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SCIENCE REPORTER

AUGUST 1977

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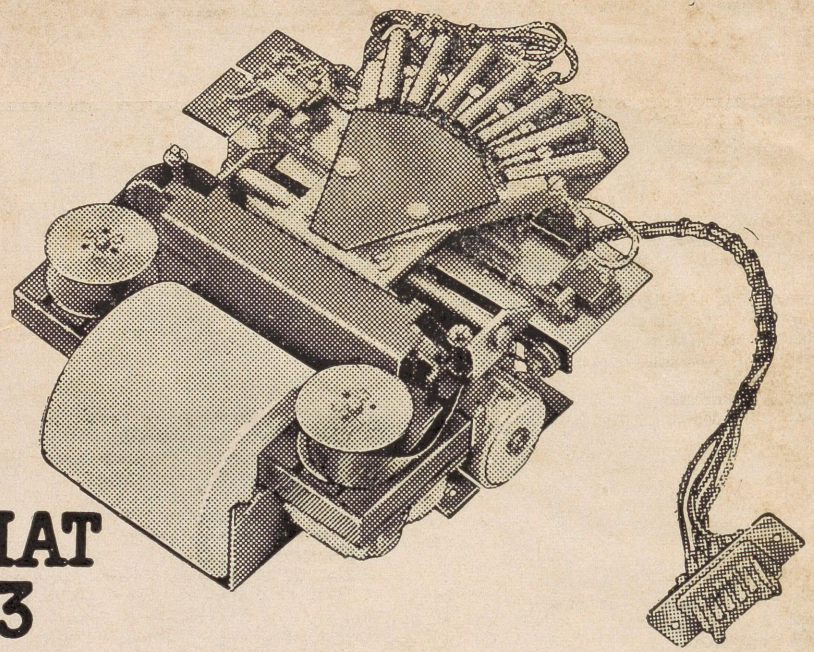

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SCIENCE REPORTER

VOL. 14 AUGUST 1977 NO. 8

COVER: (*Left*) A small portion of coastline in Goa at low tide, (*right*) The same at high tide. Tidal range is about 2 m

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LETTERS

Vitamin C

Sir, I read with interest **Vitamin C** under Science Spectrum (*S.R.*, Dec. 1976) wherein S.Ramakrishnan has given an account of the association of the vitamin with a number of human diseases and concluded that "a person *with normal metabolism* can conveniently go in daily for 1 gm to 2 gm of vitamin C to look young, to ward off diseases and to be healthy".

"*Vitamin C—myth or miracle*?" by Geoffrey H. Bourne of the Yerkes Regional Primate Centre, Emory University, Atlanta, Georgia, U.S.A., reprinted in *AROGYA*—Journal of Health Sciences (Manipal), 1975, Vol. 1, pp. 9-19, raised some pertinent points about the use of vitamin C in large doses. One argument against the regular intake of large doses of vitamin C is that once the body has adapted to these large doses, it will always require them.

Requirement of vitamins has been largely based on nutritional studies on animals as well as humans at different stages of growth. Daily allowances for a person have been recommended by Food and Nutrition Board of National Research Councils of different countries. None has advocated more than 200 mg daily intake under any stage of human growth and normal health. During the past two decades greater understanding of biochemistry of diseases has been gained and the possible role of vitamin C under various disease conditions of the human body has also been studied. Higher pharmaco-therapeutic doses from 500 mg to 2 gm are recommended till one's return to normal health. No need to continue such high doses after return to normal health.

Further, modern researches have shown that massive doses of vitamin C have the potential to interfere with drug metabolism and thus alter the pharmacologic effect of other drugs given at the same time. Modification of drug biotransformation by vitamin C in man has been the topic of recent studies (*Nature*, May 1, 1975).

More important is the finding about the substantial destruction of vitamin B_{12} by ascorbic acid in high doses. It is reported that iron and vitamin C given in large doses at mealtimes could lead to vitamin B_{12} deficiency (*The Year Book of Drug Therapy*, 1976, p. 68). It is well-known that vitamin B_{12} plays its very significant biochemical role in microgram quantities, and so it is not desirable to bring about B_{12} deficiency by taking more than the minimum required amount of vitamin C for normal health conditions.

It is also to be borne in mind how far vitamin C is retained in the body due to its high excretion rate and whether regular use of large doses of vitamin C daily may not lead to alteration in normal renal functions. Ascorbic acid may acidify the urine and contribute to renal calculi formation especially in people who have a tendency to gout or show increasing excretion of cystine in the urine. Further, oxalic acid is formed metabolically from ascorbic acid and so huge doses of vitamin C are likely to lead to an increase in the incidence of the urinary tract calculi composed of oxalic acid (G. H. Bourne, *loc cit.*)

Still another point for serious consideration from our national, socio-economic conditions will be whether the majority of Indians can afford to go in for this large dose (so essential ?), much less to mention the scarcity of the vitamin, at times, in the market due to inadequate production in our country. One would like to know if the present ambitious suggestion from a non-clinical biochemist for the intake of 1-2 gm ascorbic acid daily would have the approval of clinical experts and nutritional advisers.

The rich will rush for more from the market and the poor will be hit to a great extent!

S. SANKARA SUBRAMANIAN
Professor, Department of Chemistry
JIPMER, Pondicherry-605006

Man made gene

Sir, In the article **Can man make a gene?** (*S.R.*, March 1977) the following corrections would benefit the readers:

1. The authors have not clarified that gene is defined as a part of DNA that contains information for specifying complete amino acid sequence of one polypeptide chain. The 'one-gene-one protein' hypothesis holds true only in the cases where one type of polypeptide chain constitutes a complete protein molecule. Frequently however, two or more types of polypeptide chains must join together to form an active protein. For example, haemoglobin contains four polypeptide chains. Two are of one type called alpha chains (α) and two are of a different type called beta chains (β). The α and β chains are controlled by two different genes which are not even linked.

"However, defining gene precisely and fully has become difficult because the primary effect of gene is not always a polypeptide. Genes also code for *t*RNA, *r*RNA or are simply functional, acting as controlling segments of operons, e.g., operator and promoter regions."

2. To say that only one DNA strand acts as template for RNA synthesis is not correct. Only one DNA strand along a gene acts as template for RNA. So at any specific region

only one DNA strand is transcribed. That means in a cell both strands of DNA in a particular chromosome are transcribed but one strand acts as template for some genes while the other strand transcribes some other genes.

3. There are exceptions to the fact that RNA is a single stranded molecule. Some viruses have a double stranded helical form of RNA as the genetic material; for example, reoviruses, rice dwarf virus, wound tumor virus.

RAKESH TULI
Scientific Officer, Bhabha Atomic Res. Centre, Trombay, Bombay

1. "One gene—one polypeptide chain" hypothesis does not have much relevance to the main features of our article. Therefore, a detailed discussion on the subject has deliberately been avoided. It was thought sufficient to generalize this subject by saying that a particular nucleotide sequence or a segment of DNA is responsible for synthesis of a particular protein.

To say that "defining gene precisely and fully has become difficult", is probably not valid in the light of arguments now available. Indeed, certain genes direct the formation of ribosomal and transfer-RNA molecules and not the formation of protein; but this reservation does not mean that genes act in two different ways. They in fact direct the formation of protein molecules by ways not other than that of RNA molecules. However, "it seems more appropriate to define the term gene at the particular functional level being considered with the proviso that the gene is a section of genetic material determining this function. In terms of proteins, therefore, it is useful and commonly accepted to consider a gene as the section of DNA that determines a polypeptide since it is the polypeptide that is the basic unit characterizing the function of a particular protein" (Strickberger, M. W., *Genetics*, Colier Macmillan Publishers, London, Pp. 914, 1976). Further, we have come across another very simple definition of the gene. Those regions of the genome transcribing the messenger-RNA (which would ultimately be translated into proteins) are called the *structural genes*. The other regions, coding for the different ribosomal RNAs and transfer RNAs, are generally called the *determinants for RNA*.

2. Nowhere in our article we have written "that only one DNA strand acts as template for RNA synthesis" as Mr. Tuli has pointed out. Instead we have said that "In living cells, only one strand ('sense strand') of DNA serves as a template along which the nucleotides of RNA are lined up according to the complementary rules to form RNAs" (column 3rd, page 163). A "sense strand" means "only one DNA strand along a gene". Therefore, the correction suggested is not needed as whatever he wants to say has already been said; only a deep insight is needed.

It is not logical even to presume that both the strands of DNA are transcribed for a particular gene because only one strand "makes sense" phenotypically. If both strands along a gene are transcribed, then, both *m*RNAs will be complementary to each each other. Since both the *m*RNAs are complementary, they will hybridize to form a double stranded structure. Consequently no protein synthesis will occur as the single-strandedness of *m*RNA is essential for translation. However, transcribable regions can be found on both strands (see Szybalski, W.H. kubioski and P. Sheldrick. (1966) in Cold Spring Harbor Symposia on Quantitative Biology 31; 123 and D.S., Hogness, W. Doerfler, J. B. Egan, and L. W. Lack (1966) in Cold Spring Harbor Symposia on Quantitative Biology 31: 129).

We would like to update the statement as "in a cell both strands of DNA in a particular chromosome are transcribed but one strand acts as template for some genes *at a particular time or developmental stage* while the other strand *may* transcribe some other genes *at some other time or developmental stage*".

An easy inference that can be drawn from the above statements is that the genetic information for the synthesis of a complete product (whether protein, *r*RNA or *t*RNA) is transcribed from one particular strand of DNA (or a specific gene) at a particular stage. But this is not so in *some* cases of *t*RNA. Studies with DNAs whose strands can be separated show that *t*RNA transcribes some segments from *one strand* and other segments of the same molecule from the *other strand* (Davis, B. D. *et al.* 1973, *Microbiology*, Harper and Row, London, Pp. 1562). This means that for one *t*RNA molecule both strands of DNA can be the "sense" strands.

3. Our article does in fact take care of the point raised that "There are exceptions to the fact that RNA is a single stranded molecule." We request the attention of Mr. Tuli where we have written that "Molecules of RNA are single stranded, linear polymers of mononucleotides. Although certain types partially assume a secondary double helix configuration through complementary base pairing."

Admittedly, however, we did not mention another important exception where single stranded DNA molecule acts as genetic material, which Mr. Tuli has also failed to point out. The examples are, phage *ox* 174, filamentous coliphage *fd* and M13, etc. This single stranded DNA genome is of the same polarity as the *m*RNA. No virus with single stranded DNA complementary to *m*RNA has yet been found, although viruses with strands of both polarity in separate (viral) particulars have been characterized

(Crawford, L. V. 1969, the DNA of a minute virus of mice, *J. Gen. Virol*; 4: 37-46). However, we may mention that these exceptions, whether of RNA or DNA, do not have any relevance to the article.

SUBHASH S. ARORA
Department of Genetics
Haryana Agricultural University
Hissar-125004
(MISS) KAREN SANSI
Department of Animal Genetics
NDRI (ICAR) Karnal

Exceptional *Azadirachta indica*

Sir, The plant *Azadirachta indica* (Syn. *Melia azadirachta*) belongs to the family Meliaceae. It is a perennial tree having pinnately compound leaves which have ovate shape and serrate margin. It has a normal tap root system.

The leaves of this medicinally important plant usually taste bitter, but there is an exceptional plant of the species near Lunibahal, 2 km. from Purunakatak High School in the District of Phulbani, Orissa, the leaves of which do not have the usual bitterness. What factors are normally responsible for the bittertaste of the leaves of *Azadirachta indica* and under what circumstances this variation has ocurred may be a new fact. In the surrounding other trees of the same species have the usual leaves having bitter taste.

This exceptional *Azadirachta indica* tree has been discovered very recently, i.e., in the month of January 1977. This is not the flowering season of the plant and yet we have collected and kept some of the herbaria with much care. In the flowering season we will keep some more herbaria. We have collected also three soil samples from near the tree.

Any explanation for this newly discovered fact will be welcome.

Moreover, we would like to request you to publish an elaborate up-to-date article on *Azadirachta indica*, more specifically on the cause of the bitterness of the leaves and other parts.

VIJAYA KUMAR PRADHAN
SUSHIL KUMAR PRADHAN
High School, Purunakatak-762013
Dist. Phulbani (Orissa)

Indian Science Congress

Sir, The letter of V. K. Pandit (*S.R.*, May 1977) under the above caption is thought provoking. Every year in the first week of January, the Indian Science Congress, held under the auspices of some university, goes through the routine business of a pompous inauguration, sectional meetings, symposia and some special lectures. The Association has about 6000 members, and its annual conference is attended by more than 2000 scientists, some of them from abroad.

When the inauguration ceremony is over, and the VIP's and many of the top scientists have gone, the delegate-scientists divide themselves into some 13 sections representing as many major disciplines of science. In recent years the number of research papers presented in the different sectional meetings of the Congress has reached 2000. And it is during the reading of these papers and the discussions which follow that the organisational inadequacies come to the fore and conditions become chaotic. When I attended the 1975 Congress at Delhi, a lecture on "Differential Biology" was delivered in the mathematics section. Many of the participants were not at all interested in the subject. They were simply chatting with each other. Even the president of the mathematics section who was in the chair evinced little interest in the subject. He was busy with some other papers. Outside the lecture hall, too, the delegates not interested in the lecture made much noise which disturbed those attending the lecture.

The scientists themselves are to blame for the mess they have made of the Science Congress. The Congress is no longer a forum for presenting new findings. And why should a serious research worker present his paper in this "annual get-together" when he can easily get it published elsewhere? Many serious scientists had a bitter experience of this annual show. "At Bombay (1960), the Science Congress", J.B.S. Haldane had remarked, "appeared to be an organised conspiracy against originality in Indian Science." Never a person for mincing words, J.B.S. had also spoken about the malice that affects the Science Congress: "The root cause of all this incompetence and worse is not far to seek. A large number of Indian scientists have no pride in their profession, though they are proud of their salaries and positions. The opposite attitude is common in Europe, as it was in ancient India. I have seen a member of the Council of the Royal Society (R. A. Maccance, to be precise) turn up at a Council meeting in shabby clothes with his luggage on his back in a knapsack. In India today the unworthy successors of Durvasa and Visvamitra actually invite governors, Vice-Chancellors, and the like to address them...".

