	*Gossypium arboreum*, L.	17-21	2,000

*Castor pomace, i.e., a byproduct after extraction of oil.

of its dominant role as a supplier of the best, richest and the cheapest source of protein. The technology behind the use of soyabean as protein source is well advanced now-a-days. To illustrate its potential as a source of human food, it is said : China exists today because of the use of soyabean as food. The protein content is about 40%-42% which is higher than other sources (Fig. 3), and it contains essential amino acids (Table 4). As it has the highest lysine content (6.8%), it can combine very well with other cereals which are poor in lysine but rich in sulphur-containing amino acids.

Soyabean is as yet relatively unknown as a major crop in India. In world trade, 13.8 million tons of soyabean were exported in 1972, of which 12 million tons came from the U.S.A. On the other hand, only 1.9 million tons of all other grain legumes were exported (FAO Trade Year Book, 1973). Of course, Government of India has evinced interest in mass cultivation programmes for soyabean production since 1967. If soyabean can become a major crop in India, it will soon make an important contribution to meet our requirements of vegetable oils.

Table 6. Protein food products from groundnuts

Food product	Proteins content (%)
Lactone	26
Bal Ahar	22
Nutrobiscuts	17
Paushtik atta	13.5
Tapioca macaroni	11.0

Cereal proteins

Various cereals belonging to the family *Gramineae* have been cultivated as major crops in many parts of the world since antiquity. Grains are valued for their storability, high carbohydrate content and other nutrients and good agronomic yield. They are still the prime source of energy and also of protein in the diet. Their proteins constitute only 7%-15% of the grain. Cereal proteins have been grouped under four main classes depending upon their solubility in different solvents. They are albumin, globulin, prolamine and glutelin. In corn, wheat and barley, the bulk of protein is prolamine, whereas in rice it is glutelin. So far as the quantitative aspect of the cereal protein is concerned, rice, wheat, barley, etc., contain a fair proportion of proteins. Rice contains less protein than wheat, though rice protein is of better quality. The outer layer of cereals is richer in protein than the inner starchy kernel, and when wheat and rice are excessively milled there is some loss of protein as well as vitamins and mineral salts. If, however, foods like cereals, the admittedly poor sources of protein, are present inabundance in a diet, their contribution to the total protein in the diet is considerable. Over 60% population of India is vegetarian. Millions of Indians have to subsist on a less expensive but monotonous diet of starchy cereal grains, deficient in some of the essential amino acids. Wheat, rice and corn all lack lysine; corn lacks in tryptophan and threonine is missing in rice. Protein quality of the cereal grains can be improved by supplementing with pulses which contain 20%-25% potein so as to make them adequate for meeting the deficient amino acids.

Oilseed proteins

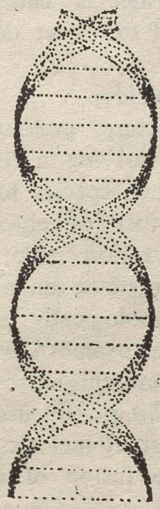
Oilseeds have attracted a great deal of interest as potential source of protein foods (G. Anderson *et. al.*, *Sver. Utsadesforen Tidskar*, 3-4; pp. 258-255, 1969). The quantitative potential of these resources is illustrated by the fact that presently available protein residues from oilseeds alone are equal to all the animal proteins. The residues left after extraction of oil from oilseeds contain 30%-35% protein that can be used in combination with cereal grains for human consumption. Because of the poor handling and processing, these protein-rich oilseed foods are unfit far human use. We are using them as for fertilizers for crop improvement and feed for animals. More economical and efficient processes for the production of foodgrade meals would increase the utilisation of oilseeds and their pro-

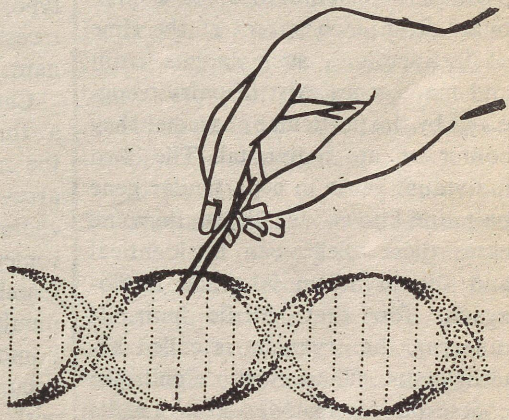
(*Continued on page* 629)

SUBHASH S. ARORA

Gene has emerged as a unit of function

GENE





Yesterday, Today & Tomorrow

CHARLES DARWIN, the eminent biologist of the ninteenth century, attempted to explain the physical basis of heredity in a very interesting way. He believed that very small, exact, but invisible copies called "gemmules" or "pangenes" are produced from each body organ. They are thrown in the bloodstream to be carried away to the sex organs where they get assembled to form gametes. Upon fertilization, pangenes from male and female sex organs come together to give rise to a new organism with the same kind of organs, tissues and cells like its parents. The transmission of heredity traits was correlated with the transmission of pangenes. Heredity was supposed to be a miscible fluid like blood in animals and man. "Bloods" of parents were assumed to mix in the offspring which explained how heritable changes could occur that might lead to the origin of new species. It was known as the doctrine of pangenesis.

It was, however, Gregor Johan Mendel (1822-1884), the Austrian monk, who put an end to this notion of heredity. He gave the first proof of the theory that characters are not transmitted directly from one to the next generation, as proposed by Darwin, but there exist discrete particles which are responsible for the appearance of different characters. He used the terms "character" or "Merkmal" for the particulate units which were later on translated into English as "factors" or "determinants".

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Darwin proposed that something is transmitted directly from each part of the organism to the corresponding part in the progeny. On the other hand, Mendel provided the first operational definition of a hereditary unit—inheritance is indirect, it is mediated by particulate determinants which are transmitted from one generation to another.

An inherited Mendelian factor is called a gene. In diploid organisms (an individual or cell having complete sets of chromosomes contributed from each parent at the time of fertilization), such as pea plant and man, genes exist in pairs recognized by the particular character they confer on an individual. The two individual genes in a particular gene pair are known as alleles. In some cases these alleles can be identical and the organism is called homozygous for that allelic pair. If different, the organism is called heterozygous. The most significant conclusion from Mendel's results was the segregation of pairs of determiners resulting in the "purity" of gametes. Allelic pair gets separated "cleanly" from one another when an individual forms gametes, that is, during meiosis. This is the Mendel's First Law, the Law of Segregation.

Terminology

Allele (Johannson, 1909)—One of the two or more forms of a gene present at a specific site (locus) on the homologous chromosomes (see below) in diploid organisms. The two alleles of gene can be identical (A/A or a/a=homozygous) or different (A/a=heterozygous). If 'a' does not make its appearance because of the presence of 'A' in the phenotype, then the former is called a recessive allele and the latter dominant.

Chromosome (Waldeyer, 1888)—a thread-like structure, present in the cell nucleus, carrying a linear array of genes. Each species has a characteristic number of chromosomes. At fertilization male and female parents contribute an equal number of morphologically alike homologous chromosomes which occur in pairs. These chromosomes, with a corresponding sequence of genes, pair together at meiosis.

Fertilization—the fusion of male and female sex cells (haploid gametes) to form a diploid zygote.

Genotype (Johannson, 1909)—the sum total of the genetic material (genes) in the nucleus. In other words, the genetic complement (or genome) that an organism inherits from its parents. Genotype determines the appearance (or phenotype) by interacting with environment.

Heredity (Spencer, 1803)—the cause of the biological similarity between parents and offsprings. Genetics is the science of heredity.

Meiosis (Farmer and Moor, 1905) —the process of cell division to form haploid gametes or spores from diploid cells. During meiosis, reshuffling of genes takes place followed by segregation of chromosomes which give rise to new character combinations in offsprings.

Mitosis (Flemming, 1882)—a process of cell division to form daughter cells which are identical to one another and the parent cell in respect of chromosome number and genetic contents.

Mutation (de Vries, 1901)—a sudden heritable change in the genotype of an organism caused by some external agent called mutagen. It includes such diverse phenomena as changes in the number of chromosomes, the gross structure of chromosomes and within genes themselves ("point mutations"). By definition, a point mutation occurs within a gene and causes the smallest possible change (i.e., change in nucleotides, the building block of DNA) in the structure of the genetic material, the DNA. Point mutations can be classified as either; (a) Base substitution—mutations due to the replacement or substitution of one base pair for another; or (b) Frameshift—mutations due to the addition or deletion of one or two base pairs from the DNA.

S.S.A.

Molecular structure of the gene

Genes, as we understand now, are sections of DNA. DNA is a long, and mostly double-stranded molecule the two strands of which are coiled helically around each other forming a structure like a spiral stair case, popularly known as the double helix. Chemical analysis shows that each strand of DNA is a polynucleotide chain made up of repeating units called nucleotides. Each DNA nucleotide is a complex combination of a phosphoric acid, a deoxyribose sugar, and one of the four nitrogen bases (adenine, guanine, cytosine and thymine). Therefore, there are four different types of nucleotides possible in DNA : adenylic acid, guanylic acid, thymidylic acid, and cytidylic acid. Each nucleotide is a separate entity connected to each other through chemical bonds between the sugar and phosphoric acid components. No restriction is imposed on the sequence and number of nucleotides within the DNA molecule. A gene, which is a stretch of DNA, can have any number of nucleotides in any order. However, a particular number and order of nucleotides constitute a particular gene—no two genes with different functions are alike. Therefore, different species are distinguished by qualitative and quantitative differences of the nucleotides.

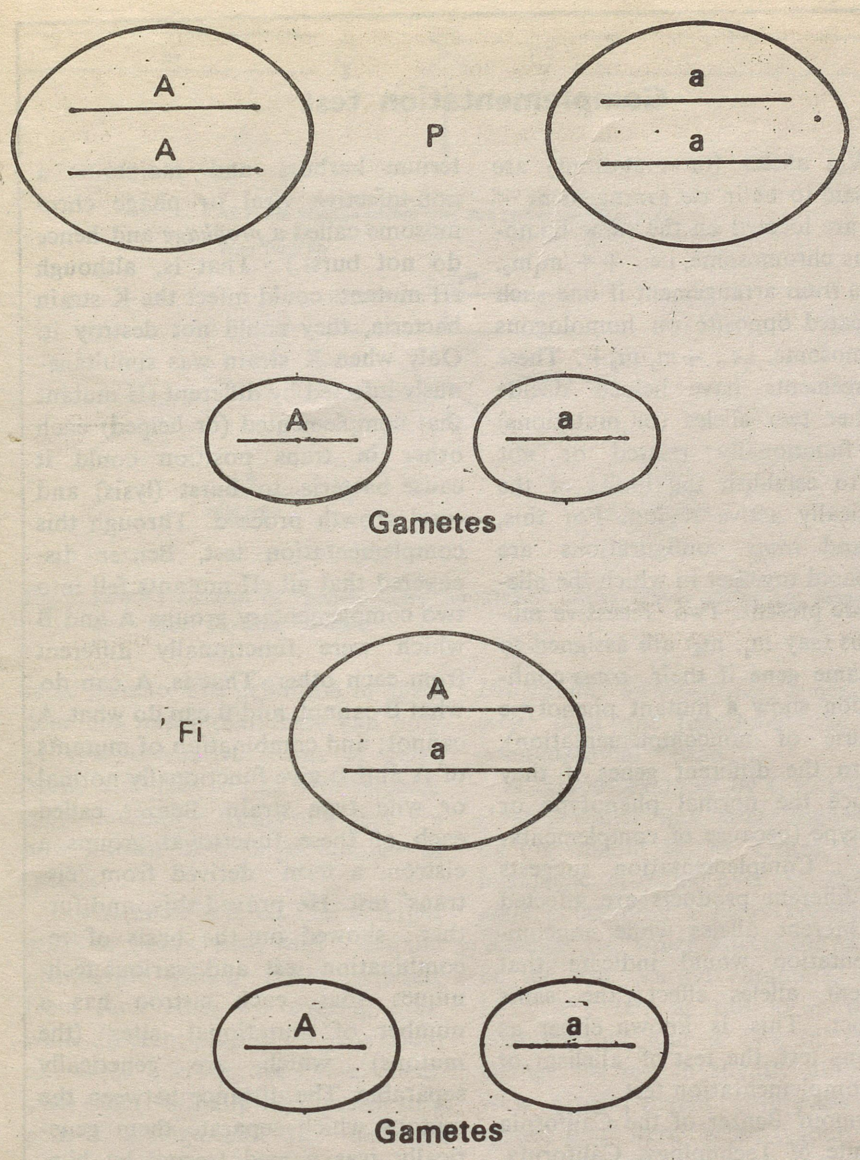


Fig. 1. Sutton-Boveri hypothesis of genes on chromosomes to explain Mendel's law of segregation

The chromosome theory of inheritance

Chromosomes of a diploid organism occur in homologous pairs because the chromosome set contributing the male gametes at the time of fertilization is homologous to the set contributed by the female gamete; so are the genes or the Mendelian factors. When an individual forms gametes through the process of meiosis, the chromosomes segregate like the genes. German biologist Theodor Boveri proposed in 1902 that the behaviour of chromosome is parallel to the behaviour of genes during meiosis. To account for this, William Sutton of Columbia University and Boveri in 1902 postulated the Sutton-Boveri "Chromosome Theory of Heredity" stating that Mendelian factors of inheritance "are on chromosomes" with a fixed location (Fig. 1). There were however four prerequisites of the theory:

1. The individuality or continuity of chromosomes from one generation to another;
2. Pairing between homologous chromosomes at meiosis;
3. Qualitative difference of pair of homologous chromosomes from other pairs; and
4. Independent recombination of different chromosome pairs.

But there was still no definite proof of this theory. The strongest and conclusive argument came from the paralell behaviour of chromosomes and genes observed by Thomas Hunt Morgan and his team of Columbia University in 1909, while working on *Drosophila*. Ironically, it was Morgan (who was earlier skeptical about the chromosome theory of inheritance,) who provided the first formidable evidencefor its establishment.

The chromosome as a string of beads

This classical concept of gene represented chromosome as a string of beads where each bead represented a different gene. The string of beads concept incorporated all the salient features about genes, i.e., that they have a constant site and do not move around, that they behave in inheritance as discrete particles which appear not to influence one another, that they are linearly arranged on the chromosome, and that during gamete formation crossing over occurs between homologous chromosomes. Gene was considered a specific "molecule" which controlled development of a particular character in all organisms, like the eyes or wing shape, etc., in *Drosophila*. The process of crossing over between homologous chromosomes was supposed to be a mechanical exchange which could cause breakage between corresponding beads followed by rejoining in a new way to give rise to a new combination of characters. It necessarily left the beads intact.

Any change in the nucleotide itself or nucleotide sequence of a gene leads to the formation of an alternative form of that gene called the allele which may produce different effects on the appearance of an organism. For example, a gene on chromosome II of *Drosophila* is connected with wing size and shape; a normal wing is long and smooth in outline. A mutation at this locus produces an alternative form of the normal gene which makes the wing shrivelled and non-functional. The alternative form was named 'vestigial locus' or 'vg' because the mutation is recessive to the wild or normal 'vg$^+$'. The alternative forms of a gene determining a single unit character are called alleles. There are two alleles of gene, at least in this case. Alleles, therefore, can be defined as genes that are members of the same gene pair, each allele affecting a particular character differently than the other. But, by definition, only one of the alternative forms of the gene can be present on each of the homologous chromosomes though it does not imply that only two alternative forms of a gene can exist.

Multiple alleles

When several mutations occur in the same gene, various alternative forms of a gene could result which are called multiple alleles. A discovery of great importance for the theory of gene was made by a Frenchman L. Cu'enot in 1904 while working on different strains of albino mice. He could show that it is not necessary to have only two alternative forms of a gene. There can be more. Returning to the locus on chromosome II of *Drosophila* concerned with wing size and shape, we know that there are two alleles, namely, vg$^+$ and vg. Another mutation, the third one, has been reported at the locus which also influences wing shape. The mutation is called "antlered", or "an" because wing form resembles antlers. It has been proved conclusively by the test of allelism that vg$^+$, vg and an are the alternative forms of the same gene—they are multiple alleles.

Two mutant genes are defined as alleles if (1) they produce a mutant (and not the normal or wild) phenotype when crossed, and (2) they do not occur together in the

Complementation test

Two alleles (or mutations) are said to be in *cis* arrangement if they are located on the same homologous chromosome, i.e., $++/m_1m_2$, and in *trans* arrangement if one such is located opposite on homologous chromosome, i.e., $+m_1/m_2+$. These arrangements have helped decide whether two alleles (or mutations) are functionally related or not and to establish the limits of the genetically active region. For this, *cis* and *trans* configurations are compared together in which the alleles are present. Two recessive mutations (say m_1, m_2) are assigned to the same gene if their *trans* configuration show a mutant phenotype (because of noncomplementation), and to the different genes if they produce the normal phenotype or wild type (because of complementation). Complementation suggests that different products are affected by different alleles while noncomplementation would indicate that different alleles effect the same product. This is known either as cistrans test, the test of allelism or the complementation test.

Seymour Benzer of the California Institute of Technology, California, used the complementation test effectively for the most refined dissection of single genetic region in bacteriophage T4 for of the rII locus where 'r' stands for the rapid lysis (rapid bursting of the bacterial cell *E. coli* due to bacteriophage multiplication inside). He found that mutations at the rII locus show host range specificity; they cannot grow on *E. coli* strain K lysogenic for the λ (lambda) phage. (Lysogenic bacterium harbors and maintains a non-infective viral or phage chromosome called a *prophage* and hence do not burst.) That is, although rII mutants could infect the K strain bacteria, they could not destroy it. Only when K strain was simultaneously infected by different rII mutant that complemented (or helped) each other in trans position could it cause bacteria to burst (lysis) and viral growth proceed. Through this complementation test, Benzer discovered that all rII mutants fell into two complementary groups A and B which were functionally different from each other. That is, A can do what B cannot, and B can do what A cannot; and combination of mutants of A and B give functionally normal or wild type strain. Benzer called each of these functional groups a cistron, a term derived from 'cis-trans' test. He proved this, and further showed on the basis of recombination test and various techniques that each cistron has a number of mutational sites (the mutons) which are genetically separable. The distance between the mutons which separate them genetically was named 'recon' by him. "The present view is that the smallest recombinational unit (the recon) is probably a single nucleotide, which, in turn, is probably the smallest mutational unit (the muton). These units taken individually are not, of course, genes" (Strickberger, 1976). But the cistron, defined by complementation or noncomplementation, has come to be regarded as synonymous with the gene.

S.S.A,

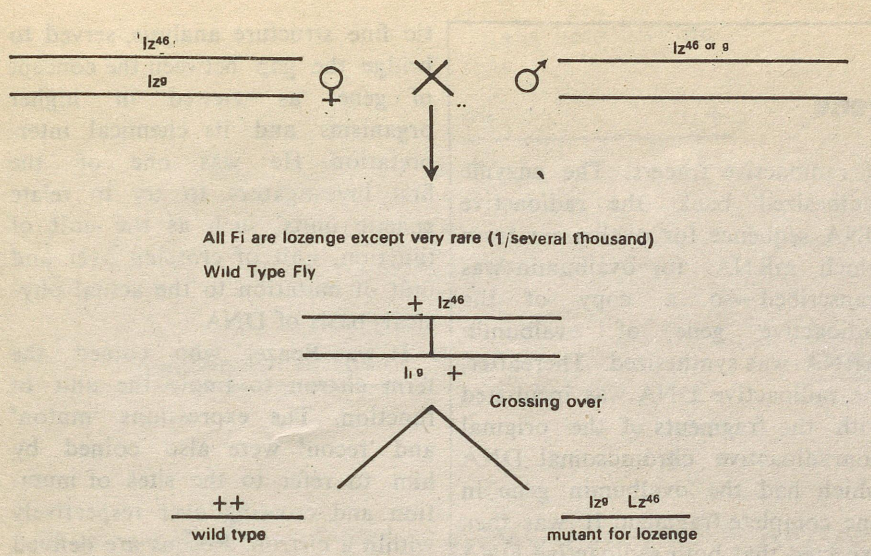


Fig. 2. Green's analysis of "pseudoalleles" or "false" alleles. These alleles are separated by a small physical distance.

same gamete. The definition of allele does not imply that there can only be two alternative forms of gene. Many examples of loci with three or more alternative forms of a gene are now known in a large number of species.

It was once believed that different genes or beads, each with a definite phenotypic effect, could separate from each other by crossing over, while different alleles of a gene could not cross over or recombine with each other. Initially the concept of a gene as a single unit that functions as a unit, changes (or mutates) as a unit, and recombines as a unit, was developed. This view, as we shall see, was an over simplification.

Recombination between alleles

Russian geneticist N.P. Dubinin in 1939 recognized that different alleles of a gene produced a graded effect on the phenotype, and named it 'step allelism'. This discovery foreshadowed the idea that gene could be subdivided. Early in the history of modern genetics, Alfred Henry Strutevant and Thomas Hunt Morgan of Columbia University, USA, demonstrated that the Bar locus in *Drosophila melanogaster* contained more than one functional and recombinational "bead".

A famous example by C.P. Oliver (1940), which was later confirmed by his student M. M. Green, is of intragenic crossing over in *Drosophila* concerning a locus known as 'lozenge' (lz) which affects the shape of the eye. Various mutants, i.e., lz^{BS}, lz^{46}, lz^{9}, at this locus were characterised and a few of them change the eye in slightly different way. Green mated *Drosophila* females that were heterozygous for two different lozenge alleles to lozenge males. The progeny were, as expected, mostly lozenge except for rare unusual wild type fly (Fig. 2). The occurrence of lozenge mutants in the progeny was in accordance with the test of allelism but the occurrence of occasional wild type progeny was not. Green therefore concluded that the two lozenge alleles might not be the true alleles of each other as they did not occupy the exact position on the two homologous chromosomes. He suggested that they were separable by a small distance. As a result of this separation, a cross over could occur between them and consequently both alleles could occur in the same gamete. It was not complete according to the test of allelism (as stated before). A redefinition of allelism was therefore put forward. The lozenge mutants were defined as "pseudoalleles" or "false" alleles. Pseudoalleles were defined as genes that behave as alleles in allelism test but can be separated by crossing over. Such alleles were considered to occupy a complex locus which can be divided into sub-loci between which recombination can occur. Pseudoallelism stimulated extensive research into the functional interaction of alleles.

In some cases crossing over between two alleles could not be demonstrated. This does not necessarily mean that crossing over cannot occur between them. It only means that we have as yet failed to detect it because the distance between two alleles is too short to allow recombination—lesser the distance between two alleles, remote is the possibility of crossing over or recombination.

Geneticists of the early 1950's could not appreciate this idea. For them, crossing over within the gene was a great surprise as they could not accept that the classical gene is divisibleand that it is composed of parts separable by crossing over. But further research on microorganisms confirmed such crossing over. The new concept of the gene then became acceptable. It fits in the knowledge that a gene is a stretch of DNA made up of polynucleotides. With this came the decline of the bead theory.

The genetic fine structure

Primarily as a result of the analysis of pseudoallelic series, the gene emerged conceptually as a unit of function or cistron. The cistron has been defined by a genetic test (the cis-trans test) designed to show the functional relatedness of genes. The test was first developed

Split gene

AND now after believing the unbelievable overlapping and jumping genes, the molecular biologists are out again to give us something unbelievable—the split genes. Our very concept of a gene is now again in trouble after the discovery that the DNA sequence needed for synthesis of a particular polypeptide (or protein) is not present at one place continuously as understood till recently but in fact lie scattered in pieces in the chromosome. In other words, "bits of protein coding DNA are separated by sequences that do not code for the protein".

One of the first reports of this shocking discovery is that of R. Breathnack, J.L. Mandel and P. Chambon of the CNRS Laboratory for Eukaryotic Molecular Genetics at Strasbourg, France. In a bid to isolate chicken gene (*S.R.*, Aug. 1976) which codes for ovalbumin (one of the several main proteins in egg white), these scientists took out the easily extractable messenger RNA (mRNA) which carries information for the structure of ovalbumin. The mRNA was then subjected to the action of an enzyme, the reverse transcriptase, in presence of radioactive tracers. The enzyme synthesized back the radioactive DNA sequence for ovalbumin from which mRNA for ovalbumin was transcribed—so a copy of the radioactive gene of ovalbumin mRNA was synthesized. Thereafter, the radioactive DNA was incubated with the fragments of the original nonradioactive chromosomal DNA which had the ovalbumin gene in one complete fragment. It was then expected that both radioactive DNA and the complete non-radioactive DNA fragment of the ovalbumin gene would recognize each other and would hybridize together. But the team was "shocked" to find radioactive DNA hybridizing with three quite different pieces of chromosomal DNA instead of hybridizing with the complete gene of ovalbumin. As they knew that their enzymes could not have cut the ovalbumin gene, "they were forced to the conclusion that the gene is split into three on the chromosome" (*New Scientist*, Vol. 76, 1977 pp. 567). So the "genes in mammals lie broken into pieces—and so do some of the basic assumptions of molecular biology" (*New Scientist*, Vol. 77, 1978) !

for higher organisms and subsequently applied to phages by Seymour Benzer of California Institute of Technology, USA, in 1950's. He revolutionised the picture of gene as an indivisible unit of function, mutation and recombination. His high resolution analysis of intragenic recombination down to the level of nucleotides, called genetic fine structure analysis, served to bridge the gap between the concept of gene as viewed in higher organisms and its chemical interpretation. He was one of the first investigators to try to relate genetic units, such as the unit of function, unit of crossing over and unit of mutation to the actual physical basis of DNA.

It was Benzer who coined the term cistron to imply the unit of function. The expressions 'muton' and 'recon' were also coined by him to refer to the sites of mutation and crossing over respectively within a cistron. Recons are defined as regions within a gene between which recombination can occur whereas mutons are the smallest elements within a cistron that, if altered, can give rise to a mutant phenotype. It is important to note that each term—recon, muton and cistron—has an operational definition, that is, recombination, mutation and function, respectively. This is the modern gene concept. However, the terms muton and recon are now less frequently used because they are known to represent the same thing in physical terms. According to Monroe W. Strickberger (1976) of University of Missouri, St. Louis, USA, "The present view is that the smallest recombinational unit (the recon) is probably a single nucleotide, which, in turn, is probably the smallest mutational unit (the muton)". Even cistron is also not popularly used and the term gene is preferred.