G. M. NATARAJAN
Biology Department
Coimbatore Medical College
Coimbatore-641014

All about alfalfa

Sir, I read the article *All about alfalfa* by D. C. S. Raju (*S.R.*, March 1977) with much interest. To a botanist, the information given in the article is quite satisfactory. But in homoeopathy, it is not only a tonic but also a remedy for deficient

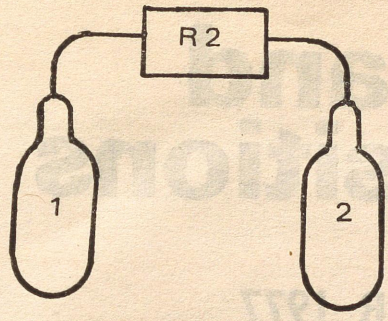
lactation diabetis insipidus, phosphaturia, neurasthenia, splachnic blues, nervousness, insomnia and also it promotes appetite and improves mental and physical vigor.

SACHIDANANDA PARIDA
D.H.M.S. (Utkal)
Udala (Orissa)

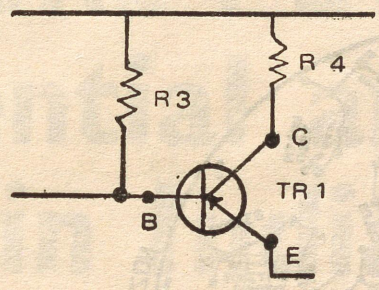
Mini emergency light (*S.R.*, **June 1977**)

Sir, I have carried out some improvement to avoid heating up of components which costs only 30 Paise more.

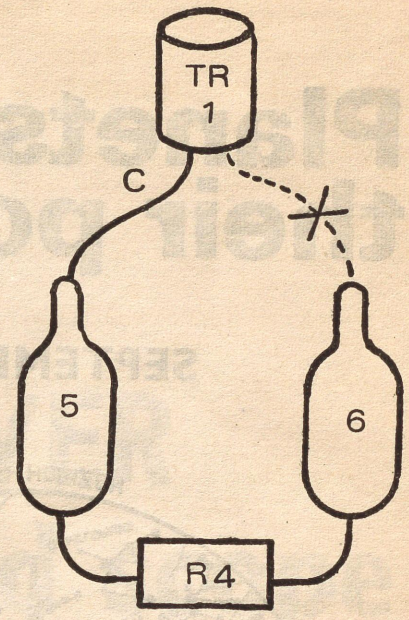
1. The value of electrolytic capacitor C_1 is 100 microfared 12 volts.
2. The value of R_2 is 100K (*not* 10K)
3. To overcome the heating effect in long run connect 390 ohms



Resistor (R_4) at the Collector of TR_1 as shown below.



4. Near by Values of Resistors can also be used.



5. A heat sink on TR_2 can be used (it is not a must)

B. SHANKAR RAO
Technical Supervisor
Inspectorate of Systems
c/o BDL, C. G. Lines,
Hyderabad-500005

DIRAC (*Continued from page 498*)

back. Thanks to Miss Dent and the depression, the choice had been made for him. And just eleven years later he succeeded Sir Joseph Larmer as Lucasian Professor of Mathematics in Cambridge, a chair whose first occupant was Issac Barrow, Newton's teacher, and the second, Newton himself.

Dirac was born on August 8,1902, at Bristol. He was educated at the Merchant Venturers' Secondary School, Bristol, and at Bristol University where he studied electrical engineering and obtained B.Sc degree in 1921. He spent the next two years at Bristol studying mathematics and then went to St. John's College, Cambridge, as a research student in mathematics. He obtained his Ph. D. degree at Cambridge in 1926 and the following year was elected a Fellow of St. John's College.

Since 1926 Dirac has travelled extensively and has studied at various foreign universities, including Copenhagen, Gottingen, Leiden, Wisconsin, Michigan and Princeton. He was a visiting lecturer at the University of Wisconsin and University of Michigan (1929) and Princeton Universities (1931). He then returned to Cambridge where in 1932 he became Lucasian Professor of Mathematics. During 1947-48 and again in 1958-59, he was a member of the Institute for Advanced Studies, Princeton, N. J. He is Professor Emeritius, Professor of Physics at Florida State University since 1971.

Dirac was elected a Fellow of the Royal Society of London in 1930 and was awarded the Royal Medal in 1939. In 1933 he was awarded the Nobel Prize in Physics. In 1938 he received the James Scott Prize of the Royal Society of Edinburgh. In 1952 he was awarded the Copley Medal of the Royal Society of London and the Max Planck Medal by the German Physical Society.

Dirac is the author of *Principles of Quantum Mechanics* and *General Theory of Relativity.*

Further reading

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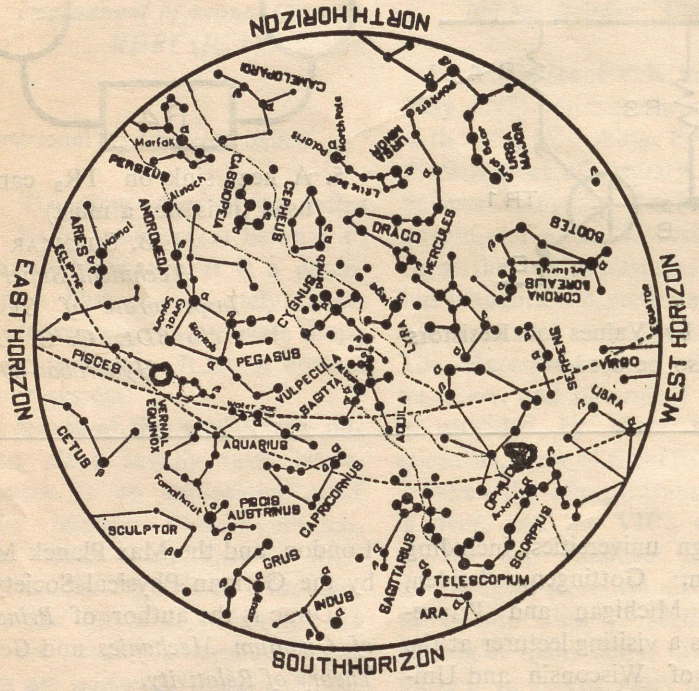
Planets and their positions

SEPTEMBER 1977



MOON

D – FIRST QUARTER 20th

O – FULL MOON 27th

The moon

NEW moon occurs on 13th at 2-53 p.m. and full moon on 27th at 1.47 p.m. I.S.T. The moon passes about four and a half degrees south of Jupiter and five degrees south of Mars on 7th, five degrees south of Venus and about five and a half degree south of Saturn on 11th and about two degrees south of Mercury on 12th. The lunar crescent becomes first visible after the new moon day in the evening of 15th.

The moon is at apogee or farthest from the earth on 5th and at perigee or nearest to it on 18th. The sun is at the autumnal equinox on 23rd.

The planets

Mercury (Budha) is too near the sun to be visible during the first half of the month. It is in inferior conjunction on the 5th. Thereafter, it reappears as a morning star and rises about an hour before sunrise. It becomes direct on 14th and is at the greatest western elongation of about 18 degrees from the sun on 21st. It is in Leo (*Simha*). Its visual magnitude varies from+1.8 to – 1.0.

Venus (Sukra), visible in the morning sky, rises about two hours before sunrise during the month. It passes about half a degree south of Saturn in the evening of 18th. It also passes very close to the star Regulus (*Magha*) on 22nd. It moves from Cancer (*Karkata*) to Leo (*Simha*). Its visual magnitude is about -3.4

Mars (Mangala), a morning star, rises about half an hour after local midnight during the month. It passes about half a degree north of Jupiter in the early hours of 5th. It is in Gemini (*Mithuna*). Its visual magnitude is about +0.9.

Jupiter (Brihaspati), visible in the morning sky, rises about half 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 the sun on 28th. It is in Gemini (*Mithuna*). Its visual magnitude is about –1.8.

Saturn (Sani), a morning star, rises about one and a half hours before sunrise during the first half of the month and two and a half hours before it during the second half. It moves from Cancer (*Karkata*) to Leo (*Simha*). Its visual magnitude is about +0.8.

(*Source*. Nautical Almanac Unit of the Meteorological office, P-546, Block 'N; (1st floor) New Alipore, Calcutta-53).

TIDAL POWER
Its potential and scope in India

It is now possible to harness tidal energy and bring in "blue coal" to India

C. K. GOPINATHAN
S. Z. QASIM

Introduction

HUMAN progress has often been judged from the ways in which man has been able to develop and harness energy, and the overall development of a nation is estimated from the total amount of energy it produces and consumes in relation to its size and population. The energy demand of man has been on the increase since the dawn of history, but a sharp increase in human population has resulted in a much greater demand for energy. With the affluence of a country, the per capita demand for energy goes on increasing, and today a single American consumes as much energy in his everyday life as probably 50-100 Indians.

Petroleum hydrocarbons (oil and gas) have been thought to be one of the best sources of energy. But our needs for energy have gone up so much that even if we pool all

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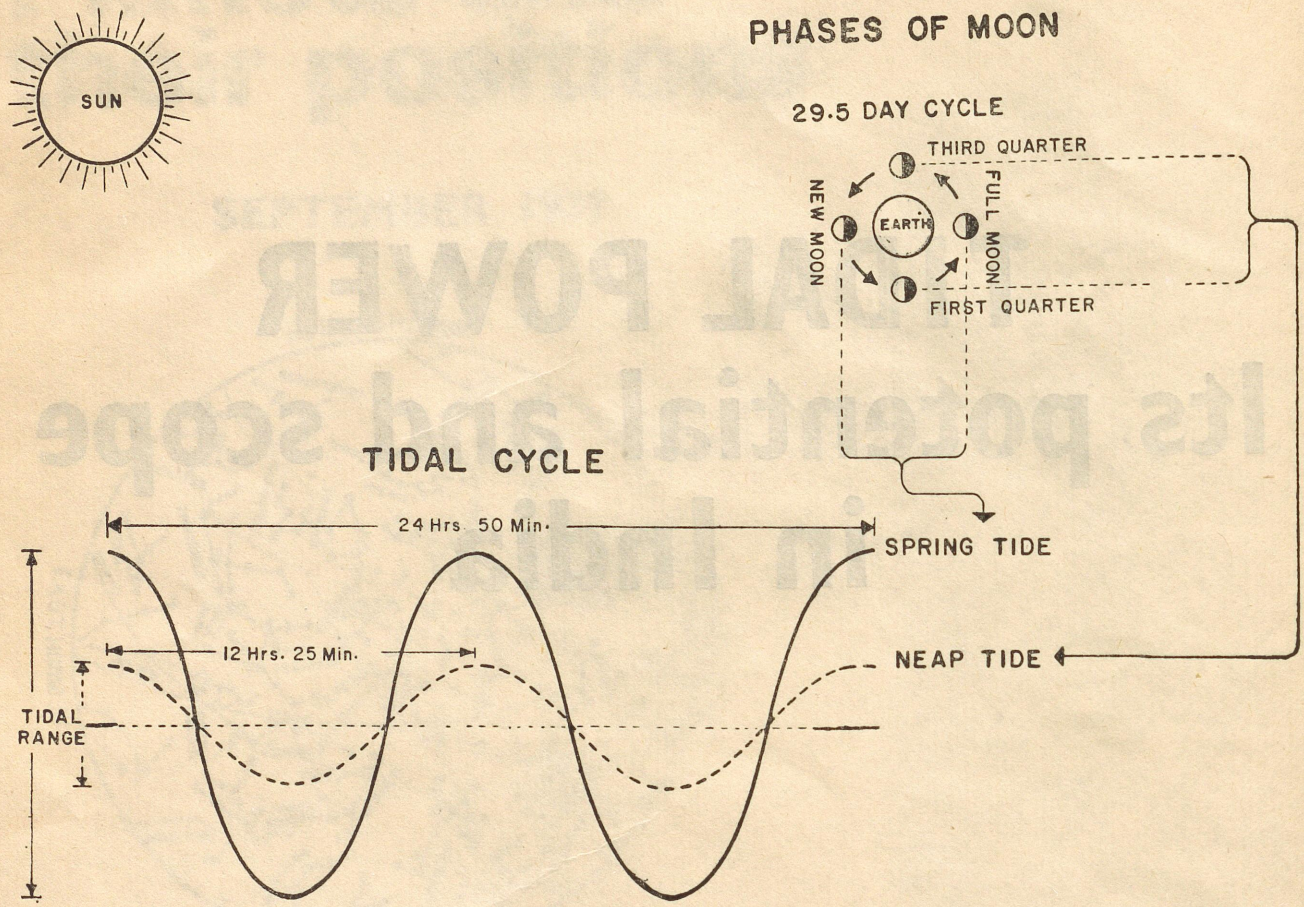


Fig. 1. Classical explanation of tidal rhythm—spring and neap tides. During spring, when the sun, moon and earth are in one direction, the range is maximum. During neap, when the moon is away from the sun and the earth, the range is minimum

the sources of power known today, such as oil and gas, coal, hydropower and atomic power, etc., they would prove to be totally insufficient in the long run.

The most important consideration connected with fossil reserves (oil, gas, coal, etc.) is its depletable nature. According to experts, any exhaustible resource extracted from the ground, in the face of increasing demand, results into a cycle. This cycle starts at zero production, increases exponentially, then decreases exponentially and finally comes to zero. The exploitation of petroleum reserve of the world is likely to reach its peak by about 1990, and by the year 2020 about 90 % of the total source of petroleum in the world would finish.