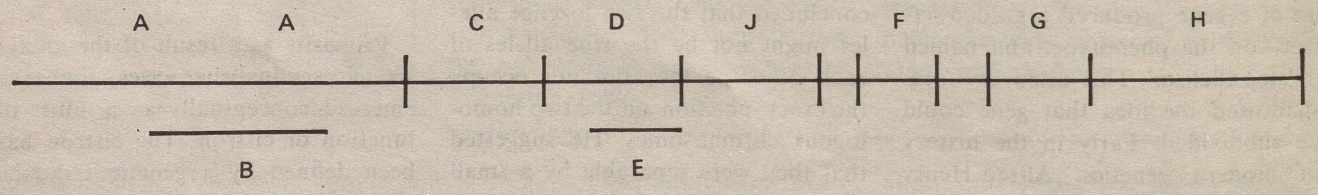


Fig. 3. Gene B is "contained" in gene A and gene E in gene D. Gene E is coincident with last 60% of gene D

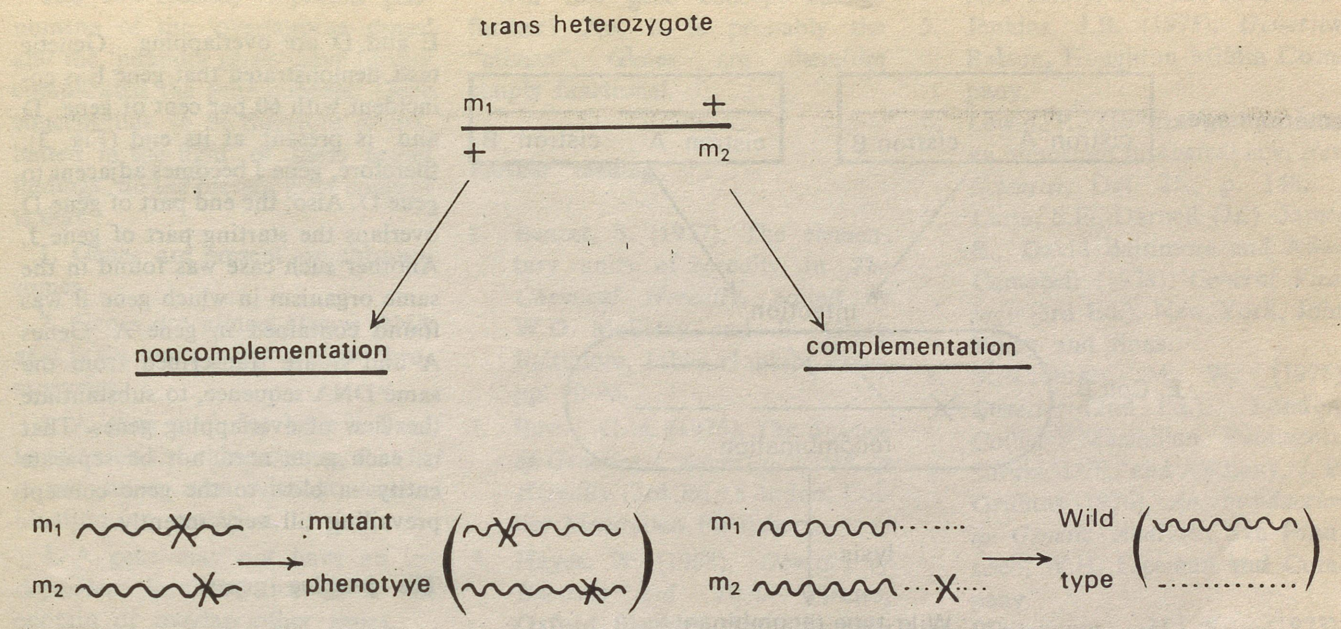


Fig. 4. Interpretation of complementation and noncomplementation in the phenotype of a trans heterozygote. Noncomplementation signifies that both mutant alleles affect the same gene product (wavy line). Complemenation signifies that one of the genes affects a different product (dottend line)

The 'One gene-one polypeptide' hypothesis

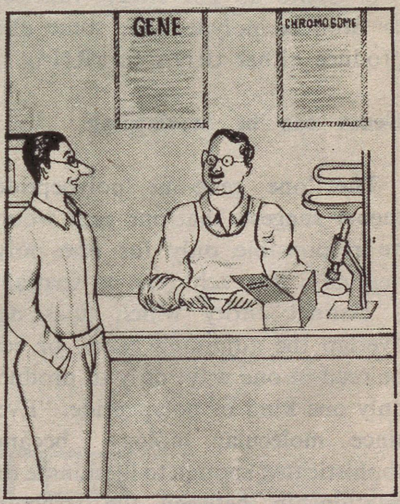
The question that bothered scientists since the discovery of genes was how they produced their products which, in turn, determine specific phenotypes. The first link between a gene and a gene-product was established in 1909 when Archibald F. Garrod, an English physician, suggested that gene-products were proteins. His hypothesis was ignored until 1940's, when it was conclusively demonstrated by George Wells Beadle and Edward Lawrie Tatum of California Institute of Technology, that genes direct synthesis of proteins that act as enzymes. It was known as the "one gene-one enzyme" hypothesis. It meant that each gene controls the reproduction, function and specificity of a particular enzyme. This hypothesis was later on modified to "one gene-one protein" hypothesis when it became clear that some genes control formation of proteins which are not enzymes. Proteins are composed of one or more polypeptide chains and each gene actually controls formation of one polypeptide. Therefore, the "one gene-one protein "theory was rephrased as "one geneone polypeptide". This statement is basically sound because for every kind of polypeptide there is a specific gene or cistron. A gene can therefore be defined as a segment of DNA which is responsible for the production of a particular polypeptide. In other words, the primary structure of protein (the linear sequence of amino acids in a polypeptide chain) is a direct reflection of the nucleotide sequence or code of its gene. It should however be mentioned here that the "one gene-one polypeptide" idea is not always applicable as there are genes which do not code for proteins. Rather they specify transfer RNA and ribosomal RNA which help in polypeptide synthesis. The gene concept may now be summed up :

1. Genes are present on chromosomes which have their individuality;

2. Genes are almost always DNA because chromosomes are mainly composed of DNA;

3. A gene has an independent location on the chromosome, that is, it does not overlap the adjacent genes;

4. A gene has a fixed location on the chromosome, that is, it does not change its position till it is forced to



"The most remarkable thing is that the genes themselves remain unchanged, only concepts about them change."

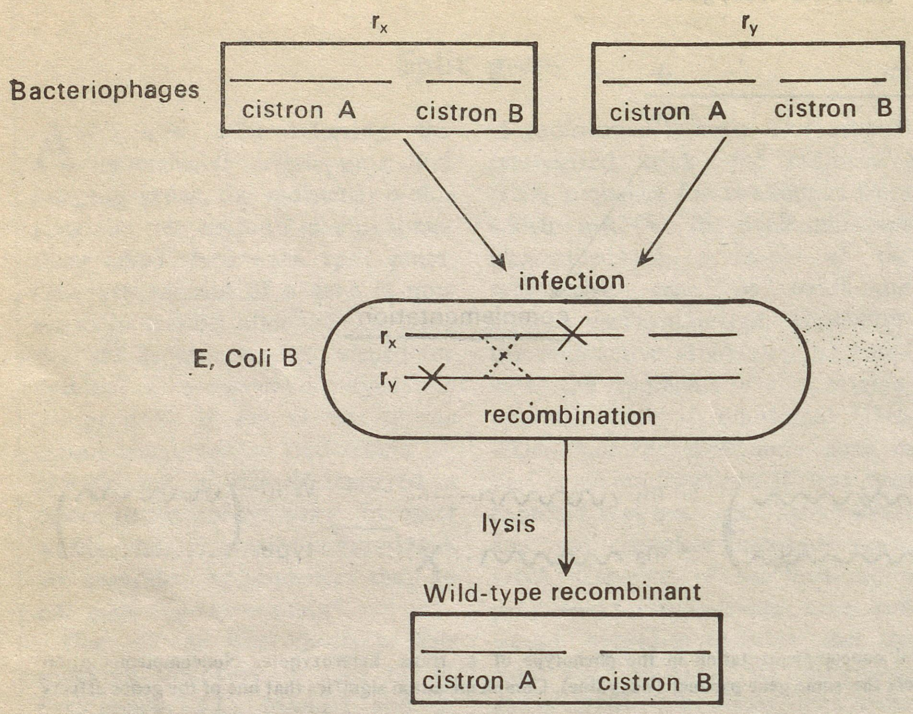


Fig. 5. Technique used by Benzer to detect wild-type recombinants between two rII mutations affecting the same cistron

do so during recombination and mutation;

5. A gene is not only a unit of function (cistron) but also mutation (muton) and recombination (recon), that is, gene has fine structure; and

6. Genes do not always function to produce polypeptide; some also produce either tRNA or rRNA.

Genes can be overlapping

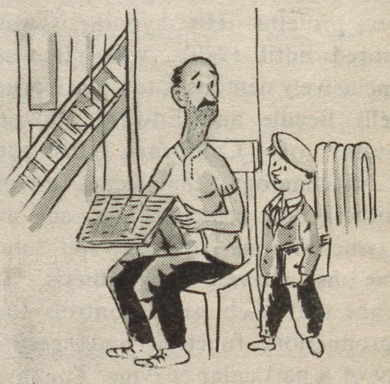
The 'one gene-one polypeptide' theory suggests that one gene would be responsible only for one polypeptide. So each gene is spatially a distinct entity which does not overlap the adjoining genes, or can be read in one way only to produce only one kind of polypeptide. "Ever since molecular biology became sophisticated enough to illuminate the relationship between the structure of genes and the structure of proteins for which they code, there has grown a steadily stronger conviction that the code written into the chemical sequence of a gene may be read in one way only" (Roger Lewin, 1976). This is in accordance with the gene concept outlined above.

But recently, Bart Barell, Gillian Air and Clyde Hutchison III of the MRC Laboratory of Molecular Biology, Cambridge, have made an epoch making discovery that a single gene can be read in two different ways to produce two different and even unrelated proteins (see *S.R.*, Nov. 1977, pp. 716-717.) It has been found in a virus $\phi \times 174$—a small icosahedral phage that infects and multiplies inside the bacterial host *E. coli.* It has a single stranded DNA molecule as its genetic material distributed among nine genes, viz., A-B-C-D-E-J-F-G and H, arranged in that order.

A series of genetic tests indicated that gene E is completely 'contained' within gene D, that is, both genes use the same DNA sequence for protein synthesis but using different coding frames. In other words, genes E and D are overlapping. Genetic tests demonstrated that gene E is coincident with 60 per cent of gene D and is present at its end (Fig. 3), therefore, gene J becomes adjacent to gene D. Also, the end part of gene D overlaps the starting part of gene J. Another such case was found in the same organism in which gene B was found contained in gene A. Genes A and B are transcribed from the same DNA sequence, to substantiate the view of overlapping genes. That is, each gene need not be separate entity—a blow to the gene concept prevailing till very recently.

The jumping genes

For long, a gene has been considered a stable structure which does not change its position on the chromosome. Genes can however change their positions either through mutations or recombination. But recently, enough evidence has accumulated to challenge this view also. It has been demonstrated in bacteria and also in higher organisms, like *Drosophila*, that genes and segments of DNA do move between and on chromosomes with frequencies as great as 10^{-2}. These moving genes have been called 'jumping genes' (*S.R.*, March 1977, p. 165).



"My poor grade in genetics ? The teacher told me that, to understand the concept of genes, I should first have the gene to conceive it."

The two recently reported phenomena of the 'overlapping genes' and the 'jumping genes' have further complicated the gene concept. Gene concept has to be therefore re-evaluated in the light of these recent findings. So the present gene concept is that :

1. Genes are present on chromosomes.

2. Genes are almost always DNA as it is the main component of chromosomes.

3. A gene may not have a fixed location on the chromosome, that is, it can move even without recombination or mutation.

4. A gene may not have an independent location, that is, it can contain or overlap other genes.

5. Gene has fine structure.

6. Genes do not always function to produce polypeptide.

Will this gene concept change further? No, it is probably the "climax". Genes are therefore simply functional.

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Indian Muntjac

A deer of research importance

The discovery that the chromosomes of Indian muntjac are exceedingly low in number and large in size has offered an excellent opportunity to investigate several unresolved questions of chromosome biology in mammals

B. C. DAS

AN interesting deer which is generally known as Indian muntjac or barking deer is of immense importance in modern cytogenetic research because of its extremely few and exceptionally large-sized chromosomes—six in females and seven in males. This is the lowest diploid number known for any vertebrate so far.

Chromosomes are the repository of genes, the carriers of hereditary characters. The diploid number and the morphology of chromosomes remain unaltered for each species but they differ from species to species. In mammals, the chromosome number is known to vary from as low as 10 in female and 11 in male of the marsupial, a black-tailed wallaby, *Wallabia bicolor*, to as high as 92 in the fish-eating rat, *Anotomys leander*. In 1970, D. H. Wurster and K. Benirschke of School of Medicine, University of California, U.S.A., discovered that the Indian muntjac, *Muntiacus muntjak*, has an unusually low diploid number. In the female there are 6 and in the male 7 chromosomes. Later in 1972, this finding was confirmed by T. Sharma of Department of Zoology, Banaras Hindu University, Varanasi and M. Sasaki and S. Makino of Hokkaido University, Japan, after extensive study of meiotic divisions in the testicular cells of muntjac. They also showed that there is a translocation between an acrocentric autosome and the X-chromosome, and established conclusively the presence of multiple sex-chromosome $XY_1 Y_2$ system instead of usual XY system in the males of this Indian deer. It is rather surprising to note that its nearest relative, the Reeve's muntjac *Muntiacus reevesi* (common deer), has as many as 46 chromosomes. The other species of this cervid family to which the muntjacs belong have diploid number ranging from 50 to 70 but the significance lies in that the amount of DNA (Deoxyribonucleic acid) of

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the nucleus of any mammal remains roughly the same, regardless of the number of chromosomes present.

Story of the deer

The Indian muntjacs belong to the primitive sub-family Muntiacinae (muntjacs and tufted deer) of the deer family Cervidae and are distributed solely in Asian forests. In India, they are available mostly in hillforests.

The Indian muntjacs are usually brownish in colour with whitish appearance under the short tail. It sometimes barks like a dog when frightened and so is named as barking deer. The males have sharp canine tusks and are said to have a biting habit. There is a prominent pit below each eye and the male has two prominent pedicles which carry two bifid white antlers that grow and are shed annually — a peculiar phenomenon observed in deer families. The muntjacs are among the first cervids to have acquired these antlers. They breed quite well in captivity. T. Sharma of the Cytogenetics Laboratory, Department of Zoology, B.H.U. has developed a good breeding colony of muntjac with 6 individuals at present. Of them, three are females—Sindhu (mother), Indu and Bindu (daughters) and three males—Tomy, Romy (fathers) and Homy (son of Indu). The gestation period of the doe is 6 months, and at a time it gives birth to one young which shows spots (in rows) at the back for a fortnight or so. The adult muntjacs are about 80cm-90cm long and 40cm-50cm in height at the shoulder and may weigh from 15 kg to 20 kg. The life span is said to be nearly 12 years.

Behaviour

As far as the social behaviour of muntjac is concerned, much study has not been done so far. However, it is observed that the muntjacs' antlers and tusks are used as fighting weapons in males. The antlers also serve as a visual symbol of social rank. At times of fighting or fear, the hairs become erect and the pit-glands become swollen and the animal grinds the molar teeth producing a repeated clicking sound audible from at least 50 meters. During the fight, the tusk blows are delivered downward and backward and make severe wounds upon an opponent's neck, shoulder and sides. The females normally remain aloof from fighting. Recently, a detailed study of fighting behaviour of muntjac has been reported by C. Barrette (1977), Biology Department, University of Calgary, Canada.

Some interesting observations have also been made regarding the sexual behaviour of muntjacs. The young muntjacs have been observed to become sexually mature at 3-4 months of age and they usually involve

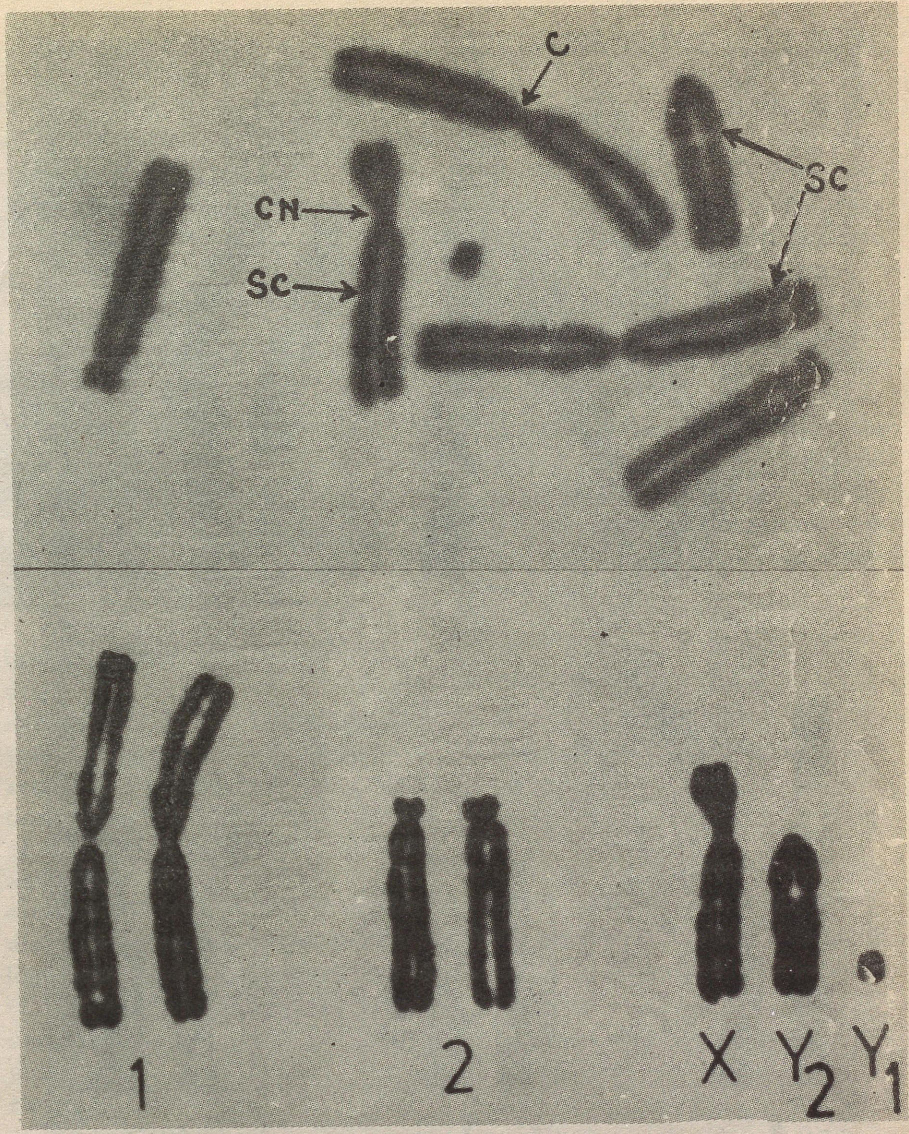


Fig. 3. Chromosomes of male muntjac (2n=7) prepared from white blood cells after culturing them *in vitro* (*above*); C=centromere, SC=secondary constriction and CN=centromeric neck. Photographed chromosomes were cut out and arranged conventionally in pairs in a karyotype (*below*). Each chromosome consists of two arms (chromatids) held together by a centromere. There are two pairs of autosomes and two sex chromosomes (XX) in female and three in male (XY Y)

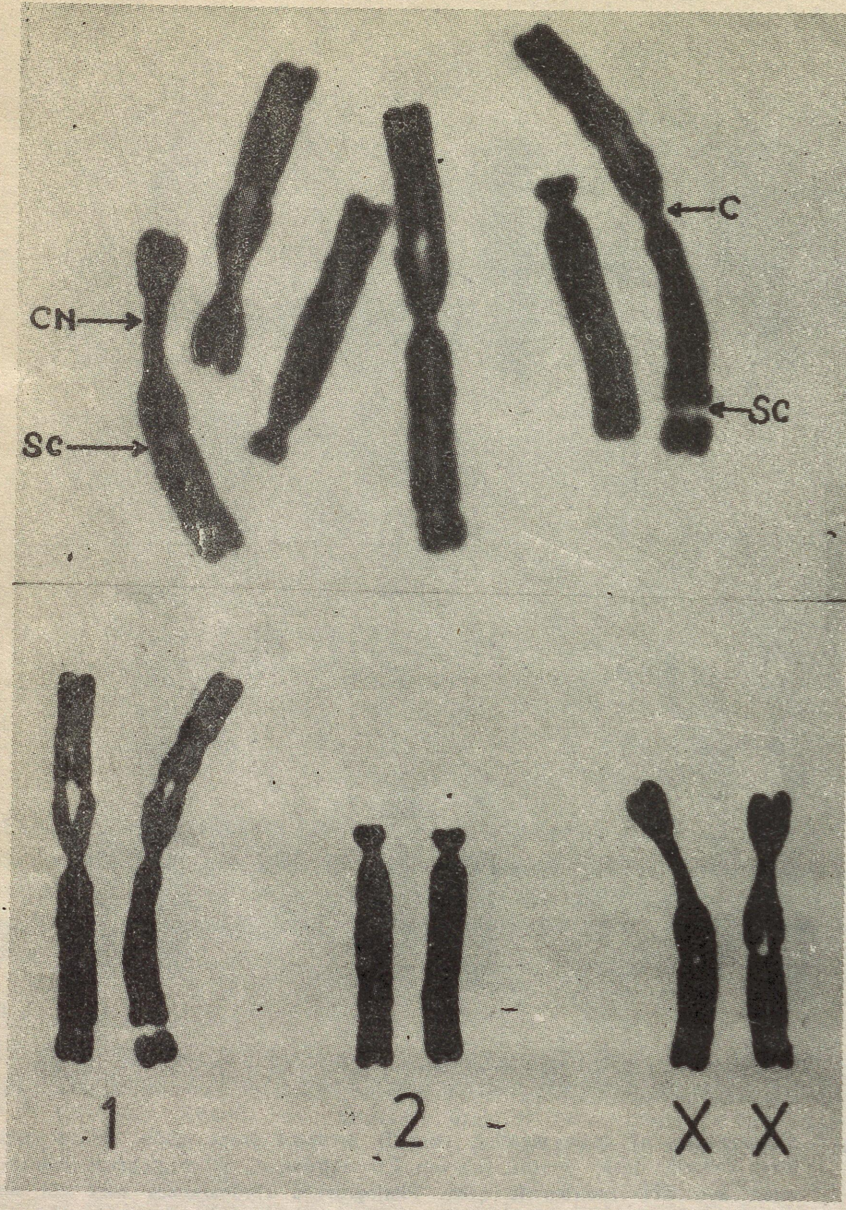


Fig. 4. Chromosomes of female muntjac (2n=6); [legend same as in Fig.3.]

in free mating as seen in other wild animals. Another interesting feature is that a female muntjac may conceive within 20-25 days of her delivery.

Chromosomes of muntjac

The chromosomes of the Indian muntjac are easily and unambiguously identifiable even under low power of light microscope. Of the seven chromosomes in males, four are autosomes—two are large metacentrics (centromere being in the middle), two are medium-sized acrocentrics (centromere being near the tip) with clear short arms. The three are sex-chromosomes which are of different sizes and morphology.

In mammals it is usually observed that the sex-chromosomes constitution is of XX (female)/XY(male) type, i.e., the female has two X-chromosomes whereas the male has one X and one Y as their sex-chromosomes in addition to autosomes. But there are some mammals with unusual sex chromosome constitution and the muntjac is one of them. In muntjac, the male is of XY_1Y_2 and the female is of XX type. This type of uncommon multiple sex-chromosome system has been reported in some other mammals, e.g., black-tailed wallaby (*Wallabia bicolor*), common shrew of Europe (*Sorex araneus*), African gerbil (*Gerbillus gerbillus*) and rat kangaroo (*Potorous tridactylis*), etc.

The X-chromosome is the second largest chromosome in muntjac It is a submetacentric (centromere slightly away from the middle) chromosome and can be divided into two parts, the long arm is the homologue of the odd acrocentric autosome on which the short arm, the actual X, is translocated. Y_2 is the unpaired acrocentric which is the homologue of autosomal portion of the compound X. Y_1 is the smallest submetacentric but usually appears as a single dot. In some females the two X-chromosomes are distinguishable from each other by virtue of the variations in the length of the centromeric 'neck'. Besides these, there are some more characteristic morphological features :

(i) a clear secondary constriction in one of the arms of the large metacentric pair;

(ii) a secondary constriction in the proximal part of the Y_2 and also at the same position of its homologue to which the original X is attached;

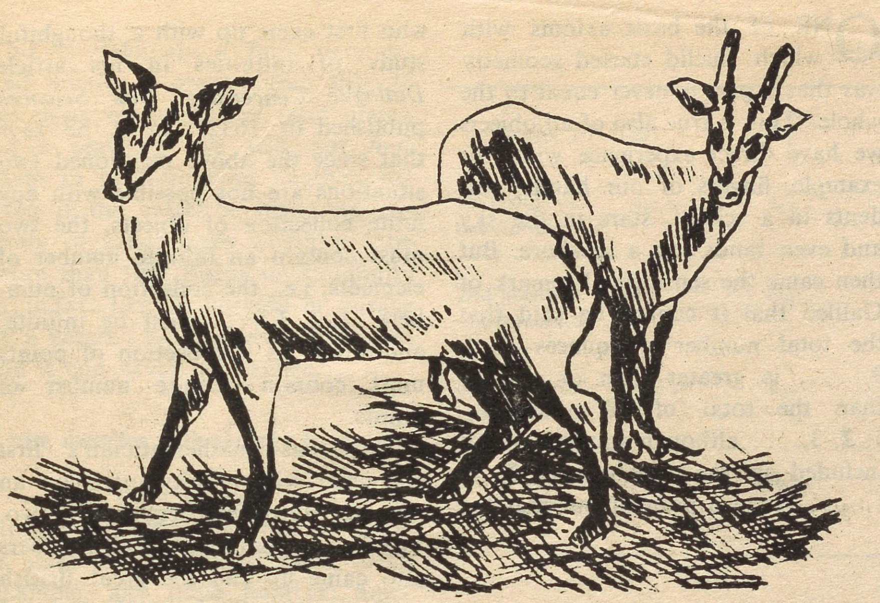
(iii) a narrow elongated centromeric 'neck' of X-chromosome; and

(iv) different sizes of chromosomes.

Furthermore, with the help of modern G, C and fluorescence banding technique a detailed characterisation of different parts of the chromosomes has also been made.

Importance in research

The discovery of the exceedingly low number and large-size of chromosomes in Indian muntjac offers a



unique opportunity to examine and investigate many previously unresolved questions of chromosome biology in mammals. Although it is impossible to have the facility of polytene system in mammals, the induction of premature condensation of chromosomes (PC chromosomes) in various stages of cell cycle of Indian muntjac will greatly facilitate the study at a much finer level. It would also help in precise detection of site of chromosome damage due to chemical agents or radiations (X-rays, etc.) and to monitor the repair of such damages.

Cell hybridization is an extremely powerful and modern technique with varied applications in the field of biological research. Recently, A.V. Carrano and his group of Lawrence Livermore Laboratory, University of California, U.S.A. (1976), have isolated and characterised each chromosome of the Indian muntjac with the help of modern flow sorting technique. This approach in muntjac will pay a very rich dividend. The other lines of research interest with this animal are the study of X-chromosome inactivation and dosage compensations; extraction, estimation and characterisation of DNA, proteins and enzymes; analysis of the kinetics of cell cycle and DNA replication; genetic dissection of chromosome morphology by various banding techniques (C, G, Q, R, N, T, and H bands) and comparative study of chromosome 'anatomy' under light and electron microscopes.

The great advantage in tissue culture work on the few and easily identifiable chromosomes of the Indian muntjac is obvious and many research laboratories of the world have now cell lines which can be maintained for any length of time. Those laboratories do not have any live animal but they have collected its skin biopsies and allowed them to grow at body temperature (37°C) in a standard tissue culture medium with serum and other requirements. The cells grown through this procedure are called fibroblasts which are made available to other workers for scientific investigations. Besides, the peripheral blood may also be cultured for a short duration say, from 32 hours to 72 hours.

It is hoped that more detailed and sophisticated research will be carried out with this excellent material which will add to our knowledge of chromosome. And the increased knowledge of mammalian chromosome will considerably help in understanding many unsolved problems of human chromosomes also.

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Playing with infinity

Infinity is like a mirage in desert. Its presence can be felt but can never be reached

RAKHI DUTTA

ONE of the basic axioms with which Euclid started geometry was that a part is never equal to the whole. This is true also of all objects we have direct experience with, for example, fingers of our hands, students in a school, stars in the sky and even sands on a seashore. But then came the sensational remark of Galileo that it cannot be said that the total number of squares—1, 4, 9, ... is greater than or smaller than the total of all numbers—1, 2, 3,. . . . .although squares are all included in the numbers 1, 2, 3, ... He also pointed out that for a line and a part of it, it cannot be said that the line contains a larger number of points than its part. This goes against our experience for we know that, any two numbers we take, it can always be said that one is greater than the other. Now, where is the flaw?

This problem must have confronted the Greeks but their inability to accept the fact that a part can be as big as the whole forced them to avoid it. The idea of infinity thus eluded Greeks and it was Galileo who first came up with a thoughtful study of infinities in his article *Dialogue Concerning New Sciences* published in 1632. In it he says that since the above mentioned two situations are not possible with any finite collection of objects, the two must contain an infinite number of elements, i.e., the collection of numbers 1, 2, 3, ... must be infinite, and a line as a collection of points must contain infinite number of points.

This was mathematician's first encounter with infinity and soon an intimacy developed between the two. The idea of infinitely small numbers also came up and the great British mathematician Sir Isaac Newton and the German mathematician G. W. Leibnitz invented calculus—the analysis of infinitely small numbers. In this article a few properties of the infinity (∞) are discussed.

The first problem is of visualising or of finding out how large infinity is. This is not an easy task as we are afraid of large numbers, or find it difficult to visualize their size. As the American mathematician P. J. Davis explains in his book *Lore of Large Numbers*, there is a good reason for this. We know small numbers fairly well because we deal with them frequently. In our day-to-day life, we rarely encounter and deal with groups of thousands of things. Higher numbers are even rarer and our feelings for them are correspondingly vague. If large numbers intrude, we frequently avoid them by a larger unit which has the effect of producing once again small numbers. For example, an astronomer deals with a small number of light years, not with an enormous number of kilometers. With infinity the problem is all the more acute because it is larger than any large number. For instance, if we consider the number of stars in the galaxy, there are not more than 30 billion.

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This is definitely a finite number, and infinity is greater than this. If we think of number of sand grains on a seashore, we will not find them to be infinite in number, for even if the earth be made up entirely of sand there would not be more than 10^{32} grains in it. Infinity is, in fact, like the horizon or mirage in a desert. Its presence can be felt but it can never be reached.

Little monster with strange properties

∞ is a little monster with some strange properties and that is why it is dear to mathematicians. For example, any finite number, howsoever large, when added to, or subtracted from ∞, fails to make any difference. We illustrate this with the help of the following example which the famous German mathematician David Hilbert frequently used during his lectures: There are two hotels in a city—one with a finite number of rooms, and the second with an infinite number of rooms. Once, a batch of, say, 50 tourists went to the manager of the first hotel and asked for accommodation. All the rooms were occupied and so the manager had to say sorry. The batch then approached the manager of the second hotel. He too had the same problem. All the rooms were occupied. Even then he managed to accommodate each and every person. What he did was simply to request the person occupying the first room to shift over to room number 51, person occupying the second room to shift over to room number 52, and so on. In fact, this manager could face the situation comfortably even if groups of hundred, thousand, ten thousand or any number approached him. The same would be the case if some of his rooms were undergoing repairs. Thus for any finite number n we have

$$\infty + n = \infty \text{ and } \infty - n = \infty$$

This, in fact, was predictable.

Table I

Guests :	a_{11},	a_{12},	a_{13},	a_{14},	....
1st group of newcomers :	a_{21},	a_{22},	a_{23},	a_{24},	....
2nd group of newcomers :	a_{31},	a_{32},	a_{33},	a_{34},	....
3rd group of newcomers :	a_{41},	a_{42},	a_{43},	a_{44},	....
4th group of newcomers :	a_{51},	a_{52},	a_{53},	a_{54},	....

Even in our daily life, a small quantity of something added to a fairly large quantity of the same thing fails to make a noticeable change. But when it comes to the addition or subtraction of ∞, to or from ∞, the results are strange. Suppose in the above example, the manager has to deal with a group of infinite number of persons; he will then have to do only a mental exercise. He may make a list of persons or guests already occupying rooms in his hotel and that of the newcomers as follows. He may proceed as indicated in the next paragraph.

Guests :	g_1,	g_2,	g_3,	...
Newcomers :	n_1,	n_2,	n_3,	...

He need not disturb guests g_1 and g_2, but may request guests g_3 and g_4 to vacate the rooms so as to accommodate newcomers n_1 and n_2. Guests g_3 and g_4 can go over to rooms numbered 7 and 8, and so on. The final arrangement of the guests and the newcomers therefore may be as follows :

Room numbers :	1	2	3	4	5	6	7	8	...
	↓	↓	↓	↓	↓	↓	↓	↓	
Guests and newcomers :	g_1	g_2	n_1	n_2	g_3	g_4	n_3	n_4	...

In this manner all the infinite number of newcomers may be accommodated and so $\infty + \infty = \infty$.

Subtraction of ∞ from ∞ gives a more interesting result. In fact, $\infty - \infty$ is indeterminate. For example, if in the above mentioned hotel, all the rooms numbered 2, 4, 6, ...are under repair, the clever manager would instantly arrive at the following solution:

Guests :	1,	2,	3,	4,	...
	↓	↓	↓	↓	
Rooms available :	1,	3,	5,	7,	...

But if all the rooms numbered 11, 12, ...are under repair, the manager will be left with only 10 rooms and the poor fellow will be in great difficulty.

Let us now take up the problem of multiplication with ∞. The multiplication of ∞ with a finite number n is same as addition of ∞, n times. For example, let us consider the product of ∞ and 5. We again go back to the same hotel with infinite number of rooms and suppose that 4 groups, each of infinite persons, come to the hotel. So there are, in all, 5 groups of infinite number of persons—one group of guests already having rooms in the hotel and 4 groups of newcomers. The manager thinks hard how to accommodate all of them. One of the solutions he may find is the following.

He first makes lists of the 5 groups

of the guests and the newcomers as indicated in Table 1.

He can then make a consolidated list of guests and newcomers in the following way :

a_{11}, a_{21}, a_{12}, a_{31}, a_{22}, a_{13}, a_{41}, a_{32} a_{23}, a_{14} ...

And now the room numbers can be allotted according to the place occupied in the above list. It must be noted that, to make the consolidated list, the manager is proceeding diagonally through the lists of guests and the newcomers (Fig. 1).

So the product of ∞ and 5 is also ∞. In general, the product of ∞ with any finite number is infinity.

Let us now consider the product of ∞ and ∞. This is in a way the addition of ∞ infinite number of times. We suppose that an infinite number of groups, each of infinite number of persons, come to the hotel. This time the manager has a tough time but he is not so easily defeated. He solved the problem of allotment of rooms as shown in Fig. 2.

We have $\infty \times n = \infty$ for any finite number n, and $\infty \times \infty = \infty$.

Now let us see the behaviour of ∞ with respect to the operation of division. By division of a number n by a number m, $(m \neq 0)$ is meant that n is divided into m equal parts and we are taking one of these parts. To see what happens when a number n is divided by ∞, let us examine the following sequences of fractions :

$$\frac{1}{1} = 1, \quad \frac{1}{10} = 0.1, \quad \frac{1}{100} = 0.01,$$

$$\frac{1}{1000} = 0.001, \quad \frac{1}{10000} = 0.0001, \ldots$$

$$\frac{2}{1} = 2, \frac{2}{10} = 0.2, \quad \frac{2}{100} = 0.02,$$

$$\frac{2}{1000} = 0.002, \quad \frac{2}{10000} = 0.0002, \ldots$$

Guests :	a_{11}	a_{12}	a_{13}	a_{14}	a_{15}	...
1st batch :	a_{21}	a_{22}	a_{23}	a_{24}	a_{25}	...
2nd batch :	a_{31}	a_{32}	a_{33}	a_{34}	a_{35}	...
3rd batch :	a_{41}	a_{42}	a_{43}	a_{44}	a_{45}	...
4th batch :	a_{51}	a_{52}	a_{53}	a_{54}	a_{55}	...

Fig 1

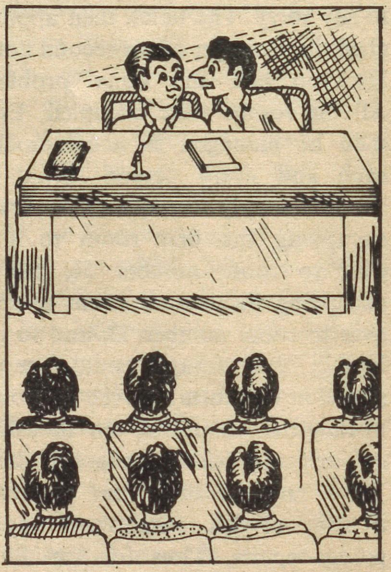
$$\frac{3}{1} = 3, \quad \frac{3}{10} = 0.3, \frac{3}{100} = 0.03,$$

$$\frac{3}{1000} = 0.003, \frac{3}{10000} = 0.0003 \ldots$$

What we observe is that, as the denominator increases, the value of fraction decreases, and it goes nearer, and nearer to zero. It will be true for any finite number n. Because of this property, we say that for any finite number n, $n/\infty = 0$.

Now we come to the division of ∞ by ∞. For this, let us suppose that we have got infinite number of mangoes and infinite number of bags. We want to put equal numbers of mangoes in each bag. We label mangoes and bags as first, second. third, and so on. In the first bag we put the first mango, in the second bag the second mango, in the third bag the third mango, and so on. So we have got an infinite number of equal parts of the infinite number of mangoes and each part contains 1 mango, i.e., $\infty/\infty = 1$. We could have divided the mangoes into an infinite number of equal parts by putting 2 mangoes in each bag— first and second mango in the first bag, 3rd and 4th mango in the 2nd bag, and so on. In this case ∞/∞ would have been equal to 2. In similar way, we can actually make ∞/∞ equal to any finite number. It can even be made equal to ∞. So ∞/∞ is also indeterminate.

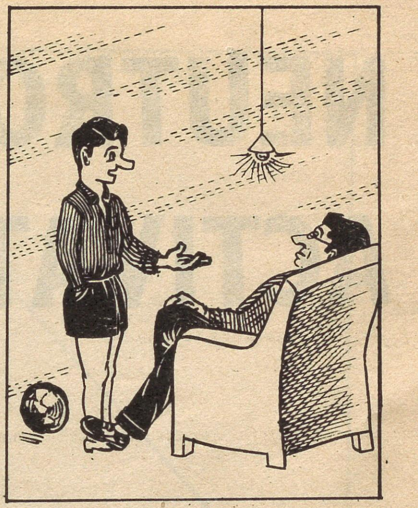
This is how mathematicians perceive ∞. But their imagination does not stop here. They talk of infinities beyond infinity and infinities beyond those. The credit for developing the arithmetic of infinities goes to the



"Sir, only the subject of your topic is infinity, not the time allotted to you."

Guests :	a_{11}	a_{12}	a_{13}	a_{14}	a_{15}	a_{16}	a_{17}	a_{18}	...
1st group of newcomers :	a_{21}	a_{22}	a_{23}	a_{24}	a_{25}	a_{26}	a_{27}	a_{28}	...
2nd „ „ :	a_{31}	a_{32}	a_{33}	a_{34}	a_{35}	a_{36}	a_{37}	a_{38}	...
3rd „ „ :	a_{41}	a_{42}	a_{43}	a_{44}	a_{45}	a_{46}	a_{47}	a_{48}	...
4th „ „ :	a_{51}	a_{52}	a_{53}	a_{54}	a_{55}	a_{56}	a_{57}	a_{58}	...
5th „ „ :	a_{61}	a_{62}	a_{63}	a_{64}	a_{65}	a_{66}	a_{67}	a_{68}	...
6th „ „ :	a_{71}	a_{72}	a_{73}	a_{74}	a_{75}	a_{76}	a_{77}	a_{78}	...
„ „ :	...	...	...	...	...	...	...	...	...
„ „ :	...	...	...	...	...	...	...	...	...

Fig. 2



"I thought you asked me to play infinitely."

German mathematician G. Canton. And now, as Leo Ziphon puts it in his book *Uses of Infinity*, "Mathematician is the greatest collector of infinities—infinitely many arrays of infinities of all kind and all types and magnitude. They are his raw materials and his tools."

The infinity is a very delicate thing and one has to be very careful while handling it. One should always keep in mind that things which look so obvious in a finite case, may not be true with infinity. For example, let us consider the following sum:

$$S = 1-\tfrac{1}{2}+\tfrac{1}{3}-\tfrac{1}{4}+\tfrac{1}{5}-\tfrac{1}{6}+\ldots.$$

A little rearrangement of terms will lead us to absurdity as follows :

$$\begin{aligned} S &= (1-\tfrac{1}{2})-\tfrac{1}{4}+(\tfrac{1}{3}-\tfrac{1}{6})-\tfrac{1}{8}+\ldots. \\ &= \tfrac{1}{2}-\tfrac{1}{4}+\tfrac{1}{6}-\tfrac{1}{8}+\ldots. \\ &= \tfrac{1}{2}(1-\tfrac{1}{2}+\tfrac{1}{3}-\tfrac{1}{4}+\ldots.) \\ &= \tfrac{1}{2}S! \end{aligned}$$

The reason is that rearrangement of terms is not always possible with infinite sums. Similar situations abound in mathematics where a little lapse in reasoning with infinity gives absurd results. And there is no escape from infinity. Logarithms, exponentials, sines, cosines, are all infinite series and we frequently make use of them. Limits and sums of infinite series play a vital role in mathematics and physics and so students must be familiar with ∞ and must be trained to deal with it.

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SCIENCE IN INDUSTRY (*Continued from page 637*)

nea, parts of South East Asia and Sri Lanka. In view of its high protein content (30%-37%), the National Botanic Gardens (NBG), Lucknow, carried out field trials on its introduction in the North Indian plains using seeds procured from Papua, New Guinea. The field trials were a great success.

Sown with the onset of monsoon, at a variety of situations from sandy loam to clay loam, the plant comes up very well, grows luxuriously and shows profuse flowering and fruiting. The bean varies in length from 6 cm to 26 cm and is the main edible part of the plant. It can be cooked as a vegetable like any other bean and can also be used as salad because of its juicy and fleshy nature. Other parts of the plant are also edible and can be used for making a variety of preparations.

NEUTRON ACTIVATION ANALYSIS

N. R. DAS

The technique is used for quick and accurate determination of trace amounts of elements

RAPID advancements in nuclear technology have enabled analytical chemists to use certain nuclear phenomenon in the development of an important technique known as "activation analysis" which is an effective tool for trace analysis. Activation analysis is a method for quantitative determination of tracer concentrations of selected elements regardless of their physical and chemical states in any material. The method, in general, utilises nuclear reactions to produce radioactive indicators from stable isotopes of the elements in a sample. This phase of the method is termed "activation".

Activation analysis was conceived shortly after the discovery of artificial radioactivity in 1933. It was first applied by G. Hevesy and H. Levi in Denmark in 1936 to determine dysprosium content of impure yttrium sample. They used neutrons produced by a 300 mCi (milli Curie) radium-beryllium source to determine 0.1 per cent of the element in yttrium. Later in 1938, G.T. Seaborg and J.J. Livingood in the United States determined for the first time trace concentration of gallium in pure iron by direct activation.

Principles

The technique is mainly based on the fact that a stable isotope, when irradiated by neutron, undergoes a nuclear transformation to produce a radioactive nuclide. From the characteristic radiations it thus emanates, the identity and concentration of the target isotope can easily be ascertained.

Radioisotopes are produced by bombardment of suitable target materials either with neutrons or charged particles. In activation analysis, neutrons are generally preferred to charged particles. This is because neutrons have a high penetration power which allows a homogeneous activation of the entire target material.

When neutrons interact with target nuclii, radioactive nuclides are produced by different nuclear reactions. The types of nuclear reactions generally in use in neutron activation analysis include (n, γ), (n, p,), (n, d), (n, 2n) and (n, α). The choice of nuclear reaction for activation analysis depends on many factors, viz., the type of sample matrix (i.e., the nature and composition of the sample), neutron flux, neutron cross-sections, nuclear and chemical properties of the reaction products etc. Each of these requires separate consideration. Of these nuclear reactions, (n, γ) reactions are by far the most common form of interaction between the neutrons and the atomic nuclii. Unlike other nuclear reactions, the radio-

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nuclides produced by these reactions are always isotopic with the target nuclii, i.e., have the same chemical properties.

Neutron source

The fissioning nuclii of ^{235}U in a nuclear reactor is the major source of high neutron flux. It has energies ranging from below 0.1 to 20 MeV, (1 MeV=10^6 eV; 1 eV=1.60×10^{-12} ergs). Sometimes, ^{233}U or ^{239}Pu are also used as a source of neutrons. Neutrons produced in the cores of most reactors can be broadly classified into three distinct neutron flux components, namely; (1) fast neutron component that has not suffered enough collisions with the moderator atoms. It has energies above 0.1 MeV; (2) neutrons of intermediate energy, which are in the process of slowing down in the moderator. This component is called epithermal or resonance neutrons, and includes neutrons with energies between 0.2 eV to 0.1 MeV; and (3) the thermal neutron component having energies below 0.2 eV. A qualitative neutron flux energy distribution in a nuclear reactor is shown in Fig. 1 in which the general trend of change in different neutron flux components, e.g., fast neutron (C), epithermal neutron (B), and thermal neutron (A) with corresponding energy changes are indicated.

Neutron flux measurement (often termed flux monitoring) is usually made by the activation of metal foils. The elements that are generally used as monitors for the measurement of neutron flux include sodium, aluminium, manganese, cobalt, copper, indium and gold. Of these, indium, cobalt and gold have got large resonance neutron cross-sections compared to their thermal neutron cross-sections and are thus very useful for measurement of resonance neutron flux. For thermal neutrons, cadmium has a very large absorption cross-section. So a monitor when placed in an appropriate cadmium container is shielded from thermal neutrons, but not from resonance or epithermal neutrons. Monitors that become radioactive by fast neutrons are generally used for fast neutron flux measurements. Fast neutrons with high energies are readily available in Van de Graff or Cockcroft-Walton accelerators which are useful for thermal neutron activation. Some moderating materials such as water or paraffin around the target material are used.

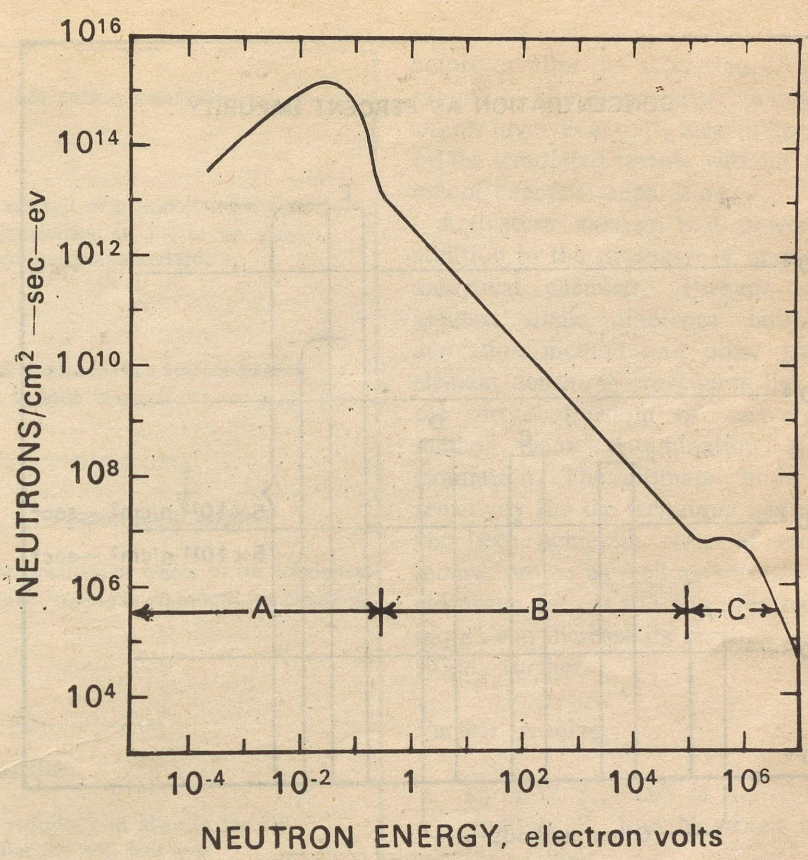

Fig. 1. Qualitative neutron flux distribution in a nuclear reactor

Because of the availability of large thermal neutron flux (10^{15}n. cm^{-2}. sec^{-1}) in reactor and large thermal neutron cross-section (10^{-3} -10^{-5} barns; 1 barn=10^{-24} cm^2) exhibited by most stable nuclides, the thermal neutron reaction (n,γ) is mostly used by the analytical chemists. Moreover, for elements with atomic numbers between 10 to 80, the thermal neutron reaction is usually highly sensitive. In certain cases, selective activation by resonance neutrons can be achieved by suppressing the thermal neutrons. Some filters made of cadmium or boron or of both elements are used for this purpose. This results in an appreciable enhancement of one activity over the other. So for the determination of manganese and sodium in blood plasma or in biological materials, this method of shielding is of great importance. In case of comparatively lighter elements, the cross-sections for fast neutron reaction activation are relatively higher than those of (n, γ) reaction cross-section.

Experimental method

In practice, the neutron activation analysis is accomplished by placing the experimental sample in a neutron beam for some time to produce a measurable amount of radioactivity of interest. The amount of activity

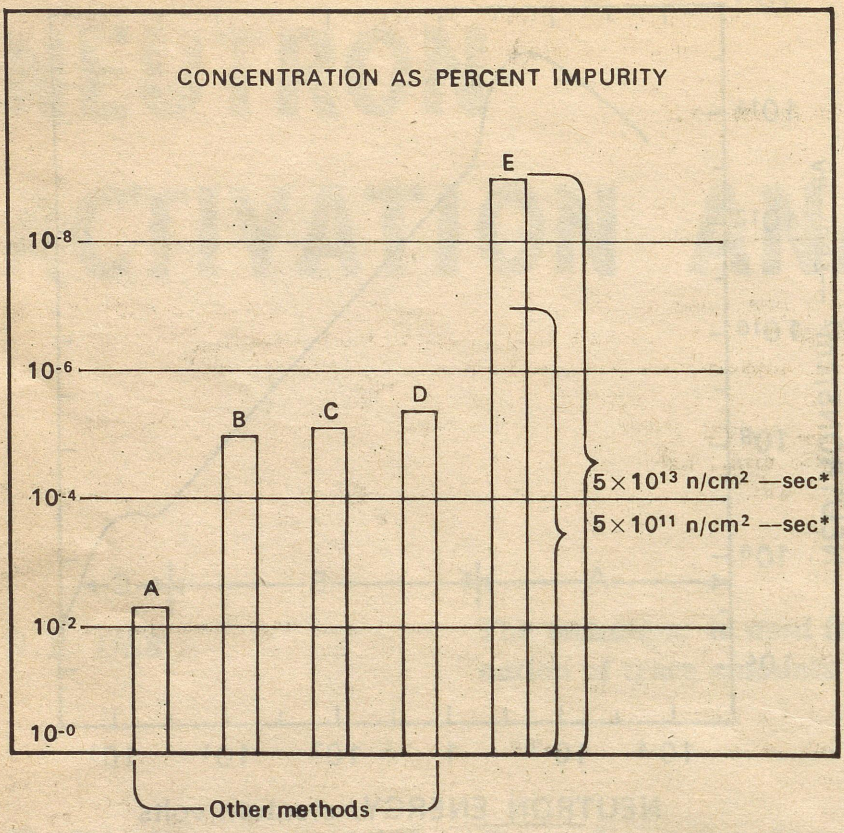

Fig. 2

produced is expressed by the following relation :

$$A_t = N_o\ f\sigma\ (1-e^{-\lambda t}) \quad \ldots(1)$$

where, A =the induced activity of the radioactive nuclide of the element concerned just after activation for time t in seconds,

N_o=number of target nuclides in the sample,

f=the activating neutron flux in particles cm^{-2}. sec^{-1}.,

σ= the activation cross-section in barn,

λ= decay constant of the radioactive product. It is equal to $0.693/T_{1/2}$, where $T_{1/2}$ is the half-life of the radioisotope.