The awareness, therefore, of the depletable source of energy is forcing many nations to seek such alternate sources of energy as are unconventional and inexhaustible. In this context, two sources of energy —solar and tidal—have been thought to be most promising.

The sea is a storehouse of several kinds of energy. There is energy in the waves, energy in the temperature difference of the water column, energy in the currents and so on. But we still do not know how to utilise these sources of energy economically.

About 20 years ago, similar was the case with tidal energy, although from the historical records it appears that a long time ago some utilization of tidal energy was made by setting up of tide-mills. However, today we know how to make use of tidal energy, largely because of the ingenuity and persistent efforts of French scientists and engineers. In the past, many persons contributed to the problem of tidal power utilisation, but the most outstanding work was of the French engineer, R. Gibrat, who first developed the theory of flexible and controllable utilisation of tidal energy and finally implemented it in the form of a tidal power plant built over the river Rance in France. Further solutions of some of the most complicated problems connected with the utilisation of tidal power came from other

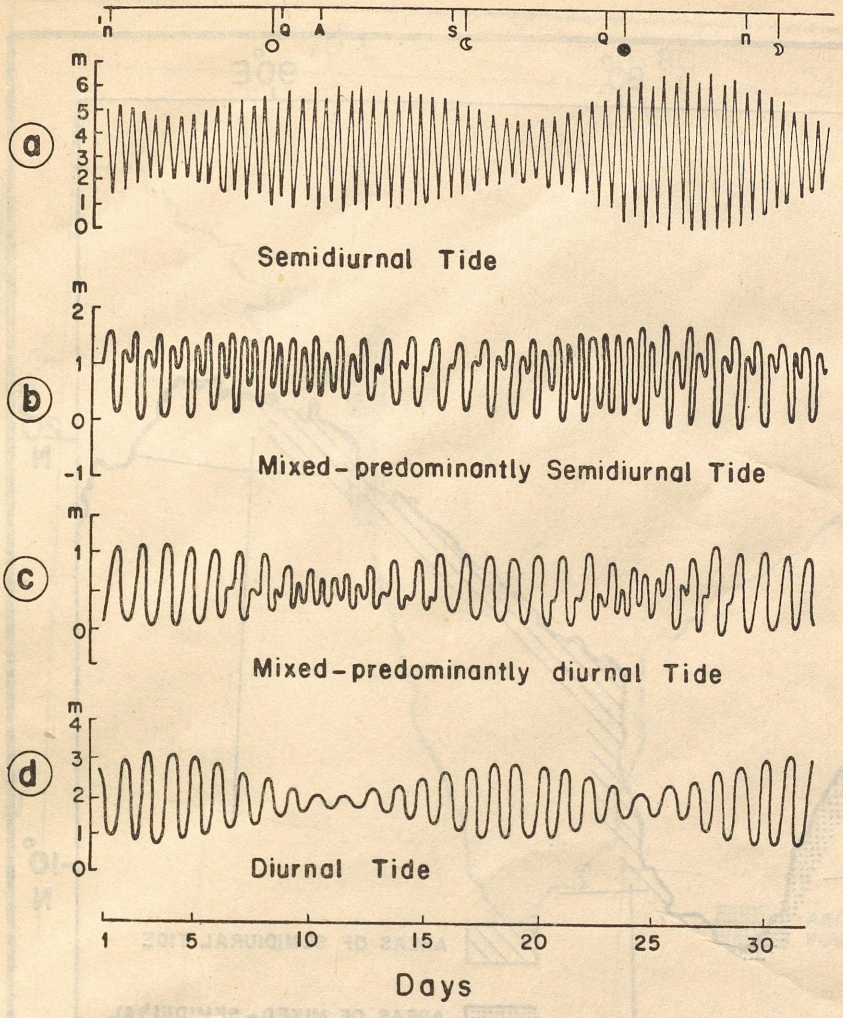


Fig. 2. Types of tides occurring in the coastal areas of India. Time in days is given below in relation to the phases of the moon shown on top

French engineers—Kamerlochez, Casacci and Rowille who developed the idea of reversible flow, bulb-housed turbine systems.

What is tidal power?

Every person living near the sea has noticed that the sea in the inshore and coastal areas rises and falls in a rhythmic fashion. The water in the adjoining bays and estuaries also oscillates up and down from the mean sea level. The flow of water, associated with the rise and fall in coastal area and bays, gets advanced and retarded with the incoming and outgoing tides respectively. When the water at a place is much above the mean sea level, it is called flood tide, and when the level is much below the mean level, it is called ebb tide. If a dam is constructed in such a way that a bay or basin gets separated from the sea and a difference in the water levels is obtained between the basin and the sea, power can be generated from this difference using low head turbines.

Tidal power in the form of electricity is obtained from the oscillatory flow of water during filling and emptying of a nearly closed coastal basin by the tides. There are a number of schemes for tidal power generation.

The construction of power house, sluice-way and dykes is essential to tidal power plants. The most important factor is the design and construction of a generating unit consisting of low head turbines. It took the French engineers nearly 20 years to develop a bulb-type reversible turbine. It is a compact machine which can serve as a turbine during the flow of water in both directions without reversing the position of the turbine. It acts as a motor when electricity is supplied to it. And it can also work as a pump in two directions, or, as a gate regulating the flow of water in either direction.

Advantages and disadvantages of tidal power plants

Tidal power plants—TPPs for short—have their own advantages and disadvantages. Their important advantages are that they replenish themselves, they are absolutely pollution free, and their overall monthly or annual output of power remains constant. There is no chance factor involved in their power generation because the tide will always come and it will always have a definite and predictable range.

In contrast to this, the other types of plants, such as thermal or atomic power plants, constantly require raw materials for their replenishment and they are well-known for their pollution problems. Similarly, the hydroelectric power plants are also known for their large seasonal and yearly fluctuations in the output of energy because they are entirely dependent upon nature's cycle of rainfall, river flow, water storage, etc.

The cost of construction of a tidal power plant is largely dependent upon its location. If its location is favourable as is the case of French tidal power plant at Rance, the cost of power production would be similar to that of the hydroelectric power. Another important advantage of tidal power is that it has a unique capacity to meet the peak power demand effectively when it works in

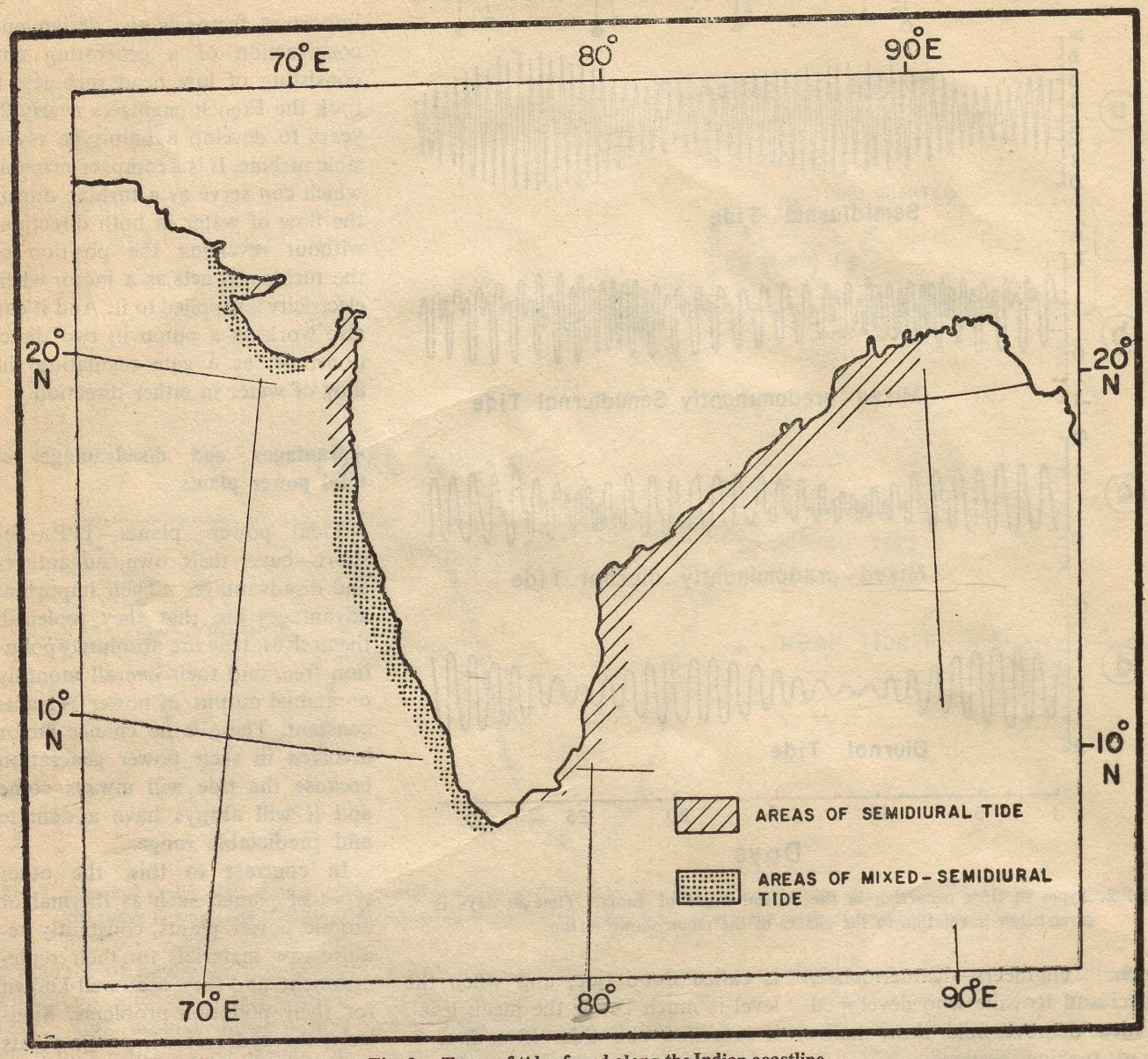


Fig. 3. Types of tides found along the Indian coastline

combination with thermal or hydro-electric plants.

The other benefits of TPPs include recreational facilities to visitors and holiday makers (as Rance Power Plant), elimination of unwanted flooding, possibility of fish farming in tidal basins and excellent road transport over the tidal barrage.

However, the TPP does not directly provide an alternative to thermal or atomic power plants, but can only supplement the other types of plants effectively. Large variations in the tidal range at fortnightly intervals and the high cost of construction of the plant are some of the constraints in the development of tidal power.

Moreover, the serious limitations in the tidal power production are the lack of suitable tidal characteristics in many coastal areas for the construction of TPPs economically and the sophisticated nature of machinery required for power generation. It is interesting to note that the output of power from a TPP varies with the lunar cycle, because the moon largely influences the tidal rhythm, whereas our daily power requirement is directly related to solar cycle. In addition to this, the daily power supply obtained from a TPP also varies intermittently. The other draw-back in the tidal power is that the utilisation of tidal energy on a small scale has not yet proved economical.

Major categories of tides

The oceanic water masses of the earth respond to the tide generating

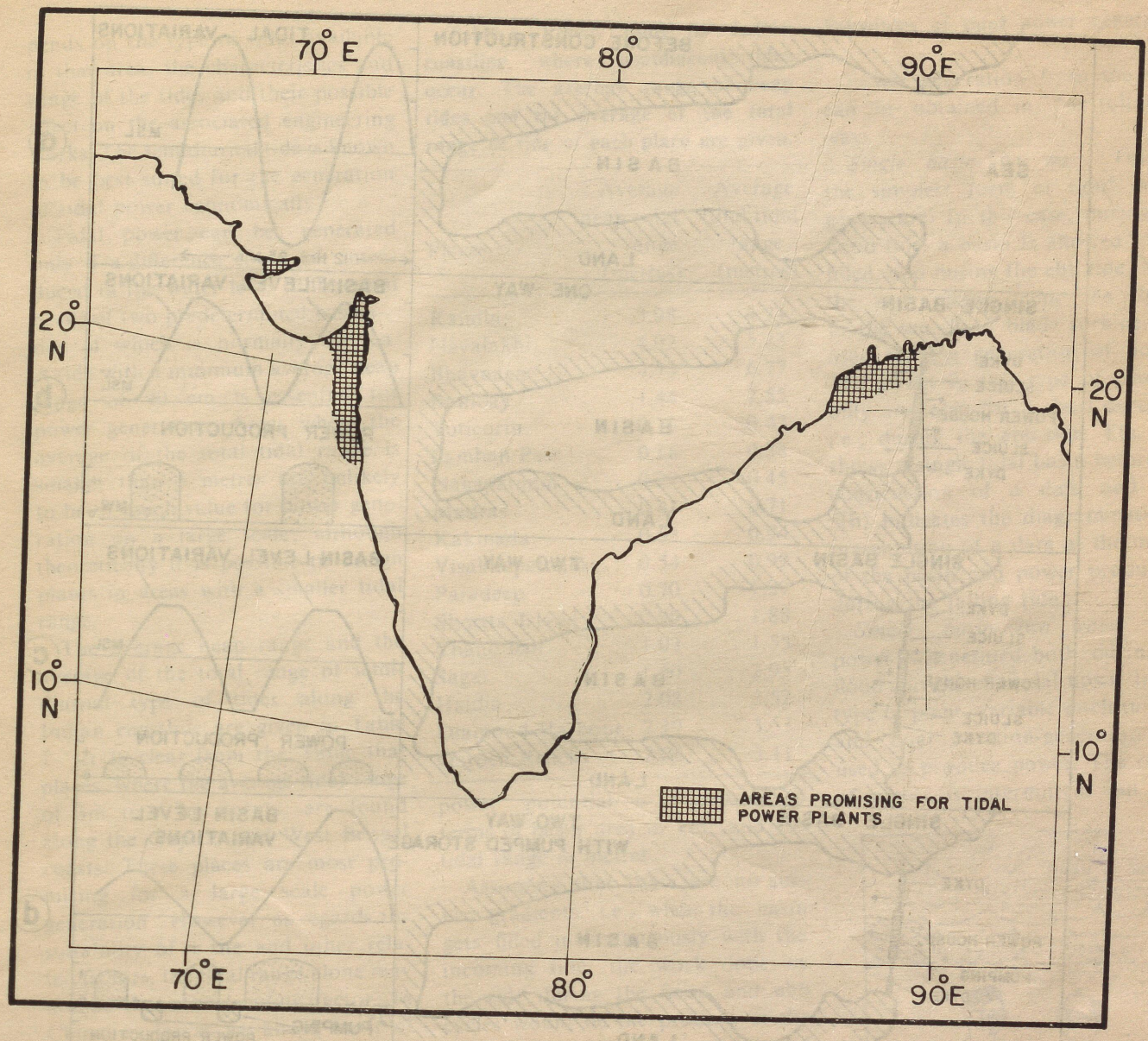


Fig. 4. Some areas along the Indian coastline which are promising for tidal power generation

forces of the moon and the sun in a very complex manner. According to the classical theory of tides, if the entire surface of the earth happens to be covered with water, there will be only two floods and two ebb tides of equal magnitude, about 50 cm in range, daily all along the oceans. But in reality it is not so. The tides in a coastal area may belong to any one of the following four categories :

In areas where lunar influence is predominant, the tide is called semi-diurnal. This has two high waters and two low waters daily, with a negligible change in the level between the two consecutive high and low waters. The duration of rise and fall in the water is nearly equal. In this type of tidal cycle, large ranges occur close to the period of full moon and new moon and they are called spring tides. Similarly, smaller ranges occur close to the 1st and 3rd quarters of the moon and they are called neap tides (Fig. 1). The shape of a 30 days marigram of this type of tide is shown in Fig. 2(a).

The second important category of tides is diurnal. Here also, the water level varies sinusoidally, but the tidal range is small and only one high water and one low water occur daily (Fig. 2, d).

In the other two categories of tides [(Fig. 2(b) and 2(c)] a combination of the two extremes, i.e., semidiurnal and diurnal tides, are found. They are mixed tides, either predominantly semi-diurnal or diurnal, depending upon whether the influence of the former or the latter is predominant. The shapes

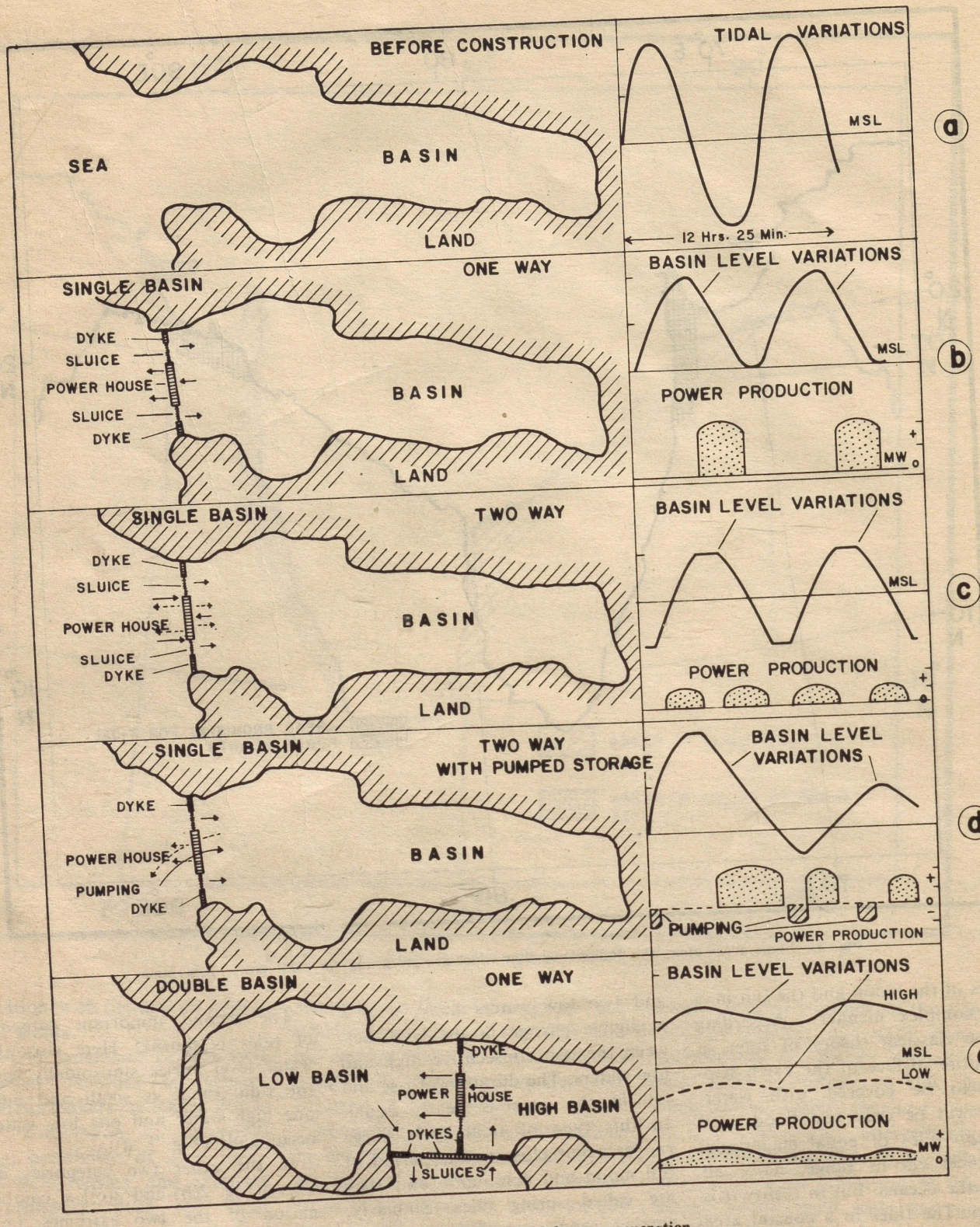


Fig. 5. Some schemes of tidal power generation

of the marigrams in a mixed but predominantly semidiurnal and another mixed but predominantly diurnal types of tides are shown in Figs. 2(b) and 2(c). The regions along the Indian coast where various types of tides are found have been shown in Fig. 3.

Suitability of an area for tidal power

The suitability of a locality for tidal power generation largely de-

pends on the type of tides available in that area, the characteristics and range of the tides and their possible effect on the associated engineering works. The semidiurnal tide is known to be best suited for the generation of tidal power economically.

Tidal power can be generated only if a difference could be introduced in the water level (differential head) of two predetermined basins—one of which is normally the sea. A tide with a minimum average neap range of 90 cm is essential for power generation. Areas where the average of the total tidal range is smaller than 5 metres are unlikely to be of much value for power generation on a large scale; although theoretically it is possible to design plants in areas with a smaller tidal range.

The average neap range and the average of the total range of semidiurnal type of tides along the Indian coastline are given in Table 1. It is clear from the Table that places, where the average tidal range of 3m to 6.7m occurs, are found along the Gujarat and West Bengal coasts. These places are most promising for a large scale power generation. However, as regards the suitability of a site and other related factors, the tidal range alone may not be the only deciding factor. In China, as far as we know, most of the TPPs make use of the minimum neap range of 90 cm. If this is true, then several other places in our country could be considered for tidal power generation. Moreover, the maximum utilization of energy sources from the tides would mean that we may have to go even for smaller TPPs incurring perhaps much higher costs per unit of power generation. Some of the areas in India which are quite promising for TPPs are shown in Fig. 4.

In a hydroelectric project, the power potential of a basin is expressed in terms of discharge rate and the head. In the case of a TPP, the power potential is expressed in terms of basin area in km² and the tidal range in metres.

Table 1. Places along the Indian coastline where semidiurnal tides occur. The average range of neap tides and the average of the total range of tide at each place are given.

Places	Average neap tidal range (metres)	Average total tidal range (metres)
Kandla	3.98	4.94
Navalakhi	4.02	5.23
Bhavnagar	4.79	6.77
Bombay	1.44	2.55
Tuticorin	0.16	0.43
Pamban Pass	0.16	0.38
Nagapatnam	0.27	0.45
Madras	0.41	0.71
Kakinada	0.53	0.94
Visakhapatnam	0.54	0.99
Paradeep	0.70	1.29
Shortts Island	0.99	1.88
Chand bali	1.03	1.55
Sagar	1.60	2.95
Haldia	2.08	3.52
Diamond Harbour	2.19	3.53
Garden Reach	2.06	3.11

Assuming that there are no surface gradients, i.e., when the basin gets filled instantaneously with the incoming tide, the work done by the tide during the flood and ebb cycles would be the product of the weight of water raised and lowered by the tide. Thus, according to Bernshtein, a Russian authority on the subject, the annual energy potential (E_p) of a tidal basin is :

$$E_p = 1.97 \times 10^6 \, H^2 A \text{ kilowatt hours,}$$

where H is the tidal range and A is the area of the basin.

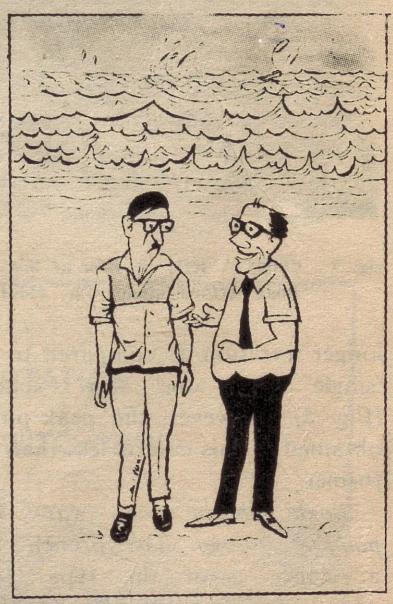
In calculating the power potential, two important assumptions are involved, i.e., the basin area during the course of the tidal cycle remains constant, and the dimension of the basin located in the direction of the tidal wave is equal to or smaller than half of the tidal wavelength.

Principles of tidal power generation

Power generation from the tides can be obtained in the following ways :

Single basin—one way. This is the simplest form of tidal power generation. In this case, during the flood tide, a basin is allowed to get filled, and during the ebb tide, when the water flows from the basin to the sea, fixed blade turbines are used for the generation of power. The power in this type of plant is only available for a short duration, i.e., during the ebb tide. Fig. 5(a) shows a single tidal basin before the construction of a dam and Fig. 5(b) indicates the diagrammatic representation of a dam at the mouth of the basin and power production during the falling tide.

Single basin—two ways. Here power is generated both during the flood and the ebb tidal flows. In this type of plant, variable pitch turbines and dual rotation-generators are used to produce power. The output of power is intermittent but of a



"We know how to generate power from the tides, but the problem is that we need power to generate tides in the sea at all times and in all seasons."

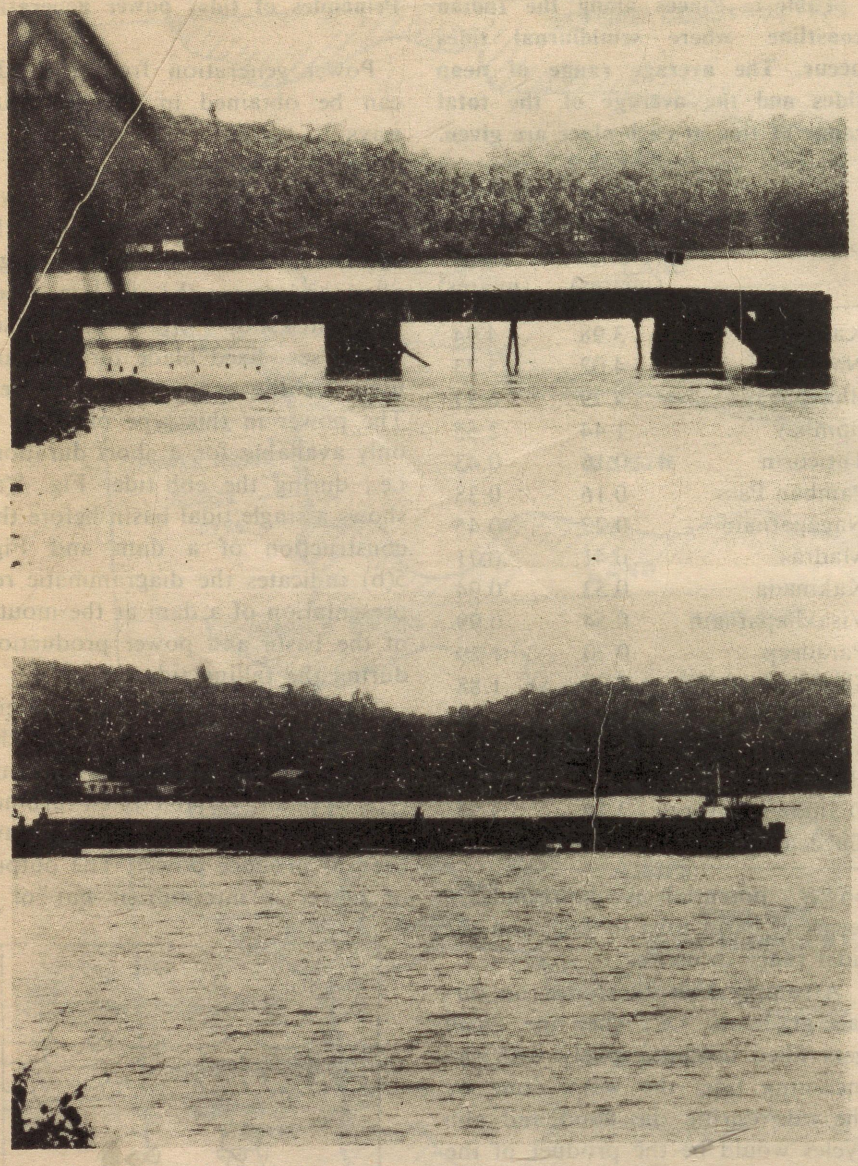


Fig. 7 (Top) A jetty in Goa at low tide (bottom) The same jetty at high tide with a boat berthed along side. Tidal range is about 2m

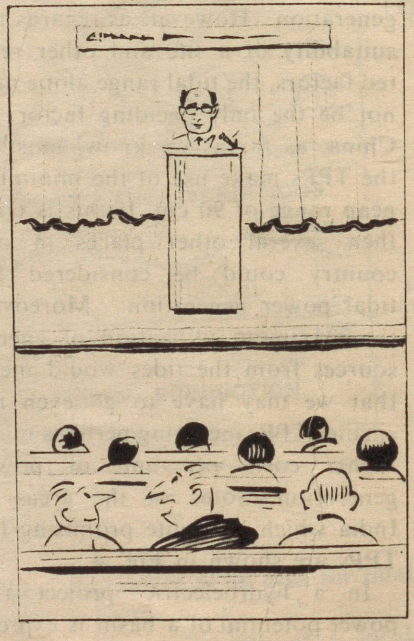
longer duration as compared to the 'single basin—one way' scheme (Fig. 5). However, the peak power obtained in this case is less than the former.