The terms $Nf\sigma$ and $(1-e^{-\lambda t})$ in equation (1) are designated as the "saturation activity" and "saturation factor" respectively. The time (t) of an irradiation must be known in order to calculate the magnitude of induced activity. After a certain time, the rates of activation and its decay become exactly equal and the sample is said to have reached saturation. The saturation activity is the highest activity that can be produced in a sample in given irradiation flux. Again, as the irradiation time (t) becomes large compared to the half-life of the product ($T_{1/2}$), the saturation factor approaches unity. Therefore at saturation time,

$$A_t = N_o f\sigma \quad \ldots(2)$$

The irradiation for one half-life produces about 50% saturation, while about 94% saturation is obtained by irradiation for four half-lives. Irradiation of any sample exceeding a period of five or six half-lives is therefore of no use.

The determination of any element is based on the expression :

$$A_t = \frac{W\,I\,N\sigma}{M}(1-e^{-\lambda t}) \quad \ldots(3)$$

where W is the weight of the element in gm, I the fractional isotopic abundance of the target nuclide, N the Avogadro's number, t the time of activation in seconds and M the atomic weight of the element.

A_t is, calculated from the measured activity, A_t' by the usual decay expression,

$$A_t' = A_t\ e^{-\lambda t'} \quad \ldots(4)$$

where A_t' is the observed activity for the time interval t' between the end of irradiation and the time of measurement. In equation 3 all the factors except W are known and so W, the amount of the element concerned, can easily be computed.

To minimise error, weighed amounts of the sample material along with a comparison standardof similar composition are sealed in quartz or polyethylene tubes of requisite dimensions and then irradiated in suitable neutron flux for a specific time. After activation, both the sample and the standard, if required, are subjected to identical chemical treatment to ensure comparison followed by activity measurements. The computation of concentration of the sample element is based on the relation,

$$\frac{A_{standard}}{W_{standard}} = \frac{A_{sample}}{W_{sample}} \quad \ldots(5)$$

where $W_{standard}$ and $A_{standard}$ are the concentration and activity of the standard sample and W_{sample} and A_{sample} are the concentration and activity of the sample element. The radiochemical purity of the separated isotopes is generally determined by beta-counting or gamma

Table 1. General procedure for activation analysis

Pre-irradiation

Seal unknown amount of element in known amount of material and a pure sample of known weight containing the sought element in quartz or polyethylene vials. The latter acts as the comparison standard.

↓

Irradiation

Irradiate the vials simultaneously under identical conditions in a nuclear particle source of known flux for a definite time

↓

Destructive analysis

Separate the desired radioactivity in both experimental and standard samples through appropriate chemical processing using known amount of some non-isotopic carrier and mount for counting

Non-destructive analysis

Place fractions or whole of the irradiated samples separately on mount for counting

↓

Measurement of radioactivity

Measure the radioactivity in the irradiated samples and identify the elements by their characteristic radiations and half-lives

↓

Computation of concentration

Determine the concentration of the element concerned by comparing the radioactivity of the element in the sample with that of the comparison standard

spectrometry. A flow-sheet for a general procedure for radioactivation analysis is shown in Table 1.

Neutron activation analysis is particularly suitable for speedy, sensitive and accurate determinations of tracer concentrations of a wide variety of elements beyond the limit of detection by other conventional procedures. A comparison of the range of sensitivity of neutron activation analysis with that of some other standard analytical methods such as gravimetric (A), colorimetric (B), spectrographic (C), and mass spectroscopy (D) is shown in Fig. 2. The most important advantage of the technique over other methods is that it can be utilised for multielemental analysis either by destructive or non-destructive way depending upon the nature of the samples. In destructive analysis, a chemical separation is needed either before or after the activation of the sample. Non-destructive analysis simply involves activity measurements on the irradiated sample without the use of chemical separation.

Activation analysis is a powerful addition to the armoury of modern analytical chemists. Perhaps the greatest single difference between activation method and other trace element detection procedures lies in the virtual freedom of activation method from contamination after irradiation. The ultimate limit of sensitivity for the technique has not yet been achieved. Use of more intense source as well as specialised electronic devices and counting techniques can increase its range of sensitivity further.

Further reading

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SCIENCE SPECTRUM

The 1054 supernova was observed in Arabia

SUPERNOVA is the last "struggling" phase of a star when it blows up all its material before dying out. It then becomes thousands of times brighter than its original luminosity. The result is that a star, which has been totally invisible to the naked eye, becomes suddenly visible in the sky. It remains so for a brief period, after which it fades back into oblivion.

In the records of the past, one finds mention of these "guest" stars—supernovae. One of the most famous supernovae is the one observed by the Chinese and Japanese astronomers in 1054 AD. Given in the Chinese astronomical treatise (*Sung-Shih*), this observation came to the notice of the Western world in 1846. That the position of the supernova is close to that of a brilliant crab-like dusty cloud in the sky, called *Crab Nebula*, was noted in 1921. Finally, it was in 1928 that Edwin P. Hubble established, from the expansion rate of clouds, that the Crab Nebula was the remnant of the 1054 supernova as recorded in *Sung-Shih*. Further evidences strengthened this link.

From *Sung-Shih*, it was concluded that when it appeared on 4 July, 1054, the supernova was brighter than Venus. While it remained visible to the naked eye at night for 6 months, it was even visible in daylight for 23 days. Western scientists were puzzled: How did such a bright object go unnoticed in Europe and Arab? Various reasons were offered. Historian George Sarton said: "The failure of medieval Europeans and Arabs to recognise such phenomena was not due to any difficulty in seeing them, but to prejudice and spiritual inertia connected with the groundless belief in celestial perfection". Others suggested that during those six months of the guest star's stay, the entire region of West Asia and Europe was covered with clouds! While the latter argument is ridiculous, George Sarton's reason became untenable when a report of a supernova which occurred some 48 years before the 1054 supernova was found in some European texts.

Today, a new evidence has come to light: an eminent physician of the time Ibn Butlan of Bagdad, had mentioned the 1054 supernova in one of his medical writings. This new evidence was discovered by physicist Kenneth Brecher of Massachussetts Institute of Technology, U.S.A.; and Elinor Lieber and Alfred E. Lieber of Israel (*Nature*, June 27, 1778).

Apart from the evidence itself, the most intriguing feature in the said writings is the mention of catastrophic effects a supernova explosion brings upon the mankind. It very much confirms the calculated hypothesis that the appearance of a supernova wreaks havoc on the earth (See **Supernova can cause catastrophes**, *S.R.*, May 1978)

Ibn Buṭlān was a Christian physician of Bagdad who lived in Cairo for three years. Later, in 1052 or early 1053, when there was a famine at that place, he shifted to Constantinople where he stayed for a year or so. From April 12, 1054 to April 1, 1055 he witnessed the epidemic there. According to him, 14,000 people died. For the next decade or so the epidemic spread to many countries. People fell ill with black-bile ulcers and swelling of the spleen. He even noticed change in the periodicity of fevers.

Ibn Buṭlān called the supernova "athāri" which means a new, star-like phenomenon. He found it in the constellation of *Gemini*. Today the *Crab Nebula* is in the constellation of *Taurus*, which means that the shift in position has come about due to the precession of equinoxes. In the year 1000 A.D., the background of supernova must have been the constellation *Gemini*. Buṭlān's medical writings however do not shed any light on the star, its position, brightness, or time variability which would be of interest to astronomers. What they do show is that medieval medical writings, due to their astrological (and astronomical) association, can provide insights into ancient astronomy.

DILIP M. SALWI

Solid rocket propellants

A rocket is a simple energy conversion device. The chemical energy is transformed into mechanical energy by expansion of gaseous combustion products through a nozzle. The rapidly liberated gases passing through the nozzle produce thrust that moves the rocket. The main application of a rocket is in the launching of missiles and spacecraft, as it produces very high power for its weight. There is yet another advantage in it. It is the only internal combustion engine which can operate in vaccum. As it carries its own oxidiser, air is not needed for combustion.

Mechanism of the rocket movement

Fig. 1 shows how a rocket motor or engine works. Fig. 1 (*Top*) is a chamber with a hole at one end. Gases which are produced during combustion exert pressure equally in all directions. But there is no pressure on the area where there is a hole below the chamber. Due to this pressure imbalance the chamber moves upward. Force F that moves the chamber is equal to

$P_c \times A$, where P_c=Pressure inside the chamber, A=Area of the hole. In practice, thrust is increased by accelerating the gas through the nozzle and expanding it to P_e, the pressure at the nozzle exit plane (Fig. 1 *bottom*). The new equation be-

$$F=A\times \%_c \times C_f$$

comes where C_f is the thrust coefficient whose value depends on P_e,P_c,A and nozzle exit plane area. So a nozzle expansion cone is needed for high performance and is used in almost all rockets.

Types of propellants

There are three types of rocket motors, viz., solid, liquid, and hybrid engines depending on the physical states of propellants. Of the three, solid propellants were used first by the Chinese in the thirteenth century.

The solid propellant motor is the simplest of all because it has few moving parts. The propellant inside the motor is known as grain. The grain is generally packed in a metal or fibre-glas-sreinforced plastic case and burns only on the interior surface known as perforation. The geometry of perforation controls the shape of the pressure-time curve after the motor is ignited. The pressure-time curve can be neutral (level), progressive or regressive. A progressive curve leads to increasing acceleration, while a regressive curve can yield constant acceleration because of weight loss as the propellant burns. Three types of perforation, i.e.' cylindrical, star and cruciform are used.

There are two types of solid propellants, i.e., composite and double base. The composite propellants consist of a solid oxidiser and a metallic fuel additive held together by a polymer matrix. Double base propellants use solid chemicals which contain both the fuel and the oxidiser, e.g., nitrocellulose. A combination of these two types of solid propellants is often used to get increased performance. In all cases, the solid charge is packed in a geometric fashion in a metal casing which serves both as a container and as a reaction vessel (Fig. 2).

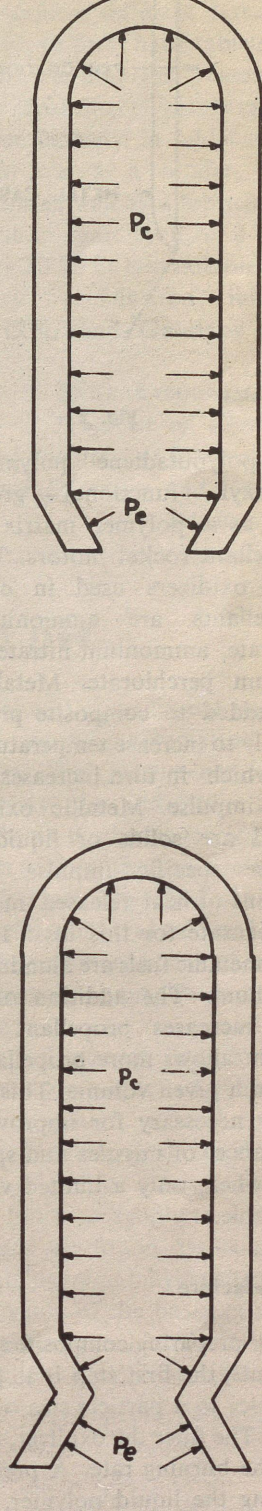

Fig. 1

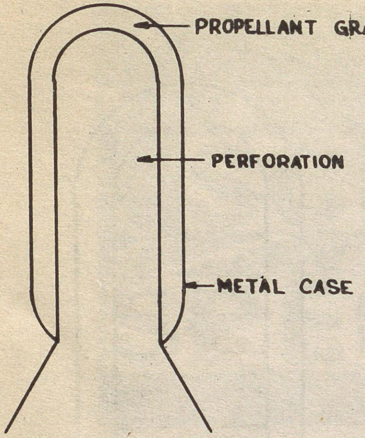

Fig. 2

A polybutadiene polymer with carboxyl functional group is used as a polymer matrix in solid propellant rocket motors. The common oxidizers used in composite propellants are ammonium perchlorate, ammonium nitrate and potassium perchlorate. Metallic fuels are added to composite propellants mainly to increase temperature of the gas which in turn increases the specific impulse. Metallic oxides produced are solids or liquids which reduce specific impulse but the amount of heat released more than compensate for this loss. The common metallic fuels are aluminium and beryllium. The addition of metals also increases propellant density which allows more propellant to be put in a given volume. This is absolutely necessary for improving performance of missiles and space rockets where only a limited volume is available.

Manufacture

For preparing composite solid propellants, the first step is to grind the oxidiser to a particle size of 1 μ to 30μ. The finer the oxidizer, the higher the burning rate. A premix containing the liquid polymer, the metallic fuel and the curing agent is often made. Either this premix is added to the vertical or horizontal mixer containing the oxidizer, or the oxidizer is added slowly to the mixer containing the premix. After blending the ingredients for a sufficient time at 60°C or more, the propellant is poured into the evacuated motor chamber. The vacuum removes entrapped air. A mandrel installed in the motor forms the perforation in the the grain. After heating for several days at a temperature between 45 °C and 60 °C, the propellant becomes a tough viscoelastic solid which is bonded directly to the walls of the moto rcase.

There are two methods of manufacturing double base propellant rocket motors — the casting powder process and the slurry casting process. In the casting powder process, solid ingredients are mixed in a volatile solvent yielding a plastic mass. It is then consolidated in a blocking press, extruded, cut in small pieces and dried. The casting powder is placed in the motor and the casting solvent which includes nitroglycerine or other nitroplasticizer is sucked into the evacuated motor to fill the voids. The motor is then heated to 40 °C to 60 °C which causes the casting solvent to swell the casting powder and form a strong grain.

In the slurry casting process, the plasticizer and solid ingredients including nitrocellulose, ammonium perchlorate and aluminium can be added directly to the mixer. The mixer is stirred until it is homogeneous and then poured into the motor and cured.

Solid propellants have found wide application in rockets, for both military and space applications because of their high reliability, low cost and instant readiness.

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Microcrystalline cellulose

POLYSACCHARIDES are naturally occurring compounds, consisting of many—hundreds or even thousands— monosaccharide units per molecule. They contain C, H and O and can be considered as derived from simple sugars (aldoses and ketoses) by condensation polymerisation. The most common and important polysaccharides distributed in the plant kingdom are cellulose and starch. They are made up of a large number of D(+)–glucose ($C_6H_{12}O_6$) units and have the general formula $(C_6H_{10}O_5)n$. These macromolecules are straight chained or branched, looped or coiled. The nature of arrangement of the sugar units differentiates cellulose from starch. The former is the chief structural material of plants, giving them rigidity and form and the latter makes up the reserve food supply of plants, mostly occurring in seeds. Both cellulose and starch are important to us and economically very valuable. Starch is our primary food for energy. Cellulose is used for its structural properties as wood and cotton and is not biochemically metabolised by humans. But for cotton, man would be almost naked.

Cellulose is the chief component of wood and plant fibres, and cotton is nearly pure cellulose. It is an amorphous, odourless and tasteless substance and is not soluble in water, dilute acids, alkalis and inorganic solvents. It is a non-reducing carbohydrate and is not so easily hydrolysed by acids. Its molecular weight ranges from 250,000 to 1,000,000 or more. There are more than 2000 sugar units per molecule. The sugar units in chains lie side by side in bundles and are twisted together to form rope-like structures in the fibres. In wood, these "ropes" are embedded in lignin to give a structure similar to reinforced concrete.

Cellulose can be converted into derivatives of tremendous industrial importance. Like any alcohol, it forms esters such as cellulose nitrate (gun cotton, pyroxyline) and cellulose acetate (cellophane, rayon) and its alkylated ether derivatives are important in the production of textiles, films and other plastic materials. Methyl cellulose is widely used in pharmacy as an emulsifying agent for liquid paraffin and other mineral as well as vegetable oils. There are different grades of methyl cellulose in the form of powder or granules for use as a suspending or stabilising agent, depending upon the viscosity of solutions.

Microcrystalline cellulose, also known as cellulose gel, has in recent years gained importance in pharmaceutical formulations. It is obtained as a fine, almost white and odourless, crystalline powder consisting of partially depolymerised cellulose and is prepared by hydrolysis of purified wood cellulose to have a molecular weight of about 36,000. Two pharmaceutical grades are commercially available: a colloidal water-dispersible powder, and a non-dispersible powder. Both grades are insoluble in water and are partially soluble in dilute alkalis with swelling. Acids and most organic solvents do not dissolve them. A mixture of microcrystalline cellulose with sodium carboxy methyl cellulose is easily dispersible in water with swelling to give an opaque gel. As a suspending agent, it has attained special importance in recent years along with other naturally occurring gums.

Properties of microcrystalline cellulose and its uses in tablet-making have been investigated in recent years. The results have been encouraging. One of the most common modes of drug administration is in the form of tablets which contain, besides the active drug, ingredients as binding substances to give the tablets proper strength during compression and disintegrating agents for the easy release of the drug in the gastric system. The usefulness of a tablet arises almost wholly from its ability to disintegrate upon contact with liquid and the subsequent release of the drug for absorption in the gastrointestinal tract. Lactose and starch as tablet disintegrants have been known for quite some time, and they have certain disadvantages such as 'browning' and 'capping'. Microcrystalline cellulose has both the abilities to form hard tablets that are not friable and yet possess an unusually short disintegration mtie. It is a unique material in tablet manufacture for use as a binder, filler, disintegrant as well as a lubricant. It is nontoxic to man even in a daily dose upto 30 g. It is available as a proprietary preparation in the U.S.A., U.K. and Germany.

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Sivalik hills and pH

THE low lying Sivalik hills, geologically ranging in age from middle Miocene to middle Pleistocene (approximately fifteen million to seventy-five thousand years B.P.) and occurring along the length of the Himalaya, occupy a significant place in the biostratigraphy of India. They have earlier yielded a few, rare and well preserved primate fossils like *Ramapithecus*, *Dryopithecus*, *Gigantopithecus*, *Procynocephalus*, etc., in addition to thousands of other vertebrate remains. The sedimentary rocks characterizing the Sivalik hills mainly comprise alternately occurring sandy and clayey layers which were deposited partly under fluvial (of streams) and partly lacustrine (of lakes) environment.

In the past few years, parts of the palaeontologically significant Sivaliks have also yielded rich assemblages of microfossils, chiefly consisting of small oval fruits and fragments of calcareous stems of the class Charophyta and isolated teeth and scales of fresh water fishes. These microfloral and microfaunal remains generally occur in association with each other. Their occurrence in the Sivalik beds can indirectly throw useful light on the hydrogen ion concentration (pH) of the basin in which these sediments were laid down after the powerful upheaval of the Himalayas at the commencement of middle Miocene epoch, about fifteen million years ago.

It is a well-known fact that the charophytes grow best in fresh clean waters with a high pH value. Further, experiments have shown that the safe range of pH for fishes is between 5 and 9. Since charophyte and fish assemblages are found associated in the Sivalik layers, it may be suggested that pH value of the basin in which Sivaliks got accu- mulated was above 5 and below 9 at least in parts.

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The versatile clays

THE plants that give us food grow on clayey soils, we eat our food from ceramic dinnerware, the buildings we live in are made of clay bricks which rest on clay containing soils. Part of our energy supply comes from petroleum which often originates in clay-containing sedimentary rocks. Outside the ceramic industry, clays are an essential part of paper, drilling fluids and even certain lubricating greases; they are used in formulations of insecticides, adhesives, ointments, and rubber or synthetic plastics; they act as catalysts or catalyst supports in many processes.

Clays are the inorganic constituents of soil and consist almost entirely of silicates and silica. As found in nature, clays are often light-to-dark grey in colour and are sometimes greenish or bluish owing to organic and inorganic impurities. Certain ion constituents also cause some colouration. In the purified form, most clays are white.

The principal building elements of clay minerals are two-dimensional arrays of silicon-oxygen tetrahedra and two-dimensional arrays of aluminium or magnesium-oxygen-hydroxyl octahedra. These tetrahedra and octahedra sheets are superimposed in different fashions which lead to various kinds of clays. In the silica sheets, the silicon atoms are coordinated with four oxygen atoms, the latter being located at four corners of a regular tetrahedron with silicon atom in the centre (i.e., silicon behaving like carbon). Three of the four oxygen atoms of each tetrahedron are shared by three neighbouring tetrahedra. The fourth oxygen atom of each tetrahedron is so placed that the sheet seems to have a hexagonal symmetry in which rings of six oxygen atoms appear. In Al—, or Mg—O—OH sheets, the Al or Mg atoms are coordinated with six oxygen atoms or OH groups which are located around the Al or Mg atom with their centres at the six corners of a regular octahedron. The analogous symmetry and almost identical dimensions in these two types of sheets allow the sharing of oxygen atoms between them. The fourth oxygen atom, protruding from the tetrahedral sheet, is shared by octahedral sheet. An octahedral sheet in combination with one of two tetrahedral sheets is called a unit layer.

Two types of silica sheet and alumina or magnesia sheet are found in clays. The two-layer clays (e.g., Kaolinites) are built of unit layers consisting of one tetrahedral (silica sheet) and one octahedral (alumina or magnesia) sheet. The three-layer clays (montmorilonites and illites) are built up of unit layers composed of two tetrahedral sheets with one octahedral sheet.

In almost every field of clay study, one has to deal with dispersions of clay in water or in another fluid. Powdered clay seems to dissolve in water, just like common salt, when observed through naked eye. However , it shows some unusual effects which are not displayed by a salt

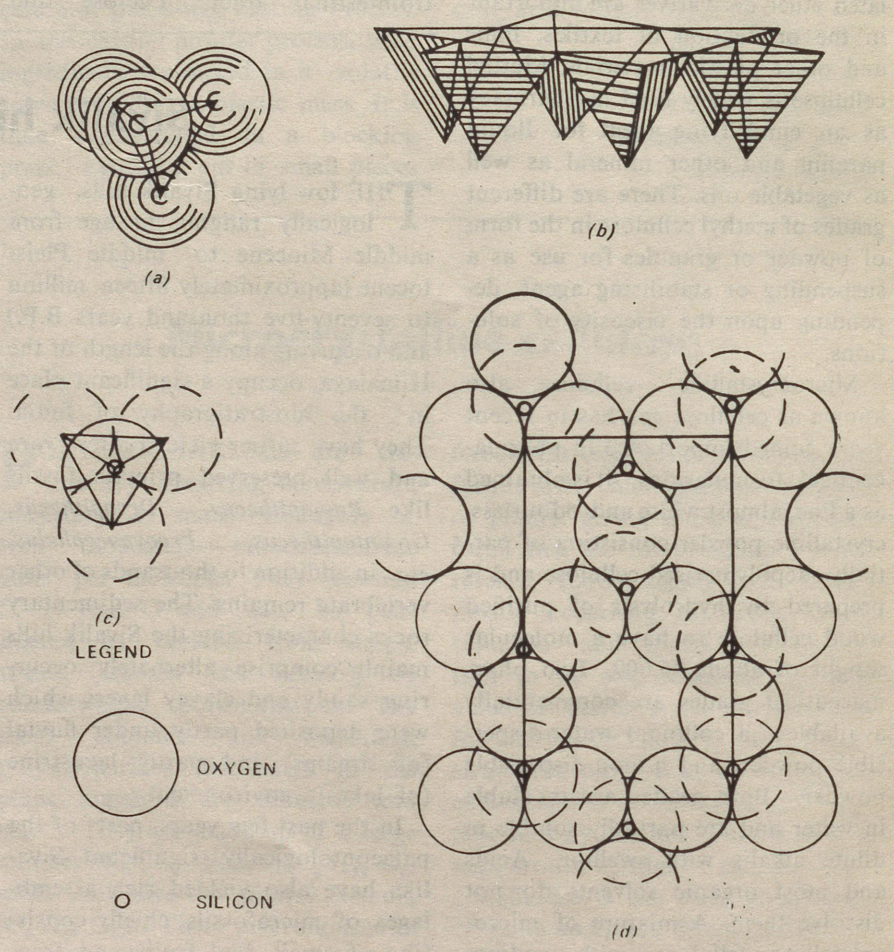

Fig. 1. Structure of the tetrahedral sheet: (a) Tetrahedral arrangement of Si and O; (b) Perspective sketch of tetrahedron linking; (c) Projection of tetrahedron on plane of sheet; (d) Top view of tetrahedral sheet (dotted line : unit-cell area). Large circles represent oxygen; small circles, silicon

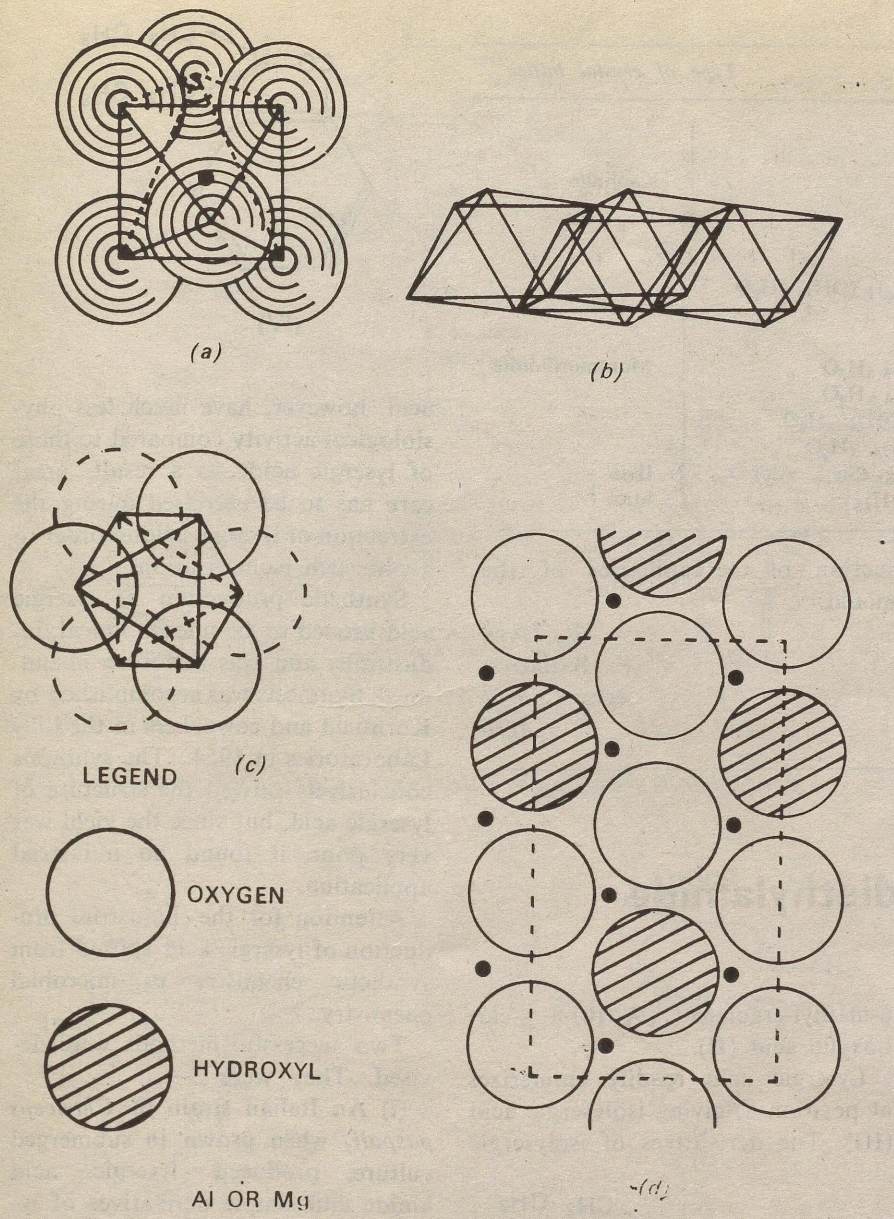

Fig. 2. Structure of the octahedral sheet: (a) Octahedral arrangement of Al or Mg with O or OH; (b) Perspective sketch of octahedron linking; (c) Projection of octahedron on plane of sheet; (d) Top view of octahedral sheet (dotted line: unit-cell area). Large circles represent oxygen ; shaded circles, hydroxyl; small black circles, aluminium or magnesium

solution. The clay 'solution' is actually a dispersion of very small clay particles and shows the properties of sols, viz., Tyndall effect, Brownian motion, electrophoresis, etc. On addition of salt, the clay particles begin to stick together and agglomerates grow on ageing. The clay dispersion converts into a suspension when particle size becomes sufficiently large. The particle size in natural clay dispersions usually varies widely and often covers a range which is typical for both sols and suspension (10^{-3}—10^{-7} cm). The agglomerates appear as 'flocs' which settle rapidly. Finally, the suspension separates into a sediment and a clear, particle-free supernatant liquid.

Clay particles carry negative charge and behave as hydrophobic colloidal systems. Suspended particles may also acquire charge by specific absorption of certain ions which are available in solution. Under an electron microscope, clay particles appear as large in thin plates and sometimes rod or needle-shaped, depending upon the nature of clays.

Clays can be dispersed in organic solvents (oils) if the particle surface is made oleophilic by adsorption of suitable organic compounds. For example, exchange adsorption of an organic amine cation or a quarternary ammonium cation usually yields an oleophilic clay which is dispersible in oils. Alternatively, certain polar organic compounds adsorbed onto the clay make it oil-dispersible. These non-aqueous dispersions of clays are used in manufacture of lubricating greases, oil-base drilling fluids, etc.

Clays have been found to be good emulsifiers in stabilizing oil-water emulsion. These emulsions are used in drilling for oils. They may be oil in a water-base mud, or emulsion of water in an oil-base mud. Oil-base 'muds' consist of oil, a colloidally suspended compound and weighting materials such as ground limestone or other materials.

In plants, root growth and proper drainage require a porous soil, the clay in the soil should in a flocculated condition. If rain water leaches out the flocculating electrolyte in the soil, the resulting peptization of clay leads to compaction of the wet soil and formation of impermeable cakes of clay within the pores between sand grains. As a result, drainage is poor and root growth is hampered. Therefore, lime or gypsum is commonly added to soil which acts as a powerful flocculant.

Ceramic objects are often made by

Table 1

Mineral	*Chemical composition*	*Type of crystal lattice*
Kaolinite	$Al_4 (Si_4O_{10}) (OH)_8$	Kaolinite
Dickite	$Al_4 (Si_4O_{10}) (OH)_8$	
Nacrite	$Al_4 (Si_4O_{10}) (OH)_8$	
Halloysite	$Al_4 (Si_4O_6) (OH)_{16}$	
Metahalloysite	$Al_4 (Si_4O_{10}) (OH)_8$	
Attapulgite	$Mg_5AL (Si_8O_{20}) (OH_2)_4 (OH)_2 4H_2O$	Montmorillonite
Pyrophyllite	$Al_4 (Si_8O_{20}) (OH)_4$	
Talc	$Mg_6 (Si_8O_{20}) (OH)_4$	
Montmorillonite	$Al_4 Mg (Si_8O_{20}) (OH)_4 \ {}_xH_2O$	
Nontronite	$Fe_4 Mg (Si_8O_{20}) (OH)_4 \ {}_xH_2O$	
Beidellite	$Al_4 Mg (Si_8) Al O_{20} (OH)_4. \ {}_xH_2O$	
Saponite	$Mg_6 (Si_8 Mg O_{20}) (OH)_4. \ {}_xH_2O$	
Illite	$K_y. \ Al_4 Fe_4. Mg_4. Mg_6 (Si_{8-y}. Al_y) O_{20}$	Illite
Muscovite	$K_2. Al_4 (Al_2Si_6O_{20}) (OH)_4$	Mica

pouring a clay suspension in a porous mould (slip casting). A certain degree of peptization ensures good pouring properties. A thick layer of clay is deposited on mould surface as water is removed by suction of the capillaries of the mould.

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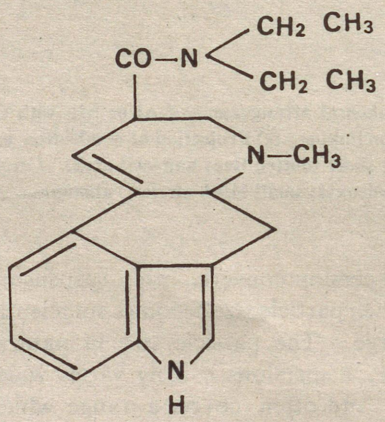
Lysergic acid diethylamide

LYSERGIC acid diethylamide, commonly known as LSD or LSD-25, is the diethylamide derivative of lysergic acid. Lysergic acid, its isomers and different analogues are present in ergot (*Secale cornutum*) which is the sclerotium of the fungus *Claviceps purpurea* (Fries) Tulasue which commonly grows on rye. The grain develops a purple brown curved body on being attacked by ergot. *Claviceps purpurea* and other species of *Claviceps* also attack other cereals and wild grasses.

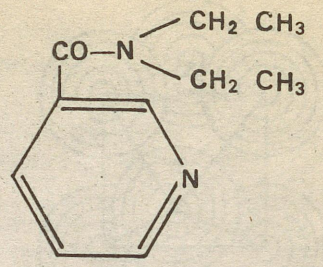
LSD is a semisynthetic compound, i.e., it is erected on lysergic acid as the basic skeleton and lysergic acid is a natural product.

Lysergic acid is an indole alkaloid containing a tetracyclic ring system which has been called "ergoline" (I). Thus, lysergic acid is nothing but 6-methyl-ergolene-(△9, 10)-8 β-carboxylic acid (II).

Lysergic acid readily epimerizes at position 8, giving isolysergic acid (III). The derivatives of isolysergic



Lysergic acid diethyl amide (LSD)



(IV)

acid, however, have much less physiological activity compared to those of lysergic acid. As a result, great care has to be exercised during the extraction of lysergic acid in order to avoid such isomerisation.

Synthetic production of lysergic acid proved to be uneconomical industrailly and was therefore abandoned. Synthesis was accomplished by Kornfield and coworkers in the Lilly Laboratories in 1954. The synthesis conclusively proved the structure of lysergic acid, but since the yield was very poor, it found no industrial application.

Attention for the industrial production of iysergic acid shifted from synthetic chemistry to microbial chemistry.

Two successful methods were devised. They were :—

(i) An Italian strain of *Claviceps paspali*, when grown in submerged culture, produced lysergic acid amide and simple derivatives of lysergic acid amides in high yield. These lysergic acid amides on hydrolysis readily produce lysergic acid which could be used as a starting material for the synthetic production of therapeutically useful pharmaceutical preparations.

(ii) The second method is the more successful of the two. It consists in isomerizing paspalic acid to a mixture of lysergic and isolysergic acid. Paspalic acid is an isomer of lysergic acid. It is 6-methyl-(△8, 9)-ergolene-8-carboxylic acid (IV). Under alkaline conditions the

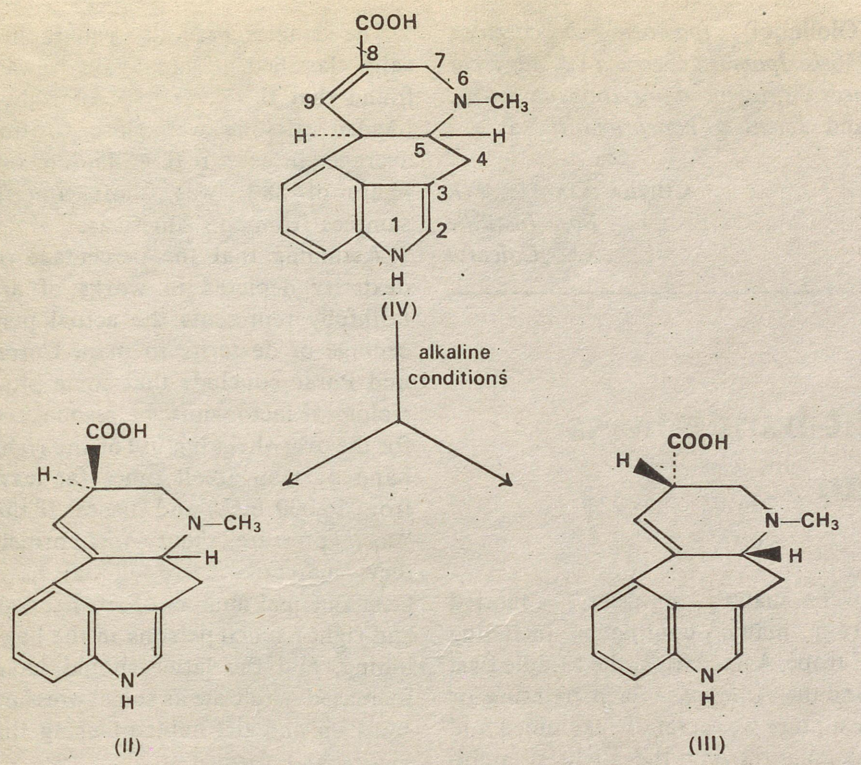
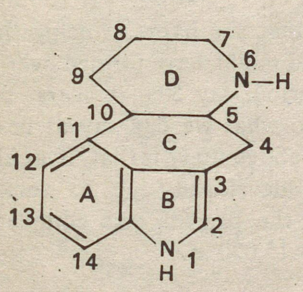
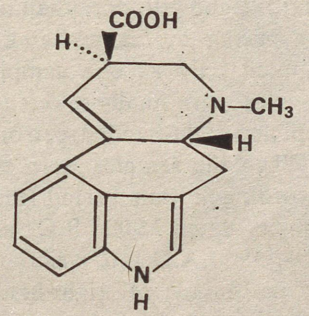


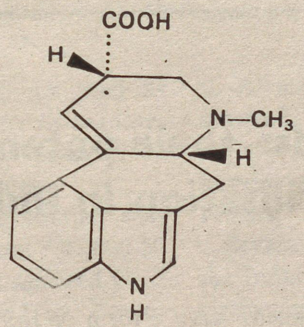
Fig. 1. Isomerization of paspalic acid to a mixture of lysergic and isolysergic acids



(I)



(II)



(III)

double bond at 8, 9-position migrates easily into the 9, 10-position, producing a mixture of lysergic and isolysergic acid (Fig. 1).

Paspalic acid is abundant in a particular *Claviceps* strain amongst the ergot found in Portugal on *Paspalum dilatatum*. This strain produces an excellent yield of a mixture of lysergic acid isomers (30% of lysergic acid, a small amount of isolysergic acid and 70% of paspalic acid).

Paspalum ergot provided a virtually untapped reservoir of lysergic acid isomers which could be used industrially for the production of various lysergic acid derivatives of therapeutic importance.

Since lysergic acid is a labile and sensitive compound, attempts were made to prepare a suitable active derivative of lysergic acid. It was during these investigations that Albert Hofmann prepared the diethyl amide derivative of lysergic acid which is LSD or LSD-25. He synthesized this as he found a structural analogy with coramine (V) which is an analeptic. Hofmann and A. Stoll first synthesized LSD using the Curtius reaction via lysergic acid hydrazide and azide.

Hofmann experienced a queer dream like (trance) state while he was endeavouring to purify LSD in the form of its tartrate. This led him to suspect that this compound had some intoxicating property. He took the smallest dose (0.25 mg) of LSD and experienced the same intoxicating effect. This discovery revealed the high psychotomimetic activity of LSD. LSD is more active in its hallucinogenic psychotomimetic property than all the other derivatives of lysergic acid.

LSD stimulates central nervous structures in the hypothalamus. This is brought about even by extremely mild doses and the symptoms are mydriasis, hyperthermia, hyperglycaemia, etc. Because of the psychotomimetic properties of LSD, it finds wide use in experimental psychiatry, neutrophysiology, etc.

Lysergic acid alkaloids which had hitherto been known only in lower fungi of the genus *Claviceps* are now found to be present in higher plants also. They are present in *Rivea corymbosa* (L) Hall. f., *Ipomoea violacea* L. (Ololinqui), *Ipomoea rubrocaerulea* Hook, *Ipomoea coccinea* L., *Angyreia nervosa*, *Ipomoea argyrophylla* Vatke, and *Ipomoea hildebrandtili* Vatke.

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New light on right-handedness in man

IT is common knowledge that contemporary man is right-handed; he prefers the use of the right hand for most of his daily work like writing, lifting things, handling and operating tools, etc. Is it a recent development or has it been so in the past? Is there any physiological reason behind this, or is it merely the result of a habit which developed because of social pressure?

Attempts have been made in the past to answer these questions. There was, however, one difficulty—the lack of reference in ancient or modern writings to the use of the right or the left hand by man. The Bible mentions at one place that 26,000 right-handed (dextrous) and 700 left-handed (ambidextrous) persons were counted in a city. But such references in literature are scant and of no use for a systematic study.

Nonetheless, there are drawings, paintings and sculptures of ancient times which show men at work using one or the other hand, and it is possible to draw some conclusions from them. This is exactly what two Canadian psychologists, Stanley Coren and Clare Porac, of the University of British Columbia, Vancouver, embarked upon (*Science*, **198**, 631, 11 Nov. 1977). They studied more than 12,000 samples, ranging over many centuries, collected from many continents including Europe, Asia, Africa, the Middle East and the Americas. Each painting or sculpture was carefully examined and samples having the slightest ambiguity were rejected. Only samples showing the clear use of one or the other hand were retained. If a single painting showed more than one persons using the same hand, it was counted only as one sample. 1180 samples were finally selected. 92.6% depicted right-handed persons.

When the samples were classified according to time period (the oldest sample dated 15,000 B.C. and the latest 1950 A.D.), it was found that the percentage of right-handedness was close to 90 in any period and there was not much variation. The lowest figure of 86% was found among samples dating about 2,000 B.C.

The samples were also geographically classified. Once again it was found that the percentage of right-handed persons was close to the average in each region. The lowest figure of 88% was found among samples from the Americas.

Assuming that the percentage of dexterity depicted in works of art faithfully represents the actual percentage of dexterity in man, Coren and Porac conclude that some physiological factor must be responsible for the overwhelming use of the right hand by man at all times (at least from 15,000 B.C.) and places. If the "social pressure" theory was correct, they maintain, there should have been an equal number of left-handed and right-handed persons in the beginning, and the latter should have increased with time as social pressure built up and the habit of using the right hand formed.

However, such a conclusion may not be correct. The earliest samples examined by the two researchers date back to 15,000 B.C. It is quite possible that the habit of using the right hand might have formed over a longer period, say 50,000 years or more. So what we can say at best from the above study is that, if at all dexterity developed due to social pressure, the process was complete by about 15,000 B.C.

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Seaweeds: their potential and utilisation in India

THROUGH ages seaweeds have been used by human beings throughout the world in some form or the other. In Japan, China, Denmark and Norway, some of the seaweeds are considered as delica-

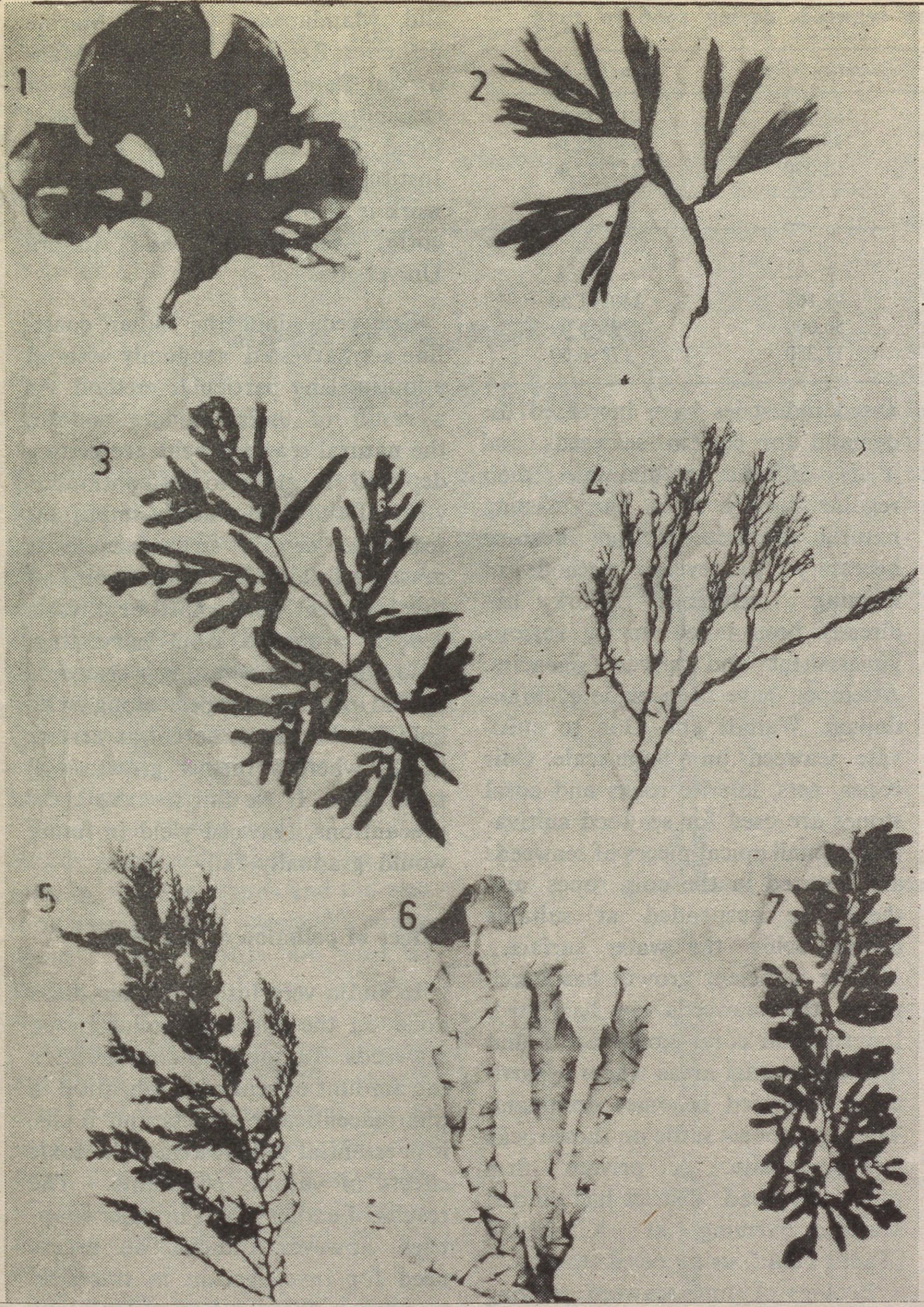

Fig. 1. Some seaweeds from Indian coast : (1) ***Padina tetrostromatica*****; (2)** ***Dictyopteris australis*****; (1)** ***Sargassum tenerrimum*****; (4)** ***Dictyota sp.*****; (5)** ***Laurencia sp.*****; (6)** ***Ulva fasciata*****; (7)** ***Sargassum sp.***

cies. Several seaweeds are used as animal feed while others as manure. Still others are in much demand for the manufacture of drugs.

The world's average annual seaweed production is about 7,47,000.50 tonnes. The maximum seaweed yield is from Japan followed by Korea, Norway, Canada, Mexico, U.K. (Scotland), Argentina, France, Spain, S. Africa and U.S.A. The world seaweed production is increasing every year. In 1973, the total world harvest of seaweeds was 1,088,000 tonnes.

Several areas of the 5,500 km of the Indian coastline provide suitable environment for the growth of seaweeds. There are about 164 genera and 389 species of seaweeds already reported from the Indian waters. Because of practical difficulties, seaweeds have been surveyed only from the intertidal regions of the Indian coastlines, and little information is available from sub-littoral beds. The existing information shows that seaweeds are present in large quantities along the Gulf of Kutch, Konkan, Goa, Karnataka, Tamil Nadu, Lakshadweep and Andaman and Nicobar Islands.

Some of the Arabian Sea Islands off the west coast of India have a luxuriant growth of seaweeds.

There is a great potential for using seaweeds in agriculture. At present, the only agricultural use of seaweeds in India is the utilization of drifted seaweeds as manure for coconut plantations in coastal areas.

F. Thivy of Central salt and Marine Chemicals Research Institute, Bhavnagar, in 1960 suggested simple methods of preparing seaweed compost which may be used as a cheap source of fertilizer, particularly in coastal areas. To determine the nutritive values of Indian seaweeds, protein, fat, calcium, phosphorous, iron, iodine, and vitamin C contents in *Gracillaria* sp, *Hypnea* sp and *Ulva lactuca* were estimated in 1956. The studies of the effects of seaweed extracts on the germination of crop plants have shown that certain seaweeds at lower concentrations show a positive effect on germination and growth of land plants. Such extracts could profitably be used as liquid fertilizers for commercial crops. Some work is in progress at the Indian Veterinary Research Institute, Izatnagar (U.P.) to determine the value of seaweeds as poultry feed.

Pharmaceuticals and drugs

Recently the importance of seaweeds as a raw material for pharmaceutical industry has received

Table 1 Expoprt position of Indian seaweeds during 1966 to 1975

Year	Quantity in kg	Value in rupees
1966	162,608	417677.00
1967	198,040	740542.00
1968	92,230	231732.00
1969	—	—
1970	—	—
1971	—	—
1972	—	—
1973	91,163	140711.00
1974	50,000	79536.00
1975	11,250	17896.00

much attention. The National Committee on Science and Technology has identified a project in which C.S.I.R laboratories such as National Institute of Oceanography, Central Drug Research Institute, Lucknow, National Chemical Laboratory, Pune, are actively participating. The project involves extraction of active components from the marine flora and fauna.

The results obtained so far are very encouraging and there is ample scope for expansion of this project.

A number of common Indian seaweeds are used in the manufacture of agar which is widely used for bacteriological culture, in pharmaceuticals, cosmetics and food industries. Agar is extracted from the red algae namely, *Geladium* sp., *Hypnea* sp., *Sarconema* sp. and *Gracillaria* sp. There are many small and medium sized industries for the manufacture of agar and sodium alginate in India. Advanced technology and sophisticated equipment for growing and harvesting seaweeds would make a considerable impact on these industries. Table 1 shows the quantities of agarophytes, mostly *Gelidiella acerosa*, exported from India during 1966-1975 to Japan, Spain, U.S.A. and other countries. Recently, the Government of India has banned the export of *Sargassum* sp. and *Gelidium* sp. because of their increasing demand in India.

Seaweed farming

The growing needs of seaweed based industries have increased the demand for certain seaweeds and it is difficult to maintain their regular supply from the existing natural resources. It has become necessary to develop methods of farming seaweeds. Work has already been taken up by various government and private agencies. Attempts have been made at Mandapam, Waltair and Goa to cultivate seaweeds on a large scale. Coir ropes, nets, laterite rocks and coral stones are used for seaweed cultivation. Small apical pieces of seaweeds are inserted in the coir ropes and these are suspended at suitable depths below the water surface.