Single basin two way with pumped storage. The French TPP at Rance is of this type. Here power is generated both during flood and ebb tidal flows. Complex machines capable of generating power and pumping the water in either directions are used. A part of the energy produced is used for introducing the difference in the water levels between the basin and the sea at any time of the tide and this is done by pumping water into the reservoir up or down. In this type of plant, continuous power can be produced for a much longer duration [(see Fig. 5 (d)] than the other two schemes mentioned above.

Double basin (De Cour type). In this scheme, the turbines are set up in between the two basins. One basin is intermittently filled by the flood tide and the other is intermittently drained by the ebb tide So, a small but continuous power is made available by the tides [(Fig. 5 (e)]. But during this process, half of the potential energy is sacrificed in introducing the variation in the water levels of the two basins. The cost of construction of a double basin plant is quite prohibitive.

Double basin with pumping from off-peak systems. In this case, off-peak power from some other power plant is used either to pump the water up the high basin or to pump the water down in the low basin. If the pumping head is lower than the basin-to-basin turbine generating head, an energy gain is possible. The construction of this scheme is also relatively expensive.

A few other schemes for tidal power generation have been suggested. According to them, power can be suplied as a function of solard time, and not necessarily as a function of lunar time. But most of these schemes are very expensive to implement. One such system is called the De cour scheme. Of all the systems planned so far to produce intermittent power, the most



"He is pouring out words in torrents". Yes, "he is talking on tidal power."

successful and efficient is the single basin—two way scheme [Fig. 5 (c)].

Tidal power plants of the world

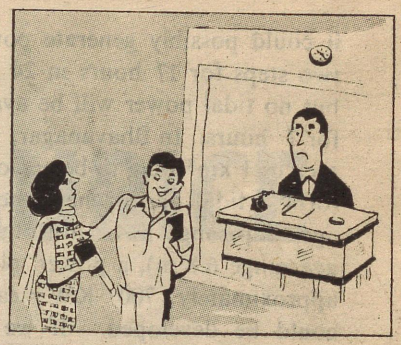
Although many countries including India have the capability of utilising tidal energy, only three nations have succeeded in putting up TPPs—largely on a pilot scale. France was the first country to complete a small pilot TPP in 1957. Taliang TPP of China was probably completed in 1958. This plant is relatively smaller with a capacity of 144 KW. In addition to this, a number of small TPPs are reported to have been constructed in China in 1958. In France, the Saint Malo pilot TPP, near the present Rance TPP, with a capacity of 9000 KW, was constructed in 1959. It is considered to be the first large pilot TPP in the world. The next and the most famous TPP at Rance was commissioned in 1966. The installation of its 24 turbines was completed in 1967. It gives 240,000 KW of power. This is the first tidal power plant in the world which is totally controlled and monitored by computers.

The other important TPP is the Russian experimental power station at Kislaya Guba in the Barents Sea. It was commissioned in 1968. In this plant, the power house was prefabricated, floated to the site and then sunk into a carefully prepared foundation. The capacity of this plant at present is only 440 KW. New TPPs are under consideration in a number of countries like U.K., France, U.S.A., Canada, Argentina and Russia.

Possibilities of TPPs in India

Like many other nations, India is also following a very conventional policy as far as her power resources are concerned. Our main commercial and non-commercial sources of energy are shown in Table 2. At present we are importing crude petroleum of the order of 14 million tonnes at the annual cost of Rs. 1,160 crores to meet our power requirements. Of our total production capacity of about 20,000 MW of electric power, the thermal plants give us 61%, hydroelectric projects 37%, and nuclear plants 2 %.

A preliminary study conducted by the National Institute of Oceanography, Goa, indicates that some areas in Gujarat are very promising for a large tidal power plant. In addition to Gujarat, several other areas can be considered for tidal power generation. For example, in Bombay, the average neap tidal range is about 1.4m and the total average tidal range 2.5 m. If a small bay of approximately 1 km² is enclosed for constructing a power plant, a generating capacity of 900 KW can be obtained (Fig. 6). With a 'single basin—two way scheme'



"His interest in tidal power is now ebbing out."

Table 2. Various sources of energy in India

Commercial		
1.	Oil and natural gas	50%
2.	Coal	29%
3.	Electricity	21%*
Non-commercial		
Cow dung		50%
Firewood, vegetable wastes, alcohol		50%

*The 21% amounts to 20,000 MW of power which includes thermal, hydro-electric and nuclear in the ratio of 61 : 37 : 2

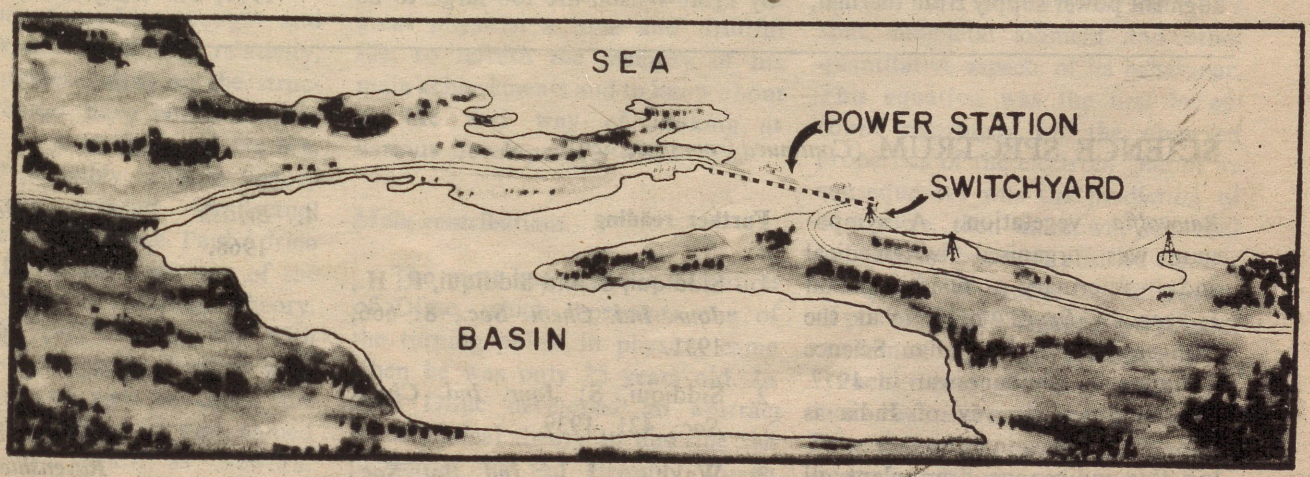


Fig. 6. A diagrammatic representation of a tidal power plant

it could possibly generate power in two steps for 17 hours in 24 hours, but no tidal power will be available for 7 hours. In Bhavanagar, if an area of 1 km^2 were to be enclosed to form a tidal basin where the average neap range is 4.8 m (total average range 6.8 m), a power plant of approximately 700 KW capacity could be developed. If we could dam the big bay in which the port Navalakhi is situated, with 1 km long power house, sluices and dykes at the Hansthal creeks, we can generate power of the order of 600 MW.

The survey conducted by the National Institute of Oceanography in the Gulf of Cambay and Kutch has indicated that the water in the Gulf of Kutch contains very little suspended material whereas in the Gulf of Cambay the water has a very high suspended load. Because of the possibility of silting in the tidal basin due to the settlement of suspended material, when water is stored, the Gulf of Kutch, inspite of its having a lower tidal range than the Gulf of Cambay, may prove to be a better area for TPP. A detailed study is required in some of the promising areas of our country on the potential and scope of tidal power generation.

As has been noted above, the most important use of TPP is to augment power supply from thermal, hydroelectric or atomic power plants to meet the additional power demands during the peak periods efficiently. It is well-known that thermal plants cannot be easily switched off without incurring heavy expenditure in restarting them. In India, the general practice is to switch off some plants during the period when the demand is low (off-peak period). However, the general outlook is changing and the plants are kept running all the time. Surplus power is used for pumping water to higher elevations to run hydel plants. This type of hydel plants are being planned in a number of states like Tamil Nadu, Gujarat, Andhra Pradesh, Bihar and Maharashtra. In Gujarat, a TPP could become an ideal substitute for hydel plants.

One of the recent developments connected with the tidal power generation in India is a report prepared by Prof. E. M. Wilson, who visited India for a period of two months as a tidal power expert of the United Nations Development Programme. He paid a brief visit to NIO also. In his excellent report submitted to the Government of India, he has identified 4 possible schemes of TPP in the Gulf of Cambay and 5 schemes in the Sunderbans area (West Bengal). He has recommended an approach to bring in "bluecoal "in India.

We feel that the projects suggested by Prof. Wilson are too large to be attempted at this stage. The Cambay-1 scheme of Prof. Wilson which can generate 4000 MW to 7400 MW of power would cost about Rs. 1,925 crores. What appears to be important for India is smaller schemes at the ideally located sites involving a minimum amount of expenditure.

Unfortunately our knowledge about the problems associated with tidal power development in India is limited at present. A detailed feasibility study on some of the basic problems such as the suitability of an area and the environmental changes associated with tidal power generation is urgently needed for our country.

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SCIENCE SPECTRUM (*Continued from page 526*)

Rauwolfia vegetation. A symposium was organised by medical and veterinary scientists on *Indigenous Drugs of India* at the 64th session of the Indian Science Congress at Bhubaneswar in 1977. The Botanical Survey of India is also taking keen interest in surveying this indigenous drug plant all over India.

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PAUL ADRIEN MAURICE DIRAC

The famed physicist will be 75 on August 8, 1977

PREM CHAND JAIN

THE fundamental conceptions of the 20th century physics have revolutionized modern thought and activity. Quantum theory, relativity, and the modern ideas on the structure of matter have contributed to a deeper understanding of Nature. They will probably rank in history among the greatest intellectual achievements of all time. Paul Adrien Maurice Dirac has been one of the chief architects of Quantum Theory. August, 8, 1977 marked the 75th birthday of this great English physicist, who can well be called the greatest living physicist and named in the same breath as Newton, Einstein, Bohr. It is worthwhile on this occasion, besides wishing the great physicist a long and fruitful life, to refresh the memory of his main achievements and to know about his life and way of looking at various developments in physics.

Main contributions

The most important contribution of Dirac, which represents one of the turning points in physics, came when he was only 25 years old. In 1928 Dirac developed an abstract mathematical theory to describe the properties of the electron. Given only the particle's charge and mass, he was able to derive the electron's spin, magnetic moment and other quantitative aspects of its behaviour. This equation was the first to account rigorously for the observed properties of the electron. One of its consequences was the prediction of a particle, then unknown, identical to electron but with positive electric charge. C. D. Anderson's discovery of positron in 1932 gave experimental confirmation of this consequence of Dirac's theory. It marks one of the most beautiful examples of how far human intellect can probe into the mysteries of the world by sheer logic

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and sense of judgement. For this accomplishment, Dirac shared with Ervin Schrödinger the 1933 Nobel Prize in physics.

In 1925 two young Dutch physicists, Samuel Goutsmit and George Uhlenbeck, in attempting to account for anomalies in X-ray spectra, suggested that every electron has a permanent spin : that it rotates about its own axis with an angular momentum of $\frac{1}{2}\hbar$. Although it disposed of the spectroscopic inconsistencies, the new model of the atom introduced difficulties of a theoretical nature, as nothing in the then current theory required the electron to spin. It thus became necessary to transform the spinning electron hypothesis from an ad-hoc assumption to a theoretically explainable fundamental of quantum theory.

First to attack the problem were Wolfgang Pauli and C. G. Darwin. Their efforts, however, suffered from a multiplicity of assumptions unjustified except for the need to introduce them into an equation describing the electron's spin. It therefore required the genius of Dirac to propose a new and more satisfactory approach.

Dirac had not set out to account for the spin of the electron. He merely tried to improve on Schrödinger's equation by writing it in a form that would fit into Einstein's theory of relativity. Dirac is mainly a mathematician and his procedure was guided by the demands of mathematical consistency and elegance. In classical relativistic mechanics the energy equation of a particle was written as

$$E^2 - p^2c^2 - m^2c^4 = 0 \quad \ldots \quad (1)$$

where E is the total energy, p the momentum and m is the rest mass of the particle, and c is the velocity of light. From this the quantum mechanical wave equation was derived by replacing E and p by the operators $i\hbar\frac{\partial}{\partial t}$ and $-i\hbar\frac{\partial}{\partial r}$ and causing the left hand-side to operate on a wave function ψ. This gave rise to squared operators $\frac{\partial^2}{\partial t^2}$. Dirac's reasoning led him to regard this matter as being the crucial difficulty, as, in general, quantum mechanics required equations to be linear in $\frac{\partial}{\partial t}$ or E. He, therefore, sought to replace Eq. (1) with an equivalent one which would be linear in E and would thus contain only linear operator $\frac{\partial}{\partial t}$.