After sufficient growth has taken place, the seaweeds are harvested. Laterite and coral stones are found in the intertidal areas where a particular seaweed becomes dominant. The algal spores settle on these rocks and germinate. A private firm of Ahmadabad district has started seaweed farming at Killakkarii (Tåmil Nadu) using coral stones.

Ecology of some seaweed growing areas has also been studied by several workers. However, no information is available from the unexplored areas along the Indian coastline.

Extensive work is being carried out at present in different laboratories of Council of Scientific and Industrial Research, and University Departments. Some of the important centres of seaweed research are Central Salt and Marine Chemical Research Institute, Bhavnagar and Mandapam; Central Marine Fisheries Research Institute, Mandapam Camp; National Institute of Oceanography, Goa, and Central Food and Technological Research Institute, Mysore. Some important work is also being taken up at Tuticorin, Madras, Pune and Andhra Universities.

Seaweeds along the Indian coastline are harvested randomly without adopting any particular method. As a result of indiscriminate harvest, the natural seaweed belts are getting depleted. In order to get continuous yield of the economically important seaweeds, certain stricter methods must be followed. At least some of the luxurient belts must be preserved or protected from harvesting. Also during harvesting, seaweeds should not be scraped along with hold-fast but must be cut at certain height whereby further growth will take place. If we fail to take these precautions, seaweed yield in future would gradually fall.

Effect of pollution on seaweeds

In India very little work has been done on the effect of pollution on seaweeds. Taking into consideration the amount of seaweed utilization in pharmaceutical products and foods, it is essential to investigate the toxic effects of various pollutants. The results of earlier works in other countries, however, indicate an urgent need for investigation in this field to protect the seaweed zones along our coast from the harmful effects of pollution.

Some pollutants such as treated sewage at low concentrations may stimulate algal growth and could possibly be used for aquaculture. High concentrations of untreated sewage, however, have an inhibitory effect due to reduction in oxygen and photosynthesis.

Marine pollution is cause by the discharge of substances such as mercury, cadmium, lead, DDT, etc., which are known to be harmful to man. Therefore, there is a need for useful monitoring of the concentrations of these substances in seaweeds used in the manufacture of food and animal feed.

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Open web joist cuts time and cost

LIGHTWEIGHT steel construction plays an important role in industrial structures due to their economy and the ease and speed with which they can be fabricated and erected. One of the efficient ways of using steel in lightweight construction is by means of open-web joists. Open-web joists have high strength-weight ratio, because they resist loads by truss action.

Open-web joists consist of two chords connected together by web rods so that the chords and the web form a triangulated system in a single plane. These joists are used as beams, columns, portal or gable frames.

The popular types of cross-sections are shown in the figure. The chords may be of bars, angles, tubes, tee or cold rolled light gauge steel sections. The web sections are invariably of circular bars bent continuously in zig zag form and welded to the chords.

Open-web joists provide the following advantages :
1. light sections; 2. high strength to weight ratio; 3. allows a standard module between connecting points; 4. construction is speeded up due to the standardization of column connections. Only a few connecting bolts are required, 5; The light weight and simplicity of these joists make erection fast and easy; 6. the open-web feature allows ducts, pipes and wiring to pass directly thiough the steel members; 7. the high strength of steel joists provide increased clear span area allowing larger bays; 8. the ease and versatility of designing with steel joists solve otherwise complex design problems; 9. due to their lightness, foundation cost is reduced, and 10. painting cost is cut.

There has been phenomenal growth of the use of open-web joists in foreign countries. The picture shows the construction of an industrial building in West Germany using open-web joists. Open-web joists have already been used in the factory buildings of the Indian Institute of Technology, Madras, and also in a few industrial buildings and sheds in Madras.

The open-web joists have some de-

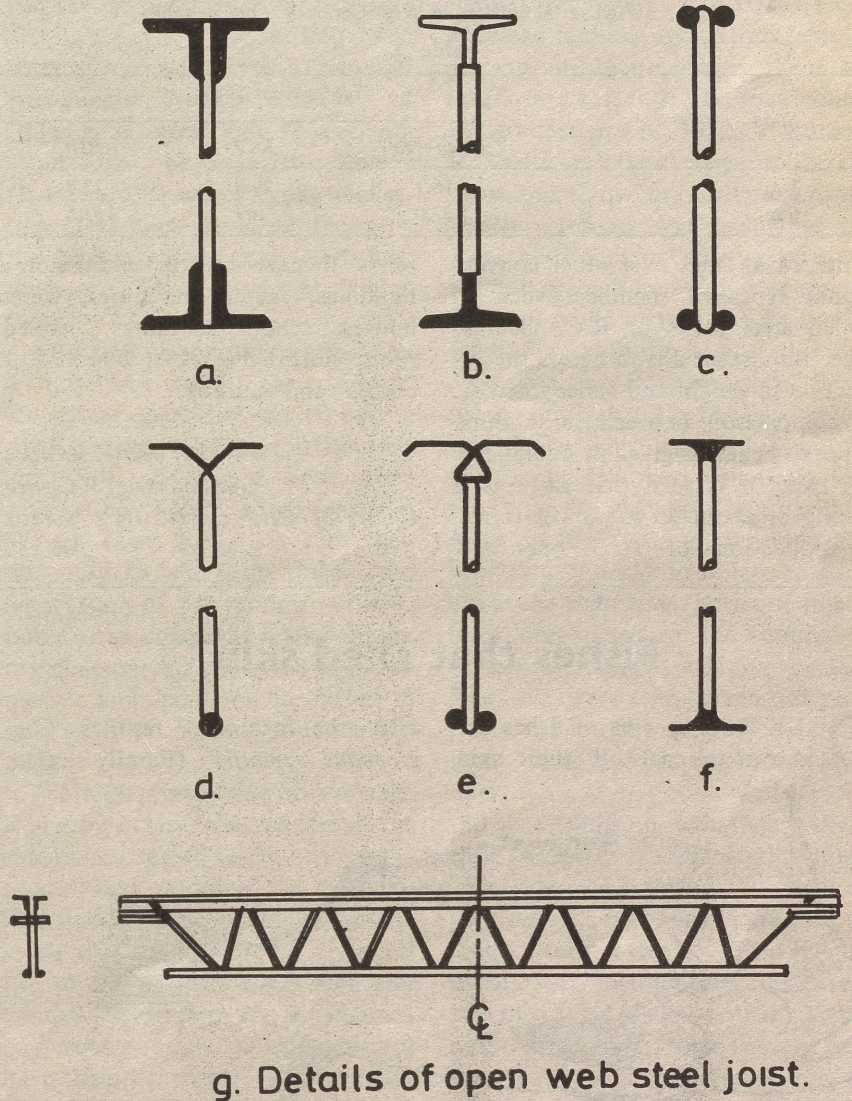

Fig. 1. Popular types of open web joists

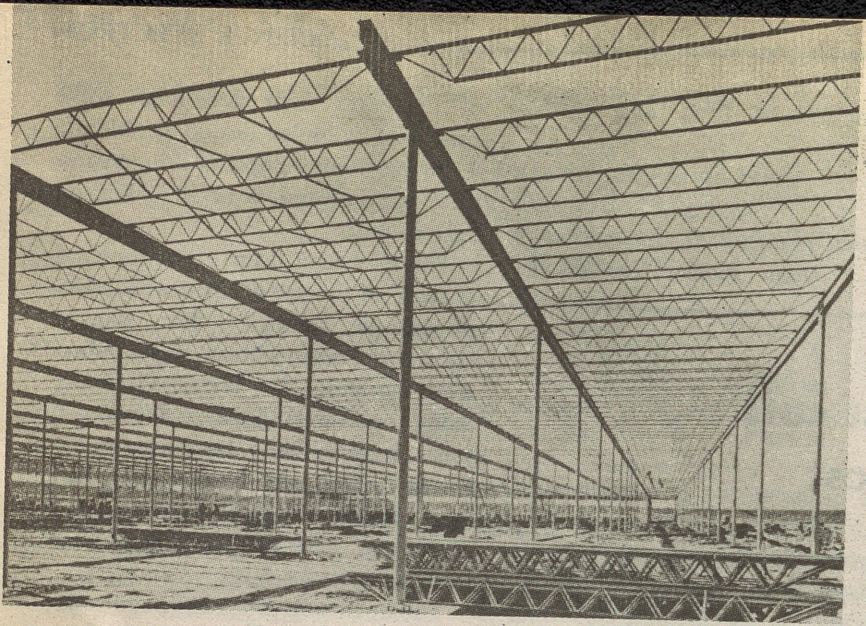

Fig. 2. An industrial building in West Germany using web joists

Table 1

Span	Total weight (kg)		
	Open-web	*RCJ*	*RC*
3 m	16.7	29.6	45.5
6 m	82.0	109	163.5

finite advantages over other conventional types of members such as rolled steel joists or R.C. beams. The important advantage is the reduction in weight and hence the cost. A comparison between these three types of beams is given in Table 1.

Hence, it is seen that there is a saving of about 25 to 40 per cent.

Application of steel open-web joists include use in multi-storey buildings, factory buildings, warehouses, school buildings, gabled roofs, northlight roofs, booms of cranes and purlins.

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Fishes that shed skin

ONLY two species of fishes are known to cast off their skin after the fashion of reptiles. *Congiopodus spinifer* (Family: *Congiopodidae*) collected by Prof. J. L. B. Smith, of Grahamstown Institute of Ichthyology, South Africa in 1961 from South African waters was the first species (Fig. 1). This grows to a length of about 35 cm. The exact way in which this species moults its skin is not yet known. In 1968, Dr. V. Ramaiyan of Marine Biological Station, Parangipettai (Porto Novo) collected the second species, namely, *Acanthosphex leurynnis* (Family: *Bathyaploctidae*) from the trawl net catches of the near-shore waters of Porto Novo, Tamilnadu (Fig. 2). This fish is about 3 cm. in length. When they were kept alive in the Marine Biological Station laboratory aquarium, at Parangipettai, they were found to cast off their skin once in 4 days, and curiously enough, the casting was found to occur around 10 a.m. The skin of the fish came off in large pieces which contained solid concretions. The concretions were not soluble either in potassium hydroxide or hydrochloric acid.

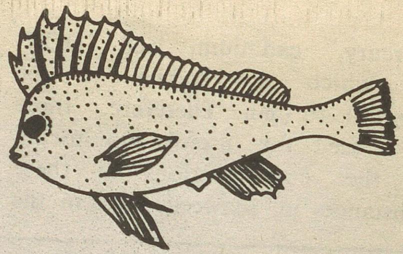

Fig. 1. *Congiopodus spinifer*

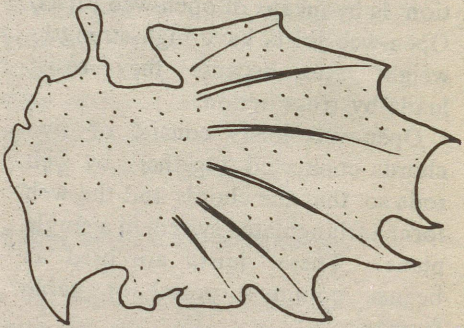

Fig. 3. Moulted skin of *Acanthosphex eurynnis*

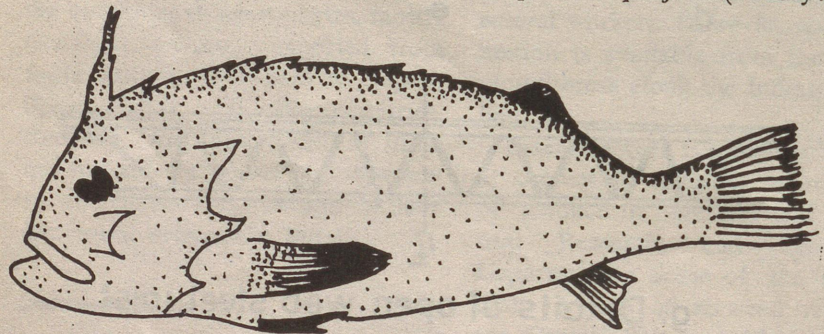

Fig. 2. *Acanthosphex leurynnis*

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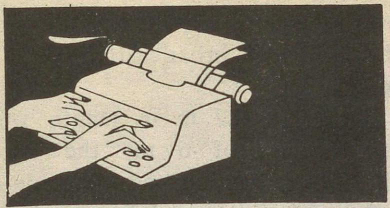

NEWS & NOTES

Selective abortion of a diseased twin fetus

ACCORDING to a news agency report in Lund, Sweden, physicians performed recently what they said is the world's first successful selective abortion on a woman bearing twins. They removed a diseased fetus without harming the other, and delivered a normal baby girl at full term several weeks after aborting her fraternal twin. Drs. Andres Aberg and Felix Mitelman aborted the twin fetus after tests of the amniotic fluid showed that it suffered from a disease that would have left it mentally retarded. The operation was performed at the University Hospital at Lund. The chromosome test in the 17th week showed that one of the two fetuses suffered from 'Hurles syndrome' (lipochondrodystrophy), a disease that would leave the baby tarded at birth and kill it before the age of ten. The ultra sound scanner used to monitor the growth of the fetus during pregnancy enabled the physicians to determine which fetus was suffering from 'Hurles syndrome'. Abortion was carried out in the 24th week of pregnancy and the healthy unaffected baby was delivered at full term in January.

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The world's first test tube baby

SHORTLY before midnight on 25th July (5.17 a.m. IST on 26th July) a girl was born to 32 year old Lesley Brown at Oldham General Hospital in North England. It was no ordinary baby, for it was conceived not within its mother's womb like other babies, but in a test tube. The birth of Louise (as the baby has been christened) marked the culmination of more than a decade's painstaking research by a team of scientists led by 65-year old gynecologist Patrick Steptoe of Oldham Hospital and 52-year old Cambridge physiologist Robert G. Edward. It was also the realisation of a long cherished dream by the Brown couple who had nine years of childless marriage behind them.

Although popularly described as a 'test tube baby', the chemists' laboratory glassware played only a small, though vital, part in Louise's birth. She developed and grew within the womb of her mother, like any other baby. The difference was only in the early stages—the fertilisation of her mother's ovum. Louise was conceived artificially by bringing together the ovum from her mother and sperm of her father in in a nutrient medium outside the body.

Normally, pregnancy occurs when a mature ovum released from the ovaries is fertilised by sperms—a process that occurs within the fallopian tube (the fallopian tubes are ducts that transport the released ova to the uterus). Many men and women (upto 10% of all married couples) who want children cannot have them because of various physiological reasons. A common problem with women is a blockage of the fallopian tube. Some men, on the other hand, do not produce enough healthy sperms for fertilisation. It is in such cases that the new technique offers hope.

The earliest work on test tube fertilisation goes back to 1944 when John Rock and M.F. Menkin of Harvard University Medical School in U.S.A. succeeded in fertilising human ova outside the body. They obtained mature eggs from female patients and then exposed them to sperm in a test tube. But they could not go farther. In 1952, Landrum B. Shettles of the College of Physicians and Surgeons, Columbia University, refined the technique of Rock and Menkin and was able to formulate a culture medium in which the eggs could mature and be made ready for fertilisation.

Steptoe and Edward started their work on test tube babies in the mid-1960s. They selected a group of about 50 women volunteers for the experiments, most of whom came in the hope of overcoming infertility. In order to isolate mature ova at the right time, hormone injections were given to the volunteers to control their ovulatory cycles. The ova were then taken out precisely at the right stage of development, using special surgical techniques.

In a test tube, an ovum starts dividing immediately after fertilisation. In a little over four days it reaches a stage with many cells called blastocyst when it can be taken out of the nutrient medium and implanted into the uterus of the mother. Ther. it is allowed to grow to its full term like any other human embryo.

By early 1971, Steptoe and his team had mastered the technique of growing fertilised human ovum even beyond the blastocyst stage in test tube. But its reimplantation into the recipient's womb presented problems. In the initial trials, many volunteers using the technique became pregnant, but miscarried within a few weeks of implantation. These problems were subsequently overcome, and Mrs. Brown was able to carry the implanted embryo safely to its full term.

BIMAN BASU

Breakthrough in balloon technology

THE commissioning of a 270-cubic metre tethered balloon at a ceremony held at the Space Applications Centre (SAC), Ahmedabad, on May 18 this year, marked a major turning point in developing and harnessing balloon technology for developmental activities in the country. The zeppelin-like simple tethered balloon, called 'Kytoon' in technical jargon, can be exploited for all applications to which a satellite is now put to use. When fully developed, such balloons can be effectively utilised for communications, TV broadcasting, remote sensing, meteorology, coast-line management and resources prospecting.

The term kytoon stuck to such balloons because, like kites, they can generate enough lift under wind conditions. And, again like kites, they are tied to the ground and their position can be manoeuvred at will. After USA, UK and France, India is the fourth country in the world to possess expertise and engineering capability required for developing the technology of tethered balloon. A joint, collaborative endeavour of SAC and TIFR (Tata Institute of Fundamental Research), the airship-like kytoon represents the sophistication India is acquiring in the field of balloon technology. Except for the two fire-proof DC motors in the pressure regulator system of the balloon, it was built with indigenous know-how and components. The nature of technology involved in the fabrication of balloon is best suited to the Indian engineering and industrial capabilities. Having realised the potentials of balloon technology, the Electronics Commission has extended its support to the Kytoon project.

The balloon is launched from a 500-metre high tower, which is so simple and flexible that it can be assembled and deassembled within half an hour. Despite its seeming simplicity, the tower is capable of performing a variety of sophisticated manoeuvres for the smooth launching and operation of balloons.

Though the experimental kytoon is designed to climb to an altitude of 1500 km from its present location, it cannot be flown above a height of 500 km because of the constraints placed by the civil aviation authorities. From a height of 1500 metres the range and visibility would be 140 km all around and an area of over 60,000 sq. km could be covered through FM broadcasting or TV relay.

Measuring 22 m in length with a diameter of 6 m, the outer skin of the balloon body is made of nylon. It covers a polythene bladder inside, which contains gas. The electrical power for the operation of balloon is supplied by a set of storage batteries carried by the balloon. The house-keeping information regarding the tension in the tether, temperature, battery voltage, etc., is transmitted to ground by a telemetry instrument on board. It is also possible to send commands from ground to operate its various systems in case of failure. The ground segment for balloon operation consists of a mooring tower, a main winch and a number of close haul winches and a circular monorail. When moored, kytoon, like a weather cock, rotates round the tower with the changing wind direction.

At present the kytoon has a limited capability. It can carry a payload of 50 kg to a height of 1.5 km and can withstand winds upto 80 km/hour. The expertise acquired in the operation of this experimental kytoon will generate skills for building bigger and more sophisticated kytoons for multi-faceted applications.

For a country like India, it offers a cheap and inexpensive means of establishing communication in diffi-

The SAC-TIFR Kytoon

cult hilly terrain, far off desert outposts and isolated Himalayan borderland. As establishing permanent communication link between offshore areas and the mainland is costly and cumbersome, balloons could be cheaply used for temporary communications. There is no doubt that in the near future the tethered balloon is poised to become poor nation's substitute for satellite.

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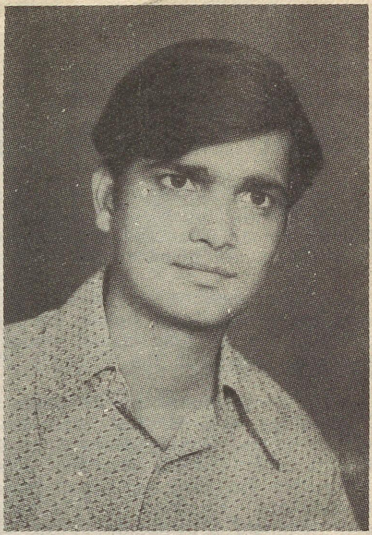
Interview

Dr. Ateeq Ahmad



Dr. Ahmad

"WE do not teach science students what science is," says Dr. Ateeq Ahmad, the 1977 INSA Young Scientist Award winner, who is presently a Scientist at Central Drug Research Institute, Lucknow. "We have largely lost the feeling for a philosophy of nature and do not understand how it may be established and enlarged". Rather surprisingly, he says that "even Ph. D.s can hardly claim to be Doctorates of Philosophy in the original sense of that term."

Dr. Ahmad seems to be a rebel. His unhappiness with the state of science in India oozes out of him. His startling remarks are nevertheless worthy of attention to our educationists and senior scientists. "The role of our so-called Ph.D.s," he comments, "is limited in our society and so also to the people they train. Even the supervisors, who guide a Ph.D.'s work, live by the golden rule of modern science— 'publish or perish'. The disease of 'Science without meaning' spreads."

Perhaps Ahmad's unhappiness with Indian science is traceable to his childhood experiences. Born on December 4, 1949 at Lucknow, his family was always busy with problems of its own. He therefore never received encouragement in science. On his own, he picked up interest in science in his school days. Though he studied throughout in municipal and Government schools and colleges, he fortunately had good teachers who encouraged him to develop self-confidence in him. Besides, he was also interested in extra-curricular activities. He was selected the best Hindi speaker in Lucknow region in 1967 and 1968. He was also the student editor of his school magazine and the *Dal Nayak* of debate and *Antyakchari* team of his Kurmi Kshatriya Higher Secondary School, Lucknow.

After his schooling, Ahmad went to Aligarh Muslim University to do B.Sc. and M.Sc. In the latter, he received the University's Gold Medal for standing first. He did Ph. D. at Neurochemistry Laboratory C.M.C. Hospital, Vellore, under the guidance of Prof. B. K. Bachhawat, whom, he calls a person who "keeps his colleagues happy, scientifically and personally." His researches come under the domain of biochemistry. He has developed novel techniques for immobilization and purification of glycoprotein enzymes.

Recently, the University of Connecticut Medical Health Centre, U.S.A., offered Ahmad a fellowship to work there, but he declined it. He says that he first wants to develop his own area of research (which is the targeting of drugs to specific tissues) in India. Afterwards, he would go abroad and learn from others in this area. "Better research could be done in the country," he claims, "only if one does careful planning, keeping in mind the available facilities and resources."

DILIP M. SALWI

Shanti Swarup Bhatnagar Prizes for Science and Technology for the year 1978

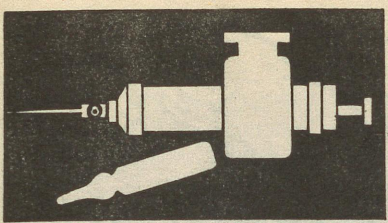
The Council of Scientific & Industrial Research (CSIR) awards each year five or more prizes, each of Rs. 10,000 for outstanding research, applied or fundamental, in the following disciplines; (i) Physical Sciences; (ii) Chemical Sciences; (iii) Biological Sciences; (iv) Engineering/Technology; (v) Medical Sciences; (vi) Mathematical Sciences; (vii) Other Sciences. The Prizes are given in the memory of Dr. Shanti Swarup Bhatnagar, the founder-director of the Council.

Nominations are invited for the Shanti Swarup Bhatnagar Prizes for Science and Technology for the year 1978. Any citizen of India below the age of 45 years as on 31st December 1977 and who has made conspicuously important contributions to fundamental/applied sciences in the particular field of his endeavour by his work done in India during the past years of the Prize is eligible for nomination.

Nominations can be made amongst others by Vice-Chancellors of Universities, Deans of Science, Engineering and Technology, and Medical Faculties, Directors of IITs, Deans of Faculties and Heads of Institutions deemed to be of University status, Director-General of the major R&D Organisations, such as DRDO, ICAR, ICMR, Chairmen of AEC, Space Commission, ONGC, etc. and Directors of CSIR Laboratories and BARC, TIFR, etc. and the Bhatnagar Prize Awardees. University Faculties could recommend persons working in their institutions only and route it through their respective Vice-Chancellors. Faculties in IITs should send their nominations through their Directors. The Directors of CSIR Laboratories can nominate a candidate in the discipline of their interest, irrespective of whether they are working in CSIR Laboratories or outside. A Bhatnagar Prize Awardee can send nomination of one person for each year's award in his own discipline only.

Each such nomination shall be accompanied by detailed statement of work and attainments of the nominee, and a critical assessment report (not more than 5000 words) bringing out the importance of the significant research and development contributions of the nominee made during 5 years preceding the year of the Prize.

The last date for receiving the nominations for the Prize is 31st October, 1978. Nominations should be sent in sealed cover, marked 'Confidential' to the Head, Extra-Mural Research, Council of Scientific & Industrial Research, Rafi Marg, New Delhi-110001.



MEDICAL NOTES

Azetomicine—a new anti-cancer drug

A new anti-cancer drug called azetomicine has been developed in the U.S.A. recently. The head of the research group that discovered the drug, Dr. Martin Apple, Professor of Pharmacology and Experimental Therapeutics at the University of San Francisco, California, claimed that the drug can kill millions of cancerous cells and is better than all the medicines now in use against this deadly disease. Azetomicine is very effective because of the fact that it remained on cancerous cells as long as 25 min. to 28 min. whereas medicines now in use, e.g., adraimycine, remained only a second. A single dose of azetomicine can kill upto ten million cancerous cells compared to 1 lakh killed by other medicines. It has been possible to cure animals having upto 15 per cent of cancerous cells with a single dose of this newly discovered drug. The above results have been obtained from a series of experiments performed on mice. The drug is yet to be tested on human beings. Dr. Apple and his group are now engaged in studying its effects on human being and their side effects, if any. The above medicine was developed with the help of Prophet, nationwide computer network of chemical and biological data sponsored by the National Institute of Health and subsequently synthesised in the laboratory. The above discovery was presented at the annual seminar of the American Cancer Society held recently at Houston (Texas), U.S.A.

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Dental amalgams

DENTAL caries or tooth decay is one of the most common dental diseases (*S.R.*, May 1977).

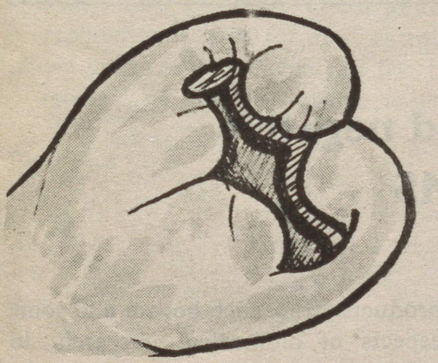

Fig. 1. Tooth in cavity bound with four walls (known as Class 1 cavity)

Treatment for dental caries consists of removal of carious portion of tooth, giving the cavity a particular shape and filling the same with suitable filling material.

The most commonly used filling material for posterior teeth, namely, molars and premolars, is dental amalgam. This is an alloy of mercury with silver and tin. It has a minimum compressive strength of more than 2500 kg/sq. cm. (i.e., it can withstand chewing pressure of 2500 kg/sq. cm. without fracture or distortion). During setting or hardening, it expands slightly upto a maximum

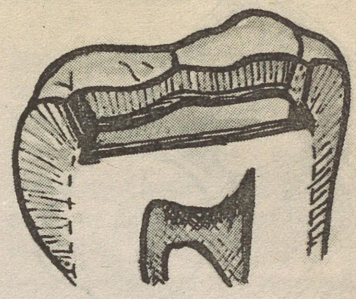

Fig. 1. Class 1 cavity shown in the cross-sectioned both

of 20μm/cm. This expansion is considered desirable because it leads to better amalgam filling into the tooth cavity and allows no leakage of fluids from oral cavity or site for bacterial growth.

Dental amalgam has some limitations : it is brittle, and has a poor edge strength unlike other metals or alloys. So, the cavity should be prepared such that the amalgam filled is not fractured or totally dislodged from the cavity. Procedure for cavity cutting involves removal of carious portion of the tooth and shaping the cavity by drilling with sharp revolving instruments, known as cutting burs, made of steel or tungsten carbide. The shape of the cavity is refined with chisel and other sharp instruments. A cavity is generally box-shaped with all the four

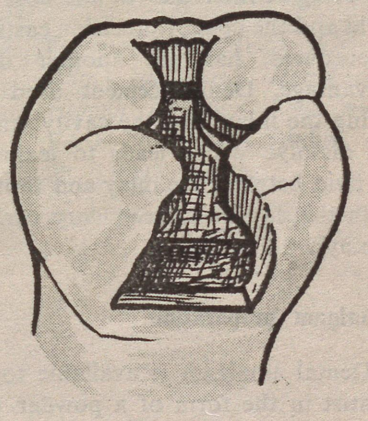

Fig. 3. Cavity with three walls of the cavity intact (known as Class 2 cavity)

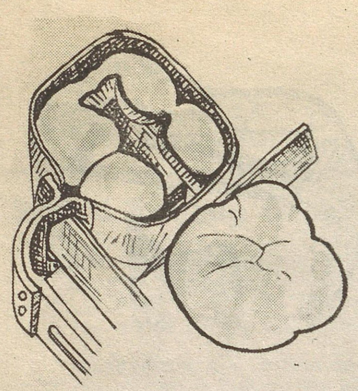

Fig. 4. Cavity from Fig, 3 with matrix fitted around the tooth

walls (Fig. 1) or three of the four walls intact (Fig. 3). In the latter, the fourth wall is built temporarily with flexible stainless steel strip known as matrix, which is removed after the filling has hardened (Fig. 4). Cavity prepared should not have any part too narrow to allow fracture to take place at that point. A desirable form of cavity is one with a base larger than its top (Fig. 2). This is known as resistance or retention form of cavity. In some cases, dental caries is so advanced that, after removal of such carious portion, it is not possible to obtain retention form for amalgam filling. Such a tooth has to be restored with gold inlay. A gold inlay is cast outside the mouth with precision casting technique and fixed into the prepared cavity with the use of dental cements. Such inlay work, in addition to being costlier due to the cost of gold and the cost of precision casting procedures, has got another disadvantage. Dental cement used in fixing the inlay into the cavity tends to dissolve which leads to leakage of fluid between the inlay and tooth, with the danger of secondary caries (decay).

Amalgam preparation

Dental amalgam is available to a dentist in the form of a powder of silver alloy and pure mercury. Silver alloy has the following composition: silver—67 % to 68.5 % (minimum); Tin—26% to 27% (maximum); copper—4 % to 5% (maximum); and zinc—0% to 1.5 % (maximum). When melted together, these constituents form an alloy consisting mainly of silver and tin. Silver tin alloy is in the form of an intermetallic compound with the formula Ag_3Sn. Tin also forms an alloy with copper forming intermetallic compounds with formulae Cu_3Sn and Cu_6Sn_5.

Filling

A dentist generally mixes the powdery alloy and mercury in 1:1 proportion in a glass mortar and pastle to make a plastic mass. This process is known as trituration. Triturated mercury alloy is collected in a piece of cloth and excess of mercury is squeezed out. The homogeneous mass of amalgam mixture is carried into the dry cavity, in small increments, and forced into nooks and corners of the cavity with the help of flat faced instruments (which may be serreted). Care is taken to avoid contamination with moisture by drying the cavity and isolating the tooth from saliva. The process of filling the cavity is known as condensation. It is continued till the cavity is overfilled. By the time condensation is complete, the mercury alloy mass becomes hard enough to allow its carving to the original tooth form without fracture or distortion. When

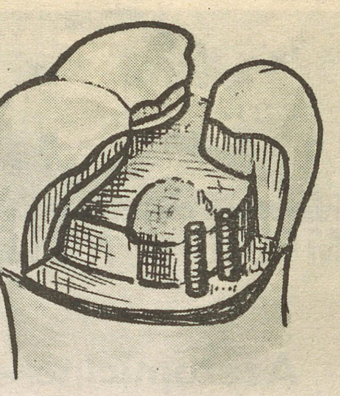

Fig. 5. Cavity fitted with reinforcement of pins which was otherwise unsuitadle for amalgam restoration

a cavity is not suitable for filling, some metallic pins placed in the holes made in the cavity, or screwed in the holes made in dentin, are used to restore the type of tooth structure (Fig. 5). This is followed by amalgam filling.

As regards mercury poisoning from silver amalgam filling, it has been conclusively proved that it does not lead to toxicity even if the amalgam mass is accidentally swallowed by the patient. The only danger of mercury poisoning is to the dentist and his assistants, in case mercury is carelessly handled in the clinic. This danger is however remote because the dentist is trained to handle mercury with care.

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Positive and negative CIMS

CHEMICAL Ionization Mass Spectroscopy (CIMS) has become one of the most versatile analytical tools in the study of natural products, drug metabolism and some aspects of biomedical research in recent years.

At the last International Congress of Pure and Applied Chemists held in Tokyo (September 4-10, 1977), Ajay K. Bose and his associates of Stevens Institute of Technology, Hoboken, N. J., U.S.A. reported the application of this brilliant technique (negative CIMS) as a clinical diagnostic tool to analyse the blood plasma directly without any extensive purification and derivatization processes. Bile acids that are produced in the body assist in the food digestion processes and remove the excess cholesterol. This report further claims success in monitoring the changes in the bile acid patterns. They also suggest the use of this technique to search for the highly toxic polychlorinated compounds sometimes produced in the body.

The reagent gas that is often used in the process is Freon-12 (CF_2Ci_2). Ammonia gas is found to be convenient as a reagent of choice for positive CIMS in the study of complex compounds like the steroid hormones, bile acids, prostaglandins, phospholipids, penicillins and other related antibiotics, oligopeptides, alkaloids and glycosides.

It is presumed that a combination of both these techniques can give a detailed picture of the individual components of a single drop of blood in less than an hour.

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PLANT PROTEINS (*Continued from page* 588)

ducts. Inexpensive proteins would then be readily available for incorporation into various food formulations, thus improving the protein nutrition of the people. In recent years, there has been an increasing interest among the people in mass cultivation of some oilseed plants (peanuts, sunflower, etc.) for commercial exploitation of vegetable oils. The residue left after extraction of vegetable oils would then serve as potential source of supplementary protein diet. Table 5 shows the average protein content of some oilseeds and their annual production figures for India.

Groundnut (*Arachis hypogea,*) is the principal oilseed crop in India. Only 5% to 6% of our annual production is used for food as roasted groundnuts and the rest for the recovery of oil; the residue is used as cattle-feed and fertilizer. Three types of products are potentially available for human consumption (a) an oil-free or low oil protein concentrate, (b) a so-called lipoprotein, and (c) a protein isolate. Groundnuts can also be used for the preparation of a wide variety of high protein products. Attention has been paid in recent years to produce inexpensive, attractive food products from groundnuts (Table 6) which may be made available to all sections of the population. Even with the latest technological and scientific knowledge, we are still poor in handling and processing protein-rich oilseeds. Most of them are used as fertilizers and feeds for animals. An economic and efficient technology for the production of foodgrade meals would increase the utilisation of oilseeds and their products. Inexpensive proteins would then be readily available improving protein nutrition of the people.

Further reading

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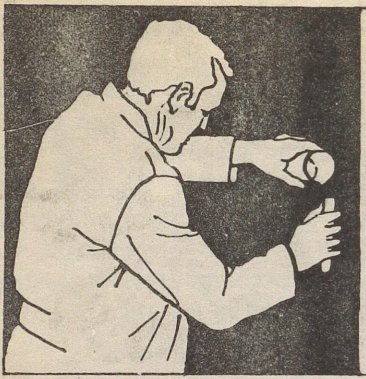

SCIENCE FOR THE YOUNG

How salt and water balance is maintained

SEVERAL important organs take part in maintaining the salt and water balance of our body. The kidneys, a pair of which serves as the chief excretory organ, the pituitary, a tiny gland with a stalk secreting hormones situated at the base of the brain, and the adrenals or the suprarenal glands placed immediately above the kidney and the liver together play various roles in the process.

Pituitary and its function

The pituitary gland, though very small, is the master of all the endocrine or hormone-secreting glands of our body. It can be divided into an anterior and a posterior part. It is the posterior part which is intimately associated with the maintenance of water balance of our body. The kidneys are composed of numerous tubules which take part in the formation and excretion of urine.

When a person is in a very dry environment, rapid loss of water from his body takes place. Water is reduced in the system and stimulates certain receptors in a portion of the brain called the hypothalamus, which initiates secretion of a hormone called vasopressin or antidiuretic hormone or ADH from the posterior pituitary. This hormone is formed in special portions of the hypothalamus and stored in the posterior pituitary. Its function is to help the tubules of the kidneys to reabsorb more water from the fluid that is passing through them, thus causing less water to be excreted and more water to be conserved. The case is exactly opposite when excess water is present and less ADH is secreted; so more water is excreted and normal water content of the body is regained.

Function of the adrenals

Adrenals are a pair of glands situated just above the kidneys. They have two parts, a central portion called the medulla and a cortical portion surrounding the medulla, known as the cortex. The cortex can again be divided into three zones, zona glomerulosa, zona fasciculata and zona reticularis. It is the glomerular zone that secretes a very important hormone, the aldosterone, which is the most potent salt

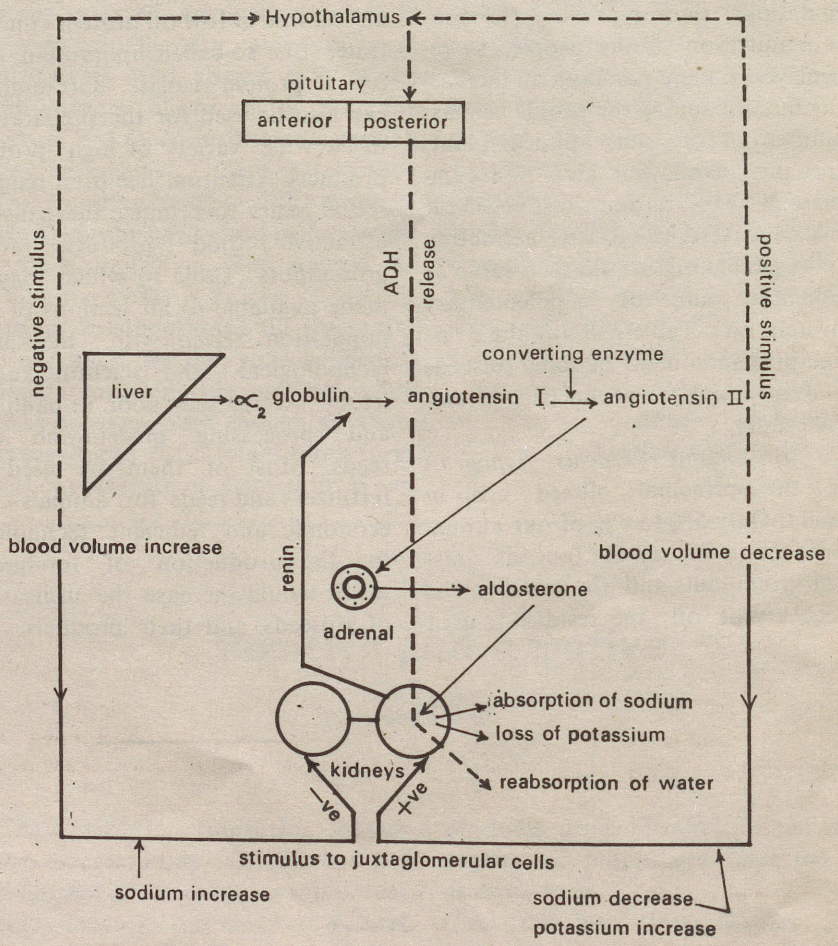

Fig. 1. A simple diagram showing the mechanism of salt and water balance maintenance

retainer. Decrease or increase of the aldosterone content upsets the salt balance completely. How this salt balance is controlled is a very interesting study.

The renin-angiotensin system

Between the tubules of the kidney are located the juxtaglomerular complexes. The juxtaglomerular cells within the complexes are sources of 'renin', a proteolytic enzyme. This enzyme acts on α_2-globulin which is a protein secreted by the liver and forms angiotensin I, a peptide with ten amino acids. Two amino acids are split off from it by a converting enzyme present in blood and angiotensin II is formed. This angiotensin II is a potent stimulator of the cells of the zona glomerulosa and initiates it to secrete aldosterone. A decrease in the blood volume sends positive signals to the juxtaglomerular cells to secrete renin into the blood stream and ultimately angiotensin II is formed which increases secretion of aldosterone. Aldosterone acts on tubules of the kidney to increase reabsorption of sodium and ultimately water. But it increases the loss of potassium ions from the body. The pathway through which stimulation of the juxtaglomerular cells takes place is still a controversial issue. After absorption of sodium and water from the tubules the change in blood volume is corrected and the initial disturbance which caused the stimulation of the juxtaglomerular cells is removed. Excess potassium and less sodium in the body also independently stimulate cells to secrete renin. The entire complex involving the juxtaglomerular cells, renin, angiotensin and the secretion of aldosterone is known as the 'renin-angiotensin system' which controls liberation of aldosterone. This system forms a very important topic in the field of endocrinology today.

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The ant lion

WHILE passing through a forest, or a *katcha* road or a pathway, we often come across small pits of loose earth, about 2.5 cm in diameter, and sloping down conically. They are traps dug out by ant lions. Ant lions are larvae of a neuropteron belonging to the family Myrmeleontidae. The name does not connote the ferocity of the lion, but indicates the insect's predaceous habit.

An adult insect looks like a dragonfly, but differs from it in having knobbed antennae. The female of the species deposits eggs in sand which hatch out in a couple of hours or a couple of days depending upon the environment. The newly hatched larvae travel some distance away from their natal site. On reaching a suitable place where the sand is loose and dry, they start making their individual pits. The mode of operation is simple. The larva initially traces a circle by depressing the posterior end of its abdomen and walking backwards. The first round of the circle described forms the diameter of the pit. From now on, the larva keeps moving round and round describing concentric circles of shrinking diameters. With each completed circle, it repeats the process until it reaches the apex of the pit which represents the inverted tip of the cone. The baby ant lion remains buried at the bottom, with its fearsome jaws protruding out, and awaits there approach of some unwary ant or spider investigating its artifact. When a prey comes, the treacherous sloping sand of the pit gives way underneath the intruder, and down it goes rolling to the bottom of the pit. The victim is now grabbed in the jaws of the awaiting ant lion. Sometimes the ant lion may miss its quarry, and the victim may try to escape from the pit. In such a case, it begins tossing sand in the air immediately. The sand tossed up all round the victim rolls it back to the bottom of the pit. When the prey happens to be a large insect or a spider, the battle starts, but seldom does the victim get a chance of getting itself extricated from the pit. Its stance on the shifting sands of the conical pit exhausts it beyond endurance and rolls it back into the pit.

The jaws of the ant lion are not adapted for biting and chewing; so the juicy contents of the prey is sucked out, and the dry carcass thrown out. The baby ant lion gets its food, grows in size, and sheds its skin as it grows. With its increasing size, it keeps enlarging its pit-trap or builds a new one. On attaining maturity, it stops feeding and changes into a pupa. A duration of dormancy follows before the adult emerges and takes to wing. The adult ant lion is nocturnal in habit and is seldom seen during the day. However, it could be attracted to strong light at night.

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Brain teasers

A farmer had a piece of agricultural land, of the shape of an isosceles triangle with both the base angles equal to 30 degrees, as shown in Fig. 1. The farmer had two sons

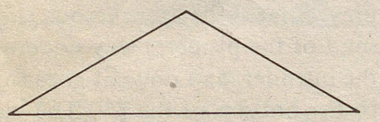


Fig. 1

from his first marriage and three sons from his second marriage. He wanted to distribute his land among his five sons. For this, he had some set plan in mind, according to which both his sons from his first marriage were to get lands of the same area and of the same shape. Similar plan he had in mind for his remaining three sons. But he had provisions in his plan to ensure that his first two sons got lands three times more in area than his remaining three sons. Can you suggest in what way should this partition be made ?

II

THE puzzles below involve some geometrical figures formed by using matchsticks. By invoking your elementary knowledge of geometry, you should be able to solve them.

(1) In Fig. 2, a hexagon is constructed using twelve matchsticks.

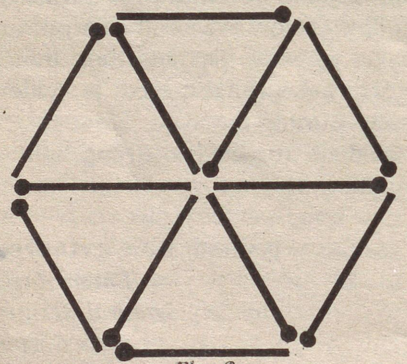


Fig. 2

Six equilateral triangles of the same size are enclosed within this hexagon. By removing just three matchsticks, can you bring down the number of triangles to three ?

(2) You have been provided with three full and three half matchsticks. (Fig. 3). Using them, can you make four equilateral triangles of the same size?

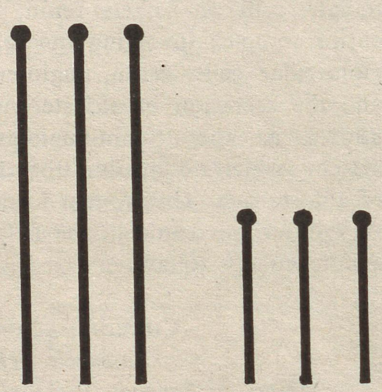
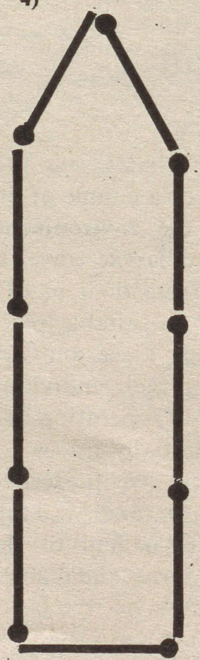


Fig. 3

(3) Using fifteen matchsticks, can you construct a geometrical figure with an area thrice that of a figure constructed out of nine match sticks? (Fig. 4)



III

YOU are given thirteen metal balls all of which except one weigh alike. The odd ball is known to be heavier than the rest. A sensitive balance has been supplied to you but without any weights. Can you in just three weighings sort out the heavy ball ?

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(*Solution on page* 633)

Science Quiz

1. Which one is the oldest known organic acid ?
   (a) formic acid
   (b) propionic acid
   (c) acetic acid
   (d) butyric acid

2. The hormone insulin is secreted by:
   (a) kidney
   (b) islets of Langerhans
   (c) liver
   (d) none of these

3. Atoms of different elements which have the same atomic weight but different atomic number are known as :
   (a) radioisotopes
   (b) isomers
   (c) iso-electronic
   (d) isobars

4. Which of the following acids do not have a carboxyl group?
   (a) benzoic acid
   (b) formic acid
   (c) picric acid
   (d) salicylic acid

5. Radar is an abbreviation of :
   (a) radio active detection and recording

(b) radium de analar
(c) radio active dispatch and receipt
(d) radio detection and ranging

6. Which of the following sub stances is used as a lubricant in heavy machinery?
(a) graphite
(b) carborundum
(c) powdered stone
(d) finely divided quartz

7. The system of homoeopathic system of medicine was invented by :
(a) Samuel Hahnemann
(b) Albrecht von Haller
(c) Thomas Willis
(d) Hildahus Fabricins

8. Which of the following diseases has a literal meaning as 'bad air'?
(a) bilharzia
(b) malaria
(c) pleurodynia
(d) borellia

9. Which of the following is a red dye and is used for staining biological tissues?
(a) heroin
(b) benzoin
(c) eosin
(d) heparin

10. The study of fossils is known as :
(a) palaeontology
(b) ecology
(c) osteology
(d) rehology

11. Dr. Jonas Salk is associated with the :
(a) anti-T.B. vaccine
(b) anti-rabies vaccine
(c) anti-polio vaccine
(d) anti-fertility vaccine

12. Which of the following metals is present in Vitamin B_{12}?
(a) iron
(b) cobalt
(c) manganese
(d) no metal is present

13. Which of the following diseases is a disease of eyes?
(a) caries
(b) cataract
(c) jaundice
(d) wart

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(*Answers on page* 636)

Solutions to brain teasers

I

The partition should be made as in Fig. 5. Here the numbers indicate the lands going to the share of the individual sons. It is now for you to see that the lands marked 1 and 2 are indeed in area three times more compared with the land 3, 4 or 5.

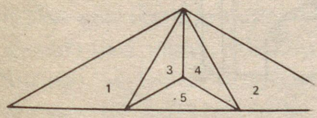

Fig 5

II

((1) See Fig. 6; (2) See Fig. 7: (3) See Fig. 8

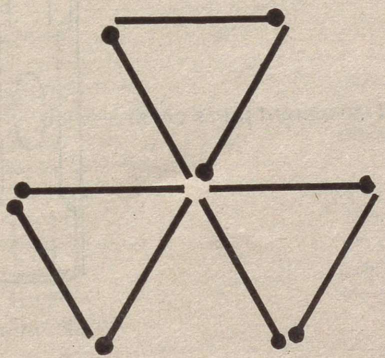

Fig. 6

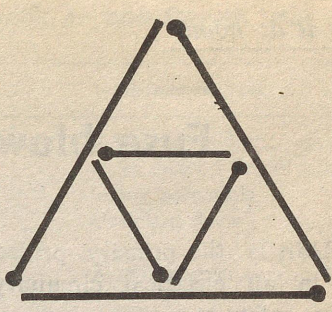

Fig. 7

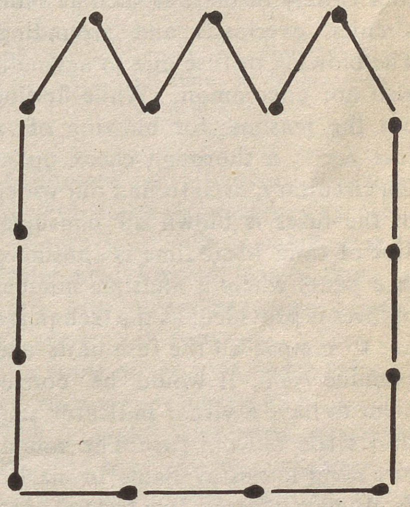

Fig. 8

III

Divide the balls into three groups: two of them containing six balls each and the third one containing a single isolated ball. Balance the two groups with six balls on the scales. If the two groups balance, then the heavier ball is the one which falls isolated in the third group. No further weighing is then needed. If however the two groups donot balance, then the side which goes down contains the wanted ball. So from the first weighing you can ascertain in which group does the heavier ball lie.

Next, take the group containing the heavier ball and split it further into three sub-groups of two balls each . The second weighing will tell you in which sub-group does the heavier ball lie. Now you are left with only two balls and this will need a final weighing (the third weighing) to ascertain the desired ball.

Do it at home

Fuse blow-off indicators

FUSE is the primary protection in all electrical circuitary to ensure safety to circuit and to equipment . The blowing of a fuse is due to a variety of reasons such as short circuits, overloads and grounding. The blowing of fuse due to ageing is also not uncommon. While finding out the reasons for blowing of a fuse needs a thorough check up of the circuitary, even to find out which of the fuses is blown off consumes alot of time. More time is consumed in a panel where a multiple number of fuses is provided, as the technician has to remove all the fuse units and examine each. It would be convenient to have a visual indicator that shows the blown. fuse The miniature neon lamps available in market as domestic lamps, line testers, pilot lamps, etc., could be used as "Fuse-Blow-Off-Indicators" (FBOI) in the manner described below.

A miniature neon lamp (Fig 1), of the same rating as of the system, is connected across a fuse in the circuit. Under normal circumstances, the miniature neon lamp does not get sufficient potential to glow because of the fuse. When there is a wrong contact at the fuse terminals, or the fuse has blown, the circuit. is completed via the neon lamps So, the neon lamp glows when fuse is blown up and does not glow when the fuse is intact. The negligible flow of current through the lamp when the fuse is off does not in any way affect the circuitary.