To do this, Dirac factored the left-hand side of Eq. (1) into two new equations, both linear in E. Either of these, when set equal to zero, became an energy equation of the sort required. Having shown that the two factors were equivalent, Dirac discarded one and was left with Eq. (2).

$$(E - c\alpha_k p_k - \alpha_o mc^2)\,\psi = 0 \quad \ldots \quad (2)$$

Here, the α's were new variables operating on ψ which had initially been introduced in order to obtain a wave equation linear in E. Dirac realized that for constructing a relativistic wave equation, it was necessary to describe the wave function at each point by four numbers ('components'). Now, since the α's can be represented by 4-dimensional matrices involving only constants, Dirac concluded that they should refer to some inner property of the electron. He proceeded to show that the property involved was precisely the electron's spin.

Dirac then modified Eq. (2) so as to represent the energy of an electron in the presence of an electromagnetic field. The resultant equation gave the electron a magnetic moment of one Bohr magneton. It further stated that the orbital angular momentum was not sufficient to uphold the conservation of angular momentum of an electron moving in a central field. Dirac showed that the conservation of angular momentum was restored by supposing the electron to have an additional spin angular momentum of $\frac{1}{2}\hbar$. He went on to show how this equation accounted for the behaviour of the electron in hydrogen atom and the anomalous spectra which had first suggested the idea of a spinning electron. Other experimental verifications quickly followed.

However, Dirac's theory encountered a serious difficulty. The equation for the electron gave two possible kinds of solution : the states of positive energy as well as the states of negative energy. In Dirac's own words: "This seemed to be a stumbling block to begin with, but it turned out that one could get over that difficulty in a very neat way at the expense of changing one's concept of the vacuum".

The vacuum was thought to be a region where there was nothing at all. Dirac interpreted the vacuum as a state of lowest energy. Now if the electrons can have negative energies too, one would want to have as many of these electrons as possible in order to get the lowest energy. However, according to Pauli's exclusion principle, there cannot be more than one electron in a state. Therefore, the lowest energy state would be a state in which all the negative energy states but no positive energy states are filled. This was the new definition of vacuum given by Dirac.

Now if we have an electron with positive energy, it cannot jump into a negative energy state in vacuum as all the states are already filled. However, it is possible that a photon could excite an electron in the negative energy state in vacuum to one in the positive energy state, thus creating an electron-hole pair. Such a hole was later interpreted as positron. Dirac also predicted that the opposite reaction could occur:

An ordinary or positive energy electron may jump into the hole and fill it up. Then both the electron and the hole disappear. This is interpreted as electron and positron annihilating one another. Their energy will be emitted in the form of chargeless photons. Both these predictions, appearing little more than mere speculations at the time they were advanced, were directly confirmed by experiment not long afterwards.

Dirac's success set a new fashion in theoretical physics. His theory was much more elegant than the earlier mathematical garments which had been laboriously tailored to fit the experimental facts. Now it became fashion to frame a new, elegant mathematical garment and to ask the experimentalists to test its validity. That trend is particularly strong in the theory of fundamental particles.

In addition to the above most important work Dirac has made several other important contributions in quantum physics, particle physics and the theory of gravitation. Dirac introduced the bra and ket vector notation in quantum mechanics and developed the non-commutative algebra—the algebra of the q numbers. So, while solving a quantum mechanical problem, one can equivalently deal in terms of the Schrödinger's wave functions, Heisenberg's matrics or Dirac's q number. Dirac's algebra is, however, found to be most useful and is widely used at present.

In 1937 Dirac put forth his famous hypothesis of large numbers. He took the mass of the electron, the radius of an electron's orbit in hydrogen atom and the time required by a photon to travel that distance as the fundamental units of mass, length and time respectively.

Using these fundamental units, Dirac calculated, besides the speed of light, the mass of the photon, etc., the age of the universe and the ratio of the electron field to the gravitational field between an electron and a proton. Surprisingly, the value of both came out to be $\sim 10^{39}$. Dirac did not take this as merely accidental but proclaimed this to be the discovery of a universal law, viz., the value of the gravitational field is reciprocal of the age of the universe. So, according to this theory, the value of the gravitational constant G is decreasing with time. He extended his assumption to assert that whenever we have an enormous number turning up in nature, it should be connected to the age of the universe. He then proceeded to calculate the total number of nucleons present in the universe which turns out to be nearly 10^{78}. This number is the square of the age of the universe at present. From this he concluded that the total number of nucleons present in the universe at any time is the square of the age of the universe at that time. This hypothesis implies the continuous creation of matter in the universe. This continuously created matter could be produced: (1) continuously throughout space, (2) locally in proportional to the amount and composition of matter already present, or (3) in special places such as the centres of galaxies, or some such-like thing. Of these, Dirac chose the second possibility.

Though it has not yet been possible to decide conclusively in favour or in disfavour of Dirac's hypothesis, it will have far-reaching implications in science if it holds true.

Another interesting contribution from Dirac came in 1948. He developed a general theory of particles with electric charges and magnetic poles in interaction with the electromagnetic field. The theory is symmetrical between charges and poles and as such predicted that separate poles could be observed. That one does not usually observe the separate poles like the separate charges was ascribed to the much larger attractive force which exists between two one-quantum poles of opposite sign as compared to the force between two one-quantum charges at the same distance. It must therefore be very difficult to separate poles of opposite sign. Owing to the very high binding energy of these particles, it was suggested that one should look for the particles with monopoles in atomic processes where energies of the order of 5×10^8 electron volts are involved. They should appear as heavily ionizing particles and would be distinguishable from ordinary charged particles by the property that the ionization they produce would not increase towards the end of their range but would roughly remain constant.

Following the prediction of the monopoles, numerous searches for them have been made. Some have even claimed to have discovered the monopole, while others have refuted this claim so that the question whether monopoles exist or not is still debatable.

Views on development of physics

According to Dirac the development of physics consists of a steady development superimposed by a number of big jumps. It is these big jumps which are actually the most interesting and important feature of this development. The background of steady development is largely logical. It takes place as a natural sequence from the previous setup by the application of the well-known fundamental principles. The big jumps are something entirely new. These big jumps usually consist in 'overcoming a prejudice'. By 'prejudice' Dirac means a conception which is there from time immemorial and is taken for granted. But then a physicist finds that the concept has to be questioned. He has to replace this 'prejudice' by something more

precise and leading to some entirely new conception of nature.

The special relativity provides a beautiful example of this shedding of a 'prejudice'. It changed the concept of simultaneity. Earlier, scientists used to think it obvious that the statement that two events take place simultaneously has a precise meaning, an absolute sense. But it was left to Einstein who, in the light of accurate experimental evidence, really grasped the need for getting rid of this absolute concept of simultaneity and replacing it by a new four-dimensional picture of the world in which the space and time have to be considered on the same footing.

Quantum theory has developed through several big steps. Planck's introduction of finite quanta of energy in the electromagnetic field, Bohr's model of the atom and the final formulation of the quantum theory have all been big jumps and each represents the replacement of an old concept by an altogether new one. That how difficult it is to get rid of the deep-rooted old concepts and how these 'prejudices' block the path of further progress may be clear from the following candid assertion of Dirac:

"Up until about 1930 physicists thought there were only two fundamental particles, the electron and the proton. The reason for that was that there are two kinds of electricity, positive and negative, and a particle is needed for each of them, and that is all that one needs. There was very strong reluctance to postulate new particles up until about that time.

"That led me astray when I first worked out the ideas about the holes in the vacuum distribution of electrons. I felt that the holes must represent protons because they certainly had a positive charge. I thought right at the beginning I would expect them to be symmetrical with the electrons and to have the same mass as the electrons. But it was rather inconceiveable to me that there should be a new particle with a positive change and the mass of the electron. I reasoned that if such particles did exist, the experimentalists would certainly have seen them.

"Why did the experimentalists not see them? Because they were prejudiced against them. The experimentalists had been doing lots of experiments where particles were moving along curved tracks in a magnetic field. The curvature indicates which way the particle is moving along the track if one knows the sign of its charge. The experimentalists regularly saw electrons coming out from a source and having the appropriate curvature in the tracks. But they sometimes saw the opposite curvature, and interpreted the tracks as electrons which happened to be moving into the source, instead of the positively charged particles coming out. That was the general feeling. People were so prejudiced against new particles that they never examined the statistics of these particles entering the source to see that there were really too many of them.

"Since about 1930, the climate of opinion about new particles has changed completely. Many new particles have been discovered and experimenters and theoretical people are both willing to postulate new particles on the flimsiest grounds."

Though Dirac feels that the Quantum Theory is an extremely good theory and it is in wonderful agreement with observation over a wide range of phenomena, he does not feel complacent about the present state and is fully aware of its shortcomings too. How one can form a consistent picture behind the rules for the present quantum theory is one kind of difficulty. Another difficulty of this theory is that when one applies these laws to extreme conditions–to phenomena involving high energies or smaller distances—one sometimes gets results that are ambiguous or not really sensible at all. Of these, he does not attach much significance to the first difficulty which is of conceptual nature. He regards that the developments of the physicist's conception of nature is continuously evolving and at present we are nearly in an interim stage. We must not attach too much importance to the present concepts as we must expect future developments of fundamental character which will change these concepts.

Dirac believes that it is more important to have beauty in one's equations than to have them fit experiment. A search for beauty together with a real, sound insight is a sure line of progress. If there is no complete agreement between the results of one's work and experiment, one need not feel discouraged, as the discrepancy may be due to minor features that are not properly taken into account and that will get cleared up with further developments of the theory.

Life and awards

In seeking to understand the achievements of this great physicist one might well wonder the role played by chance. Dirac would have, under normal conditions, pursued a career in electrical engineering, a field in which he graduated from Bristol in 1921. On graduation he looked for a job but could not get one because of the depression in that field. He went back to Bristol and decided to study mathematics. Dirac and Miss Dent were the only two students in the honours course in mathematics. Miss Dent was quite determined to take a course in applied mathematics. In order that the mathematical faculty does not have to give two sets of courses, Dirac also chose applied mathematics. That was his way back to science from where he never looked

(*Continued on page 483*)

THE WORLD OF PRIMES

The prime numbers are like stars in the galaxy to be looked at with ever increasing curiosity and wonder

SHYAMAL K. MAJUMDAR

FOR a long time now, both professionals and amateurs in number theory have shown great interest in the sequence of integers 2, 3, 5, 7, 11, 13, 17, 19, 23, 29, 31... known as prime numbers. The basic characteristic of these numbers is that they have no divisors except unity and themselves. Although it is not possible to say exactly when the concept of prime number was first clearly defined, some elementary facts about them were known to the ancient mathematicians. For example, in the works of the Greek geometer Euclid (300 B.C.) we find the following theorems about the prime number :

(i) Every positive integer can be expressed as a product of primes. The factorisation is unique except for a rearrangement of the factors; (ii) The number of primes is infinite; and (iii) The primes can be listed by the 'Sieve of Eratosthenes'.

An elementary proof of (ii) based on Euclid is as follows : Suppose there exists a largest prime number p. Take the product of the primes $2,3.5,7....p$ and call this number. N. Consider the number $N + 1$. This number is obviously greater than p. Also, no prime from the set $2, 3,.... p$ divides $N + 1$ as they all leave the remainder unity. So, either $(N + 1)$ is itself a prime or by (i) $N + 1$ has a prime factor larger than p. Both conclusions contradict the hypothesis of p being the largest prime.

Eratosthenes (276-194 B.C.) was another Greek scholar who developed a procedure for sorting out the primes. Suppose we want to list all the primes less than 100. We first write out all the numbers from 1 to 100. Starting from 2, we strike out from the list every second number which is a multiple of 2, i.e., 4, 6, 8, 10,....till 100. Next we discard from 3 every third number which is a multiple of 3, i.e., 6, 9, 12,...., etc. Then start from 5 and discard every fifth number, i.e., 10, 15, 20...., etc. Obviously, numbers like

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6, 12, 15, will occur more than once in the discarded list. This repetition is partially reduced by using the fact that for primes upto N, we need to erase all multiples of the primes 2, 3, 5, 7,.... which are less than $\sqrt{N}$. For example, if $N=100$, we need not strike out multiples of 11 ($11 > \sqrt{100}$) since prime multiples of 11, e.g., 22, 33, 55, 77, 99 have already been discarded earlier. An algorithm based on this idea and suitable for use on a modern computer for finding primes below N is given below :

1. Store 3 as the first prime number and as N.
2. Add 2 to N.
3. Start dividing N by the primes found earlier.
4. If the remainder is zero for any of the division then N is not a prime number. Go to step 2.
5. If the square root of the prime number which was the last divisor exceeds N, then N is itself a prime number. Store it in prime number list.
6. If $N<10^6$ (say), go to step 2.
7. Print the prime number list.

Note that the even prime 2 must be added to the final list to make it complete. The set of primes between 1 and 209 are given in Table 1.

Table 1

Primes below 100	Primes between 100 and 200
2, 3, 5, 7, 11, 13, 17, 19, 23, 29, 31, 37, 41, 43, 47, 53, 59, 61, 67, 71, 73, 79, 83, 89, 97	101, 103, 107, 109, 113, 127, 131, 137, 139, 149, 151, 157, 163, 167, 173, 179, 181, 191, 193, 197, 199

The number 2 is the only even prime, the rest are all odd. A number that is not prime is called composite. Tables giving the prime factors of composite numbers are often useful. A factor table gives the least prime divisor of a composite number. Since it is not difficult to find out whether a number is divisible by 2, 3, 5, the numbers divisible by them are often excluded from the factor tables so as to economise on the size of the table. One of the most authentic factor tables of numbers upto ten million is the work of D. N. Lehmer (1867-1938) of U. S. A.

How are the prime factors of a composite number determined? One of the early attempts in this direction was made by the French mathematician and jurist P. de Fermat (1601-1665). An odd composite number is expressed as the difference between two squares which is easily factorised. The pair of numbers in these factors are then determined by an iterative method. Let n be an odd composite number and suppose

$$n=ab,\ b \geqslant n \qquad \ldots(1)$$

We want to write n as

$$n=x^2-y^2=(x-y)\ (x+y) \qquad \ldots(2)$$

which means

$$a=x-y \text{ and } b=x+y.$$

It follows that

$$x=\frac{b+a}{2},\quad y=\frac{b-a}{2} \qquad \ldots(3)$$

Now as n is odd, both x and y are odd integers. From (2) we can write

$$x^2=n+y^2 \qquad \ldots(4)$$

We see from (4) that $x^2 \geqslant n$ and so $x \geqslant \sqrt{n}$. We now successively substitute on left hand side of (4) values of x greater than $\sqrt{n}$ and check whether the corresponding x^2-n is a perfect square. Through his factorisation technique, Fermat was able to decompose a large number of odd composite numbers into their prime constituents. For example, Fermat found that the factors of 2, 027, 651, 281 are 46, 061 and 44, 021 each of which is a prime. The chain of computation in this factorisation procedure is actually not very lengthy because in most cases the last two digits of x^2-n tell us whether it is a perfect square or not. We know that the last two digits of a square number are confined to the following 22 possibilities :

00	21	41	64	89
01	24	44	69	96
04	25	49	76	
09	29	56	81	
16	36	61	84	

Fermat, one of the greatest number theorists, derived a few important theorems on primes and made some interesting conjectures (incidentally, number theory is a fertile field for conjuncture making!) about the primality of numbers of certain types. Fermat conjectured that all numbers of the form $2^{2^n}+1$ are primes. These numbers are known as Fermat numbers F_n. It is easy to verify that for $n=0, 1, 2, 3, 4$, the corresponding Fermat numbers 3, 5, 17, 257 and 65, 537 are all primes. Fermat's conjecture was proved to be false by the Swiss mathematician L. Euler (1707-178A.D.) who discovered that

$$F_5=2^{2^5}+1=4294967297$$
$$=641 \times 6700417$$

is a composite number. Euler also developed a factorisation method which applies to numbers which can be represented as the sum of two squares. He also proved a theorem of Fermat that every prime of the form $4x+1$ can be represented as the sum of two squares. For instance, when $x=1, 3, 4,$.....we get primes of the form 5, 13, 17....., and they can be expressed as the sum of two squares, e.g., $5=2^2+1^2$,

$13=3^2+2^2$, $17=4^2+1^2$

Fermat proved that for every number 'a' not divisible by the prime p, $(a^{p-1}-1)$ is eactly divisible by p. Euler generalised this theorem of Fermat by proving that if the positive integers a and m are prime to each other then $(a^{\phi(m)}-1)$ is exactly divisible by m where $\phi(m)$ is the number of integers from 1 to m that do not divide m exactly. For example, when $m=9$, $\phi(9)=6$. If $m=p$ and p does not divide a, we get Fermat's theorem.

M. Mersenne (1588-1648 A.D.) was a Franciscan friar and a contemporary of Fermat. Mersenne was interested in numbers and in a list prepared by him in 1644 he conjectured that numbers of the form 2^p-1 were primes, where p itself was a prime $\leqslant 257$. Numbers of the form 2^p-1, where p is a prime, are known as Mersenne numbers M_p. Like Fermat numbers, all Mersenne numbers are not primes. In fact, several errors were detected in the list of Mersenne in late nineteen forties. Table 2 taken from a recent article by John Brillhart, D. H. Lehmer and J. L. Selfridge (*Mathematics of Computation* Vol. 29, No. 129, 1975), gives the recent status of some of the Mersenne numbers M_p.

The first twelve Mersenne primes appearing in the first row of Table 2 were known long before the appearance and use of computers in research. For example, M_{31} was found by Euler in 1750. From early nineteen fifties, computers have been giving impetus to research in different branches of number theory. Computer-aided researches are directed towards (1) searching for new primes; (2) factorising numbers having special forms into prime components; (3) verifying or demolishing outstanding conjectures; and (4) studying twin primes.

Pioneering researches relating to problems (1) to (4) have been carried

Table 2

p	Character of 2^p-1
2, 3, 5, 7, 13, 17, 19, 31, 61, 89, 107, 127	Prime
(All other $p < 172$) and 179, 181, 197, 233, 239, 241	Composite and completely factored
199, 227, 257	Composite but no factor known

out by D. H. Lehmer (b. 1905), his wife Emma Lehmer and their associates at the University of California, Berkeley, U. S. A. Over the past forty years they have developed a variety of factorising methods and tests for identifying a prime, e.g., the electronic sieving machines that carry out the factorisation process automatically and accurately at a very high speed.

The primality of M_p for $p=521$, 607, 1279, 2203 and 2281 was announced by this group in early nineteen fifties. Later, it has been established that M_p for $p=3217$, 4253, 4423, 9689, 9941 and 11213 are primes, the last three being discovered by D.B. Gillies. The 23rd Mersenne prime $2^{11213}-1$ was found by Gillies in 1963-64 on the computer at the University of Illinois, U. S. A. and was the largest known prime till 1971. The people of Illinois were so happy at this discovery that they arranged for the US Post Office to cancel the stamps on locally posted letters with the statement "$2^{11213}-1$ is a prime." The 24th Mersenne prime, $2^{19,937}-1$ was found by Bryant Tukerman using an IBM 360/91 computer at the IBM Research Centre at Yorktown, New York, on the evening of March 4, 1971. This is the latest and largest known prime number having 6002 digits beginning and ending with 4315424.....8041471.

The concept of perfect numbers owes its origin to the Greek number theorist Pyhthagoras (582-507 B.C.) and his associates. Perfect numbers are closely related to Mersenne primes. An integer n is called perfect if it equals the sum of its divisors. The numbers 6 and 28 are elementary examples ($6=1+2+3$ and $28=1+2+4+7+14$). An even integer is perfect only when $n=(2^p-1)2^p-1$ for some prime p for which 2^p-1 is a Mersenne prime. The largest prime found so far is M_{19337} and the 24th even perfect

"Although he lives in his world of primes, he has not given me the feeling that I have a secondary place in it."

number is $(2^{19337}-1).2^{19936}$. This is the largest perfect number so far. This number has 12,003 digits and begins and ends with 931144.... 942656. These results were found by Bryant Tuckerman in 1971.

Factorisation of Fermat numbers and numbers having specified forms such as $2^n \pm 1$, $2^{2n} \pm 2^n + 1$, etc., have been attempted by D. H. Lehmer and his associates at California University. The seventh Fermat number $2^{2^7} + 1$ was decomposed into to its prime constituents on the IBM 360/91 machine by Michael A. Morrison and John Brillhart on the morning of September 13, 1970. The number has 39 digits and had previously withstood many attempts at its factorisation. One of its prime factors is 59649589127497217. We know that the number of primes is infinite but how are they distributed among the total set of integers ? The distance between the successive primes is irregular and appears to increases as we move higher up in the sequence of integers. Let x denote any positive number and $\pi(x)$ the number of primes within and including x (e.g., if $x = 10$, then $\pi(x) = 4$). The Prime Number Theorem (PNT) asserts that as x is made arbitrarily large, the difference between $\pi(x)$ and $x/\log x_e$ falls off as higher powers of $x/\log x_e$. The French mathematician J. Hadamard (b. 1865, died recently) and the Belgian de la Vallee Poussin (b. 1866) independently gave the first complete proofs of the PNT in the year 1896.

Two famous conjectures, one on primes and another on perfect numbers, that are yet to be proved or disproved are worth mentioning. The first one was proposed by the German mathematician and civil servant C. Goldbach (1690-1764 and is known as Goldbach's conjecture. Goldbach speculated in 1742 that every even integer $\geqslant 6$ is the sum of two odd primes and every odd integer $\geqslant 9$ is a sum of three primes. The Russian number theorist Vinogradov proved in 1937 that every sufficiently large odd number is a sum of three primes, but this result is in no way a proof of the conjecture. Vinogradov received the first prize of 100,000 roubles for his work on Goldbach's problem. The second conjecture relates to the odd perfect numbers. Do there exist any odd perfect numbers? Nobody has been able to prove or disprove their existence! Recently (1968) B. Tuckerman announced that an odd perfect number, if it exists, must have at least 36 digits.

The phenomenon of twin primes poses questions regarding their distribution and pattern formation similar to those arising in the case of primes. The least possible distance between two consecutive primes (excepting 2 and 3) is 2. The prime pairs separated from one another by an even multiple of 2 are known as twin primes. The twin primes under 100 with separation distance 2 are (3, 5), (5, 7), (11, 13), (17, 19), (29, 31), (41, 43), (59, 61), and (71, 73). In the general case, a prime p and its escort p' is at a distance d where $p' = p + d$. A list of primes under 100 with $d = 6$ are (5, 11), (7, 13), (11, 17), (13, 19), (17, 23), (23, 29), (31, 37), (37, 43), (41, 47), (47,53), (61, 67), (67, 73) (73, 79), (83, 89), (97,103). This pair is more numerous than the previous pair ($d = 2$). It has been observed that under thirty million there are 152892 prime twins with $d = 2$, but nearly twice as many, viz., 304867 prime twins with $d = 6$. The density of prime twins with d=2, 4, 6, 8,....70 has been investigated by D. H. Lehmer and E. Lehmer. It seems that twin primes become quite rare in the tables as x is made larger and larger.

This brief survey of the prime numbers, highlighting some of the recent attempts and achievements in unveiling their secrets, is likely to create the impression that the world of primes is a strange world about which we perhaps know more than what we understand. This view is not altogether wrong. The primes are really like the stars in the galaxy to be looked at with ever increasing curiosity and wonder.

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THE SEARCH FOR EXTRA TERRESTRIAL LIFE

S.N. SINHA
J.J. GHOSH

The Viking mission has failed to find any sign of life on Mars. Does it mean we are alone in the universe?

EVER since man started understanding the scientific basis of the origin of life and the evolutionary processes on earth, he had been asking himself : Is earth the only place in the universe where life evolved ? What are the factors that control the origin of life in a heavenly body ? Is it that life evolves by chance or out of necessity when the starting materials are present ? With these questions in mind, man started searching life in his own solar system with the hope that a second finding of carbon-based life in the same solar system would support the notion that life is indeed a property of carbon atom. Of all the elements, carbon and silicon happen to share the infinite capacity to combine with other elements to form large molecules. Although we have seen the unity among diversity of the carbon-based life in our planet, we have not yet come across any silicon-based life.

The search for extraterrestrial life depends upon a complete analysis of environment and soil of the planet which in turn calls for a meticulous experimental design free, as much as possible, from geochauvinism (we are all bound by our understanding of earth life, which may not be the case for the planet under study). In addition to this, a balanced advancement of a number of inter-disciplinary subjects are required. Fortunately, the last twenty-five years have seen tremendous developments in space science. The technology has reached such perfection as to undertake space missions for distant planets and to land fully automated and miniaturised laboratory for conducting physical, chemical and biological analyses of soil samples of remote planets. The present article will deal only with the biolo-

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gical analysis of soil samples which are used as markers for searching extraterrestrial life.

Soil as the marker for life

Since the life detection device makes its first impact on the surface crust of other planets, it is the soil where the search for extraterrestrial life seems pragmatic. Apart from this, it is known that soil is the repository and source of the widest diversity and the greatest density of microbial life. As we know, soil as an environment for microorganisms possesses certain unique features, which, although probably do not change the genetic and biochemical potentials of microorganisms, probably influence their phenotypic expression. Soil microbiology happens to share several points of relevance with the search of life on other planets. Search for primitive types of microbial life in the soil of other planets is, however, based on certain chemical assumptions, e.g., carbon is the most likely element on which extraterrestrial life would be based; that all biochemical reactions probably take place in aqueous solution; that the energy to sustain life is derived from sun through photosynthesis

In the first step, proper sampling of extraterrestrial soil becomes imperative. The samples are to be taken from an area unaffected by the landing of spacecraft. Stringent precautions are taken to avoid contamination of extraterrestrial soil with terrestrial microorganisms.

Life detection techniques: Methodology

Once an extraterrestrial sample is obtained, it is subjected to life detection experiments. The general experiments for the detection of extraterrestrial life are listed below:

Physiological studies

(a) Morphological evidence,
(b) Evidence of growth, and
(c) Evidence of reproduction.

Chemical and biochemical studies

(a) Evidence of metabolism,
(b) Evidence of photosynthesis, and
(c) Presence of organic compounds of biological interest by—(i) physical, (ii) chemical and (iii) biochemical assays.

The outlines of the experiments encompassing only metabolism, growth and reproduction are described below.

Metabolic studies. For the evidence of metabolism the instrument developed is known as "Gulliver", which essentially contains an incubation chamber, radioactive substrates, a gas trapping device and a Geiger counter (for measuring radioactivity). Radioactive substrates containing ^{14}C and ^{35}S in aqueous solution are injected into the soil sample. If microorganisms are present in the extraterrestrial soil, they will metabolise the radioactive substrates and produce radioactive gases. These radioactive gases are then collected by chemical precipitation and the precipitate thus obtained is measured for the presence of radioactivity by a radiation counter. An exponential increase in radioactivity is indicative of the existence of life with growth or reproduction. A suitable control is run simultaneously with the same soil sample in order to distinguish between a metabolic response and an inorganic reaction with the extraterrestrial sample. Inhibition is induced in the soil of the control unit by application of heat (sterilization) or by a chemical antimetabolite (inhibitors of metabolic pathways). "Gulliver" has undergone a number of modifications from time to time and its general applicability has rigorously been evaluated with terrestrial microorganism.