This can be done at home by amateurs as illustrated in Fig. 2. The expenditure incurred will be approximately Rs. 10/- per pair of fuses. In the single-phase domestic main board having three branch circuits with fuse cut-outs, three numbers of flush type two-pin wall sockets shall be fitted below each cut-out. Inside main board the terminals of wall sockets are connected by means of P.V.C. 250 V. rated cables to the terminals of respective fuse cut-outs. The two pin plug-in type neon lamps of 230/250 V. are plugged to the wall sockets so provided. Now the F.B.O.I. is ready . The components required are (i) flush type two-pin wall sockets, 5A., 250 V., (ii) neon night lamps 2 pin plug-in type, (iii) P.V.C. cable 250V., 3/1.22 mm, and (iv) wood screws for fixing wall sockets.

Fig. 3 shows how the miniature neon lamp is to be incorporated within the fuse carrier itself with a little modification to fuse carrier. The neon lamp's terminals are connected to the fuse carrier as an integral part of the fuse unit. It enables an easy identification of the condition of fuse.

F.B.O.I. has a wide range of applications such as in the control panel board of automotives, traction locomotives, sub-station, generator station and any electrical ciruit or appliance where fuse protection is required.

The following are the advantages of F.B.O.I.,

(a) Whether the fuses are parallel

(*Continued on page 636*)

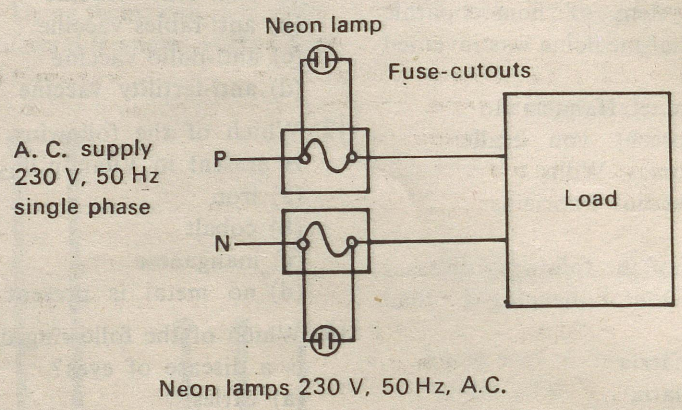

Fig. 1

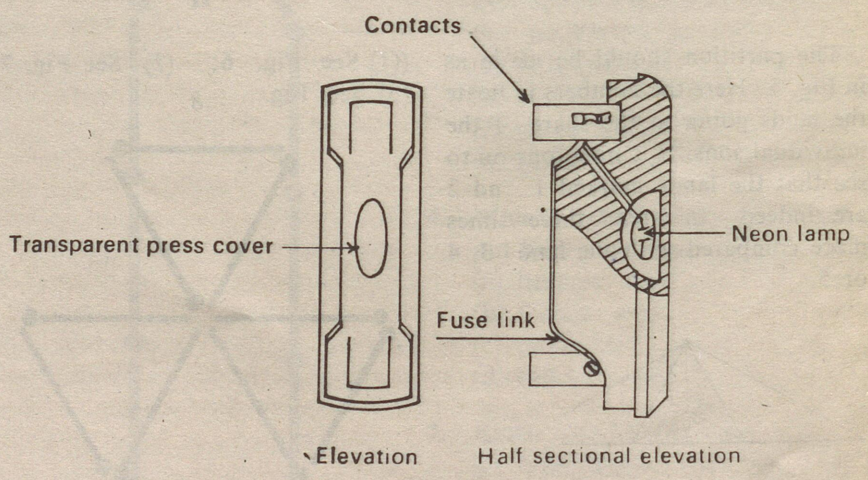

Fig. 2

FOR HER

Milk—an ideal home for bacteria

MILK is a complete food. It contains fat, protein, carbohydrate and vitamins. Usually people are not aware of the quality of milk unless it becomes sour or is seemingly adulterated with water. Milk is an excellent medium for the growth of microorganisms like bacteria, moulds and yeasts. Growth of such organisms not only brings about physical and chemical changes in milk, but also reduces its market value. It is, therefore, important to know about the normal and abnormal microorganisms found in milk.

Milk in the udder of a healthy cow is sterile. It has a pH of about 6.8. Some species of saprophytic bacteria of the genera *Micrococcaceae*, *Bacillaceae*, *Escherichiae*, *Corynebacteriaceae* and *Lactobacillaceae* are , however, able to grow a short way up in o the milk duct of the teats. The first milk drawn is usually contaminated with bacteria in hundreds to thousands per millilitre. This milk should be discarded. It also gets contaminated with yeasts, moulds and many other saprophytes during mechanical milching, by the use of dairy utensils, from soil and dust in air and even during hand milching. So a wide range of microorganisms constitute the normal flora of milk. The presence of these bacteria in milk is usually not a serious matter because they do not cause diseases, but if they are allowed to multiply they render milk sour quickly and develop undesirable flavour and curdle.

Collectively, bacteria found in milk are of four types : Psychrophilic—which grow at 0°C; Mesophilic—which grow at a temperature between 25 °C to 40 °C; Thermophilic—whose optimum range is 50°C-55°C; and Thermodeuric—which grow even after pasteurization.

If milk is refrigerated, the growth of thermophiles and heat-resistant spore forms is retarded, but psychrophiles grow at refrigeration temperature of 10 °C. Common dairy psychrophiles are *Pseudomonas*, *Achromobacter*, *Alcaligenes*, *Flavobacterium* and *Micrococcus* species.

Sourness of milk is chiefly due to lactic acid formed from lactose of milk. Moulds and yeasts are capable of growing in sour milk. They utilize some of the acid and produce a corresponding decrease in acidity. The principal lactic acid producing bacteria are: (i) *Streptococcus lactis* and related species, and (ii) *Lactobacillus* species.

The rate of multiplication of organisms is slow in the first 1-2 hours of milching, but gradually it increases. Several organisms produce a a condition known as 'ropiness' in which milk becomes ropy or slimy (and may be pulled out into threads). The most important bacterium responsible for this condition is *Alcaligenes viscolactis*. Several organisms have been isolated which are capable

Table 1. Important diseases communicable to man through milk

Disease	*Organism involved*	*Disease in man*
1. Tuberculosis	*Mycobacterium tuberculosis*	T.B. in children; specially those under 5 yrs. of age are highly suceptible
2. Brucellosis	*Brucella abortus* *Brucella melitensis*	Undulant fever
3. Q-fever	*Coxiella burnetti* (Rickettsial organism)	A typical pneumonia
4. Salmonellosis	Members of *Salmonella* species	Food poisoning, enteric fever, gastrointestinal disturbances
5. Pyogenic condition (sore throat)	*Staphlococcus aureus*	Severe gastroenteritis
6. Mastitis	A number of organisms involved	Spread infection in tonsil, intestine of staphylococcus in man

Table 2. Human diseases spread through milk

Disease	*Organism*
Typhoid fever	*Salmonella typhosa*
Paratyphoid fever	*Salmonella paratyphi* and *Salmonella schottmulleri*
Scarlet fever	*Staphylococcus pyogenes*
Septic sore throat	-do-
Diptheria	*Corynebacterium diptheriae*
Cholera	*Vibrio cholerae*
Poliomyelitis	a virus
Dysentery	*Shighella dysenterae*
Hepatitis	a virus and bacteria
Encephalitis	-do-

of imparting brilliant colours to milk. For example, blue milk is produced by the growth of *Pseudomonas syncynea*; red milk by *Serratia marcescens*, and yellow milk by *Pseudomonas synxanttia*. Bitterness of milk is caused by the growth of *Streptococcus cremoris*. *Pseudomonas icthyosma* is responsible for a fishy taste and odour, and coliform organisms produce unclean flavor.

A variety of diseases can be transmitted through milk (Table 1). The source of a pathogenic agent occurring in milk may either be a cow or a man (Table 2) and it may be transmitted to either. It is possible for man to infect cows. Mastitis (inflammation of udder) is caused by a variety of organisms including *Staphylococcus aureus*.

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Coffee

WHILE people do not forget to take coffee daily, they know very little about what it contains and what changes the process of roasting brings about.

The Prevention of Food Adulteration Act of 1954 defines coffee as the seed of the plant *Coffea arabica*, *Coffea liberica*, *Coffea excelsa* or *Coffea robusta* freed from all, but a small portion of its spermoderm by decortication.

The most important constituents of raw coffee are oil, cellulose, water and reducing sugar. Coffee contains on an average 1.2% of caffeine, which is responsible for the stimulating effect of coffee. Another alkaloid—coffearine—is also present in the beans in very small amount, but is not extracted from the decoction by $CHCl_3$, as is caffeine. Coffee beans may be extracted with ethyl acetate to produce a caffeine free coffee; the percentage of remaining caffeine is about 0.1.

The process of roasting (at about 200°C-250°C) caramellizes the sugar, reduces moisture content and at the same time develops the characteristic flavour of coffee, which is due to an oily volatile compound known as caffeol. It has been shown that there is a loss of about 5% caffeine on roasting, but as there is loss of water also the percentage of caffeine in the roasted coffee varies but little. The sugar present as dextrose is 4% in raw berries, but is reduced to 1.5% to 2% after roasting. The amount of tannin present is about 4.5% in raw coffee, but this disappears on roasting, probably forming caffeinic acid and quinic acid.

To preserve the aroma, the roasted coffee berries are sometimes oiled with fat or coated with sugar solution. Other substances that have been used for glazing purposes are resin, petroleum and shellac. But the Indian PFA rules lay down that coffee (green, raw or unroasted), roasted coffee, ground coffee shall be free from any artificial coloring, flavouring, facing, extraneous matter of glazing substances. It must be in dry and fresh condition, free from rancid or obnoxious flavour.

The most frequent adulterant of coffee is chicory. Chicory is more soluble in water than coffee and thus gives a stronger decoction. It also contains inulin, a polysaccharide, while coffee does not. Hydrolysis of insulin gives levulose. This character and solubility in water are used in detection of chicory in coffee.

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SCIENCE FOR THE YOUNG (*Continued from page 634*)

or series branch circuits, the indication of blow-up is found straight away on the fuse which is blown.

(b) When a fuse is blown, technician can identify whether it is due to short circuit or ageing from the change in the brightness of the neon lamp glow.

(c) The life of the cut-outs will increase as the frequent opening of cut-outs for checking is not required.

(d) The life of the indicator is almost infinite, being sturdy with no sensitive elements.

(e) Negligible consumption of power. This is only during fuse blow offs.

(f) Technician's time is saved in identifying the faulty fuse.

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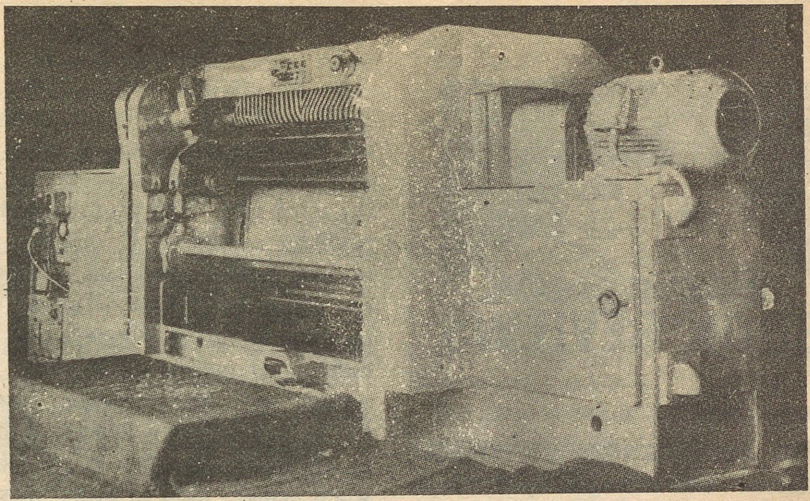
Answers to Science Quiz

1. c 2. b 3. d 4. c 5. d
6. a 7. a 8. b 9. c 10. a
11. c 12. b 13. b

Science in Industry



Leather Shaving machine

Indigenous hydraulic leather shaving machine

FOR the first time in India a 1250 mm wide leather shaving machine of sophisticated design and rigid construction has been designed, developed and manufactured with 100 per cent indigenous material and technology by Mechanical Engineering Research and Development Organisation (MERADO) , Madras, a regional centre of the Central Mechanical Engineering Research Institute, Durgapur. This machine was awarded a special prize by the Leather Fair Society, in the Leather Fair recently held at Madras.

Robust in construction with two rigid side frames connected by tie pieces, the machine ensures accurate, vibration-free shaving at all times. The machine besides being designed for high quality performance is geared for high output, and can shave upto 140 sides per hour. It is easy to operate, adjust and maintain, and is ideal for side leathers, as well as skins after chrome splitting and for completely shaving chrome or vegetable tanned leather. The skin is fed through the machine in full and taken out from the bottom. The dynamically balanced shaving cylinder gets smooth peripheral. speed from the electric motor of 40 HP through universal couplings.

A standard geared motor is used for the traverse of the grinder carriage by an endless chain along the bed carrying the grinding wheel and the lubrication tank and ensures uniform grinding of shaving blades even during the shaving operation. The grinder motor is specially designed for extra compactness. A standard lubricating pump is incorporated for lubrication purposes.

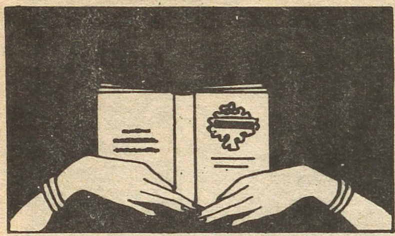
In operating condition, the shaving cylinder is lifted along with its side supporting brackets by hydraulic mechanism, and its position is obtained by servo mechanism in accordance with the final thickness of the leather required. The hydraulic circuit for raising the support roller and driving the feed roller uses only standard components indigenously manufactured. The feeding motion is controlled by a hydraulic motor which gives an even cut and fast adustable speeds upto 40 metres per minute. The hydraulic power pack including the built-in oil tank is compact, and is installed by the side of machine for easy accessibility for maintenance, which can be conveniently carried out without opening the machine. The use of hydraulics ensures a positive 'lock-up' of the support roller to the shaving cylinder, thereby producing a consistent thickness of cut.

The machine has certain special built-in features, which add to its versatility. Provision has been made for setting the support roller at an angle so that taper shaving can be achieved. By setting the thickness adjuster, the desired thickness of leather can be obtained in the range of 0.1 mm. 'Open' and 'Close' of machine is operated through an electronic unit. The foot switch in conjunction with the above control unit operates the solenoid valves of the power pack. Provision is incorporated to vary the time interval between successive shaving operations.

NBG introduces winged bean in Uttar Pradesh

A highly proteinaceous legume, winged bean (*Psophocarpus tetragonolobus*) is one of the under-exploited tropical plants. It is grown only as a backyard crop in a few parts of the world, such as Papua New Gui-

(*Continued on page 605*)



BOOK REVIEWS

THE CHALLENGE OF SPACE, selected and arranged by S. Gopinathan, *Federal Publications* (Available as a set from Affiliated East West Press Pvt. Ltd., G-1/16, Ansari Road, Daryaganj, New Delhi-110002) Pp. 101, Rs. 197 per set.

To conquer space, man needs not only sophisticated spaceships, knowhow and knowledge of what space is like, but also courage and patience. The book reveals that, apart from these, international co-operation is the biggest challenge of space facing mankind now, for, those romantic years of space flights are over and various practical and political issues are coming to the fore. Man is "outwardly bound", and therefore what more challenges are in store cannot be anticipated now.

The book simply makes one aware of the various challenges man faced from the beginning of the Space Age. The challenges are expressed in the words of astronauts, space scientists and writers. How does one feel when one is the first to go into the "unknown" space? The Russian cosmonaut Aleksei Leonov narrates what his feelings were before, during, and after the so-called space walk. Likewise, other Russian cosmonauts express their feelings in the part "Personal Testaments". Surprisingly, in none of the confessions one finds any element of romance or thrill. Still, one gets to know a lot about the feelings of those who pioneered the great effort.

In the second part "Man and space", various authorities discuss the necessity of an outer space law and international cooperation. In the third part "The promise and the problem", Arthur C. Clarke, the science writer, discusses at length the role satelllites are likely to play in the near future. He says that it is difficult to predict what effect they would have on mankind, just as in the last century it was difficult to envisage the effect of telephone when people used to think messenger boys would serve the purpose. It is nevertheless true that promises are also harbingers of problems. Today every country wants to secure a place in space. This is discussed subsequently.

The book, being a compilation of various articles published in the UNESCO magazine *Courier*, is not a well-knit account, but all the more a pleasure to go through. Nice photos and realistic illustrations are its plus points.

Dilip M. Salwi

TUNNELLING AND NEGATIVE RESISTANCE PHENOMENA IN SEMICONDUCTORS *by* D. K. Roy, *Pergamon Press*, Headington Hill Hall, OX3 OBW, Oxford, England, Pp. 213, $ 17.50

With the invention of various types of semiconductor devices, integrated technology and lately the microprocessors, the list of achievements in the field of electronics has been lengthened in the current solid state era. The continuing researches in this field will serve the mankind still further.

The latest investigations in the field of semiconductor devices by the author and his coworkers, challenged the conventional assumptions of tunnelling theory. The author, who is with Indian Institute of Technology, New Delhi, therefore, tells the need of the revision of the theory of tunnel diodes. The major portion of the book is devoted to tunnel diodes. This includes underlying fundamental principles along with the revised theory, applications and the circuitry and technology of tunnel diodes.

The negative resistance devices such as Gunn and IMPATT diodes have also been included. Almost all the aspects of these devices have been discussed briefly.

The switching devices, which offer high impedance in their 'off' state and a very low impedance in the 'on' condition, have also been discussed in detail. Describing the future of such devices the author observes : "There is a vast variety of potential applications for these versatile devices and their importance is sure to increase."

Although each chapter ends with a big list of references, a comprehensive bibliography of tunnel diodes has been given at the end of the book which includes more than 600 references.

The book is an excellent text on the subject and is useful to the researchers and the students who study solid state physics.

Vijender Sharma

OPERATIONS RESEARCH by Kanti Swarup, P. K. Gupta and Man Mohan, *Sultan Chand & Sons*, 4792/23, Daryaganj, New Delhi-110002, Pp. 728, Rs. 35.00

A large number of good books on Operation Research are available but many of them do not provide sufficient contents and detailed treatment of O.R. techniques. The need of a well written book which includes recent developments in the subject as well as a detailed treatment of O.R. techniques has been fulfilled by the present authors.

The book contains in all 23 well written chapters and begins with a chapter numbered zero. In this chapter a broad classification of different O.R. models, scope and limitations of O.R. are discussed. A brief introduction to Linear algebra, finite differences and probability in Chapter 1 and details of Markov Analysis in Appendix 'A' are given as prerequisites to make the book self-contained. Rest of the chapters discuss in detail other O.R. techniques such as Queueing theory, Sequencing problems, Deterministic and Probabilistic inventory problems, Applications theory, Replacement problems, Simulation and Network scheduling by PERT/CPM. Shannon theory has been discussed in brief and a few recently developed important techniques of mathematical programming are given. Some important cases in O.R., taken from actual decision-making situations, have also been presented which offer challenging problems to the would be O.R. consultants.

The book gives an overall and well balanced picture of the vast subject. It is written in a simple and lucid way with a number of sample problems. It encompasses the needs of the degree students of mathematics, statistics, engineering, economis, commerce and management. Throughout the book theory and alogorithms are discussed simultaneously and most of the techniques have been preceded by relevant theory and followed by suitable examples. Also, all major steps in the computational procedure of important techniques are presented by means of flow charts to clarify the ideas of readers.

RAM NARAYAN
SURYA PRAKASH

BIOCHEMISTRY OF THE PLANT AND ANIMAL *by* A. Sankaram, *Bangalore Printing and Publishers Co Ltd.*, Mysore Road, Bangalore 560018, Pp. 186, Rs. 14.00

IT is difficult to define the limits of biochemistry for the simple reason that its horizons have expanded; and are expanding rapidly. However, there are certain biological or biochemical compounds and processes common to the plants and animals as well as the cell and organelle level except, of course, the process of photosynthesis which is unique only to the green plants. In the book under review the author attempts to abbreviate this vast subject, to cater to the needs of the undergraduates in our agricultural universities. It would be welcomed by them because similar high priced foreign books are beyond their means.

The author has tried to cover the basic biochemical processes in this volume. The introductory chapter is a historical account of the science and its ramifications. The second chapter on 'cell and its organization' is a foundation for further developments discussed in subsequent chapters on carbohydrate, fat and protein metabolism, etc. The chapter on photosynthesis is incomplete without a discussion on C_4-plants and the Hatch-Slack pathway. Only a passing reference to this is made in the chapter on respiration. Dark fixation of carbon dioxide by the Crassulacean plants is not mentioned anywhere in the volume.

The contents of different chapters appear desultory. The presentation should have been more appealing and comprehensive for the students for whom the book is intended. There are some sentences which confuse the reader. For instance, here are the first few lines from the introductory chapter:

'Sir Frederick Gowland Hopkins, though regarded as the father of Biochemistry, some of the contributions of the earlier scientists on the subject deserve special mention. Thus in 1828, Wohler for the first time accomplished in vitro the synthesis of urea, followed by synthesis of acetic acid by Kolbe in 1844. . . . .and all this gave a death blow to the belief in the doctrine of vitalism.'

Similar confusing statements can be found in a few other places. The book appears to be hurriedly compiled. Typographical errors occur throughout the book.

The book is handy but needs considerable improvement.

D. CHIDVILASA SASTRI.

Books Received

1. **NITROGEN FIXATION** *by John Postgate Edward Arnold*, 25, Hill Street, London WIX,LL8 England, pp. 67 £1.50
2. **TRANSPORTATION ENGINEERING** by C.T. Sriramuju and R. Nagumani; *Macmillan Co. of India*, 2/10, Ansari Road, New Delhi-110002, pp. 312, Rs. 15.00
3. **THE CHROMOSOMES** by Archana Sharma, *Oxford & IBH Publishing Co.*, 66, Janpath, New Delhi-110 001, pp. 236, Rs. 16.00
4. **BIOCHEMISTRY VOL. I** by S.K. Dasgupta, *Macmillan Co. of India*, 2/10, Ansari Road, New Delhi-110 002, pp. 445, Rs. 24.75
5. **BIOCHEMISTRY VOL.II** by S.K. Dasgupta, *Macmillan Co. of India*, (As above), pp. 312, Rs. 17.25
6. **BIOCHEMISTRY VOL. III** by S.K. Dasgupta, *Macmillan Co. of India*, (As above), pp. 276, Rs. 16.00

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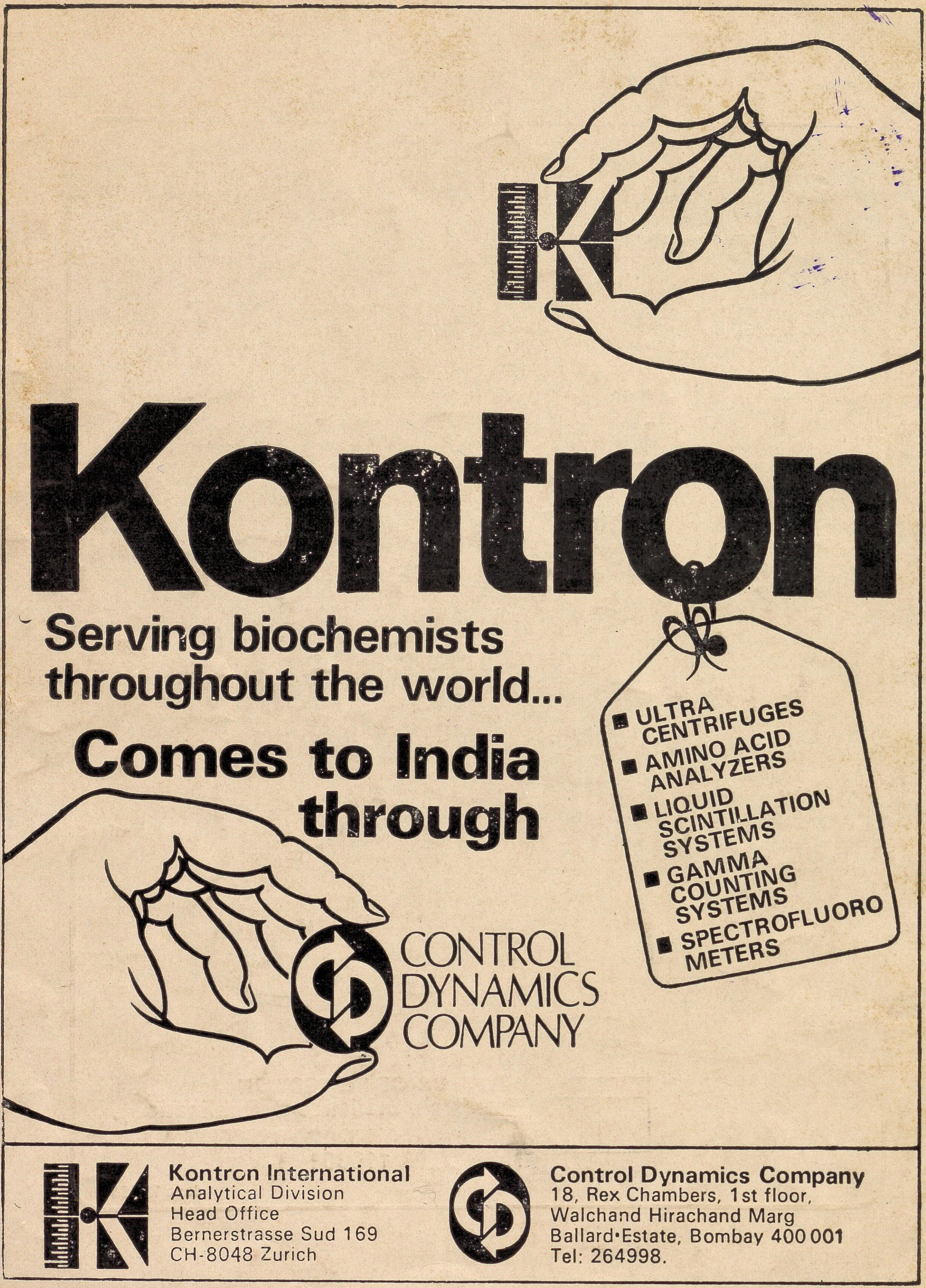

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