Experiments on photosynthesis. It is assumed that any extraterrestrial life will obtain its ultimate energy from sun. In order to validate this hypothesis, test for photosynthesis in the exotic environment becomes essential. To carry out the test for photosynthesis, a small quantity of the soil and its overlying atmosphere are enclosed. Radioactive carbon dioxide is then introduced into the trapped atmosphere in presence of light and time is allowed for any photosynthetic organisms present in the soil to fix carbon dioxide including the radioactive carbon dioxide. The enclosed atmosphere is then replaced by a fresh extraterrestrial atmosphere and light is excluded. The evolution of radioactive carbon dioxide takes place due to endogenous respiration of the photosynthetic microorganisms. The radioactive cabon dioxide thus produced is monitored by a process similar to "Gulliver".

Detection of adenosine triphosphate (ATP). The intermediate energy-rich adenosine triphosphate (ATP) is known to be present in every living terrestrial cell. A sensitive assay for ATP employs the luciferase enzyme system present in the lantern of firefly. This assay system is therefore employed to detect ATP in the exotic soil with the hope that existence of such an energy-rich compound would ratify the presence of extraterrestrial life. A sample of the soil is so treated as to release the microbial ATP, for example, by extraction with dimethylsulfoxide. An aliquot of this extract is then injected into a solution containing the luciferase system extracted from the firefly lantern (luciferase, luciferin, and magnesium ion in the presence of dissolved oxygen). Presence of ATP will result in the appearance of light. The peak intensity of light produced is directly proportional to the amount of ATP present. The reaction is monitored in an instrument containing a photomultiplier tube and the result is displayed on an oscilloscope

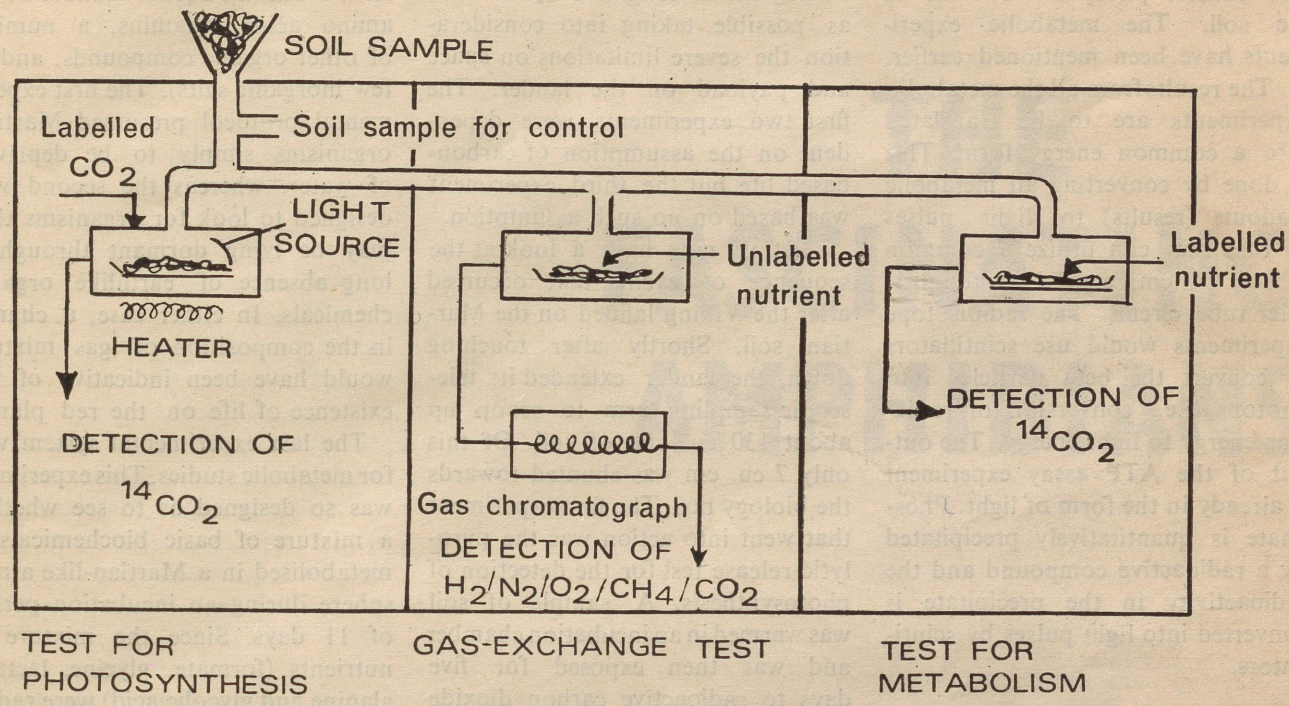


Fig. 1. Biological analysis of the Martain soil sample

or recorded in a strip chart. The miniature model of ATP assay instrument can extract ATP from particulates and conduct quadruplicate assays within two minutes. Although this assay is fairly sensitive, the mere presence of ATP however cannot establish the existence of life. The reason is that under primitive earth conditions, ATP was presumably synthesized abiogenically (non-biologically). Nevertheless, indication of an increase in ATP content with time in a soil sample can be regarded as a firm evidence for the existence of life.

Phosphate uptake experiment. Requirement for inorganic orthophosphate for the synthesis of ATP and nucleic acids is a well-known phenomenon in terrestrial biochemistry. Therefore, the uptake of orthophosphate from solution can be regarded as a further evidence of metabolism in extraterrestrial soil. Radioactive phosphorus is not used due to its short half-life. Orthophosphate solution is incubated with the soil, and at intervals aliquots are removed and filtered. They are then assayed for the disappearance of dissolved orthophosphate by stannous chloride—ammonium molybdate method. Uptake of orthophosphate can take place even in the absence of growth or reproduction. Therefore a control is also run along with the experimental test. The antimetabolite used in the control is 2, 4-dinitrophenol which is a well-known uncoupler of oxidative phosphorylation.

Automated microbial metabolism laboratory (AMML)

It was realized as early as 1965 by NASA and the biological community that a successful planetary exploration programme requires the integration of a number of individual biochemical experiments into a single instrument package. This package would constitute an automated laboratory to be landed on the surface of the planet. AMML has been developed by Dr. Gilbert V. Levin and his group of Biospherics Research Inc., Washington, D.C. and was supported by the Bioscience Programmes, Office of Space Science Applications, NASA.

Six metabolic experiments and six associated physical determinations of biological interest are incorporated into the AMML. The physical measurements serve two purposes. They are useful for interpretation of the biological results and, with relatively minor modifications, give an idea of the environment. Specifically, the parameters to be studied are temperature, atmospheric oxygen, pH of soil,

light intensity, background radiation and soluble phosphate content of the soil. The metabolic experiments have been mentioned earlier.

The results from all the metabolic experiments are to be translated into a common energy form. This is done by converting all metabolic readouts (results) to light pulses so that they can utilize a common sensor system, e.g., a photomultiplier tube circuit. The radioisotope experiments would use scintillators to convert the beta particles into photons, i.e., conversion of radiation energy to light energy. The output of the ATP assay experiment is already in the form of light. Phosphate is quantitatively precipitated by a radioactive compound and the radioactivity in the precipitate is converted into light pulses by scintillators.

Is our red planet alive ?

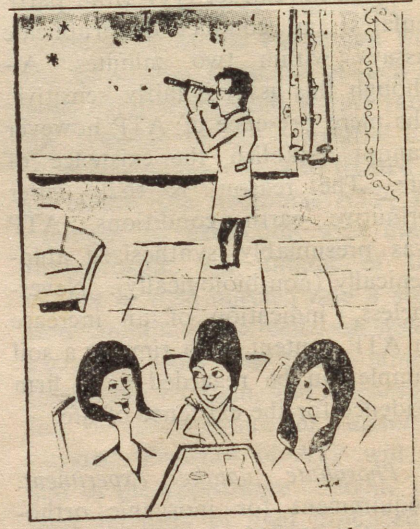
With this background of the principles encompassing the extraterrestrial life detection experiments, let us now discuss the biochemical experiments that have been immaculately performed by the "Viking landers" to search life on Mars. Since the exact experimental details, the observations and inferences thereof are beyond the scope of the present write-up, only a general description of the experiment will be attempted. The Viking mission was set to perform the first extraterrestrial biological experiments and is therefore looked upon as a landmark in the history of exobiology. Three separate biological experiments packed into a miniaturised laboratory which measured only one cubic foot was developed at a cost of 50 million dollars. The three biological experiments in Viking's package laboratory were for (a) Photosynthetic analysis, (b) Metabolic analysis, and (c) Gas exchange analysis. These experiments were based on different fundamental assumptions of Martian life, thus casting the investigative net as wide as possible taking into consideration the severe limitations on space and payload on the lander. The first two experiments were dependent on the assumption of carbon-based life but the third experiment was based on no such assumption.

Let us now have a look at the sequence of events that occurred after the Viking landed on the Martian soil. Shortly after touching down, the lander extended its telescopic sampling arm to scoop up about 130 cu. cm. of soil. Of this only 7 cu. cm was shunted towards the biology box. The first experiment that went into action was the pyrolytic release test for the detection of photosynthesis. A sample of soil was warmed in an incubation chamber and was then exposed for five days to radioactive carbon dioxide under the glare of an artificial sun (a Xenon arc lamp). The assumption was that as this gas is common in the Martian atmosphere it is likely to be exploited by organisms, and that these organisms harness the energy of the sun, just as plants and other photosynthetic organism do on earth. After the incubation was over, the gas was driven off and the sample was heated to 700° C to breakdown any organic compounds that were formed by photosynthesis, releasing radioactive carbon dioxide, which was monitored as described previously.

The next experiment that went into action, one day after the pyrolysis experiment, was the gas exchange test which was designed to determine whether carbon dioxide, nitrogen, methane, hydrogen or oxygen can take part in some kind of dynamic interaction with a sample of incubated soil. During a 10-day incubation period the gas composition was determined five times with a highly sensitive and miniaturised gas chromatograph. This experiment was done either with moistened soil or with soil bathed in a nutrient broth (an aqeous mixture of 19 amino acids, vitamins, a number of other organic compounds, and a few inorganic salts). The first experimental protocol presumed Martian organisms simply to be deprived of water, whereas the second was designed to look for organisms that may be lying dormant through a long absence of earthlike organic chemicals. In either case, a change in the composition of gas mixture would have been indicative of the existence of life on the red planet.

The last experimental system was for metabolic studies. This experiment was so designed as to see whether a mixture of basic biochemicals is metabolised in a Martian-like atmosphere during an incubation period of 11 days. Since the mixture of nutrients (formate, glycine, lactate, alanine and glycolic acid) were radioactive, utilization of these nutrients by organisms would release radioactive carbon dioxide. Controls for all the three experiments were run simultaneously with heat-sterilised soil (Fig. 1).

(*Continued on page 511*)



"There is a bit of self-contradiction in him. In lab, he is excited to his search for life outside the earth, but at home, he says life outside the earth could not be worse than the one on the earth."

THE FASCINATING AMPHIBIANS

Amphibians were the first vertebrates to conquer land. They gave rise to reptiles, birds and mammals

P. MOHANTY-HEJMADI

AMPHIBIANS represent the smallest group of vertebrates. There are approximately 3000 species of amphibians found on every continent except Antartica. The greatest variety occurs in the tropical jungles of the old and new worlds. Frogs and toads are never found in the sea. A small amount of the sea water is fatal to most developing tadpoles and an adult will die in a few minutes if immerged in sea water. Their vertical distribution is rather impressive, ranging from a few feet underground upto 450 meters (1500 feet) high up in the Andes and the Himalayas.

Of other major zoological classes, amphibians are least harmful to man. None of them has a poisonous bite, they do not rob us of our grains or fruits and they do not inflict any major disease upon us.

Amphibians are interesting animals. The first vertebrates to conquer land, they ultimately gave rise to reptiles, birds and mammals. Modern amphibians are divided into three groups : the caecilians or the limbless snake-like amphibians, the urodeles or the lizard-like salamanders and newts, and the anurans or the frogs and toads. In India there are 15 species of Caecilians, only one species of newt (*S. R.*, August, 1976), and a considerable number of anurans.

Importance

Frogs have done much to help man in his educational and scientific activities. They are easy to get, and their different systems like the alimentary, circulatory, nervous, and reproductive, can be traced with little effort. Amphibians are indispensable for biological and medical research. They can be maintained in confinement with little effort.

Much of our knowledge of limb regeneration is based on the studies of the larval and metamorphosing frog. A metamorphosing froglet which loses a limb can regenerate it but a fully formed adult cannot replace the lost limb. The fundamental work on transplantation was also done on amphibians. It was an exposed nerve in the leg of a dead frog which led to the experiments on transmission of electric current by the Italian physiologist Galvani. Frogs are used to diagnose "pregnancy" in women. In this test the urine of a woman is injected into a male frog; the

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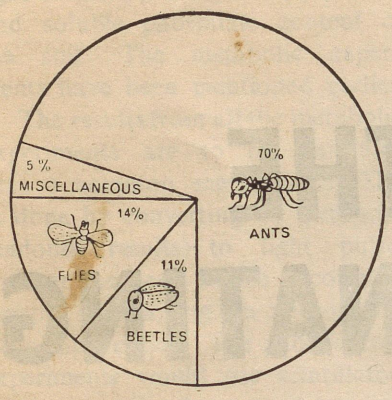

Fig. 1. Diet of *Bufo melanostictus* (reconstructed from Behura *et al.*)

pregnancy related hormones cause the extrusion of sperms within hours.

Parotid glands of toads located behind the eyes emit an irritating poison, when a toad is frightened or injured. Small amounts of the same poison are secreted by glands all over the skin. Predators that have tried to swallow a toad once never make the mistake again because the poison causes a burning sensation in the mucous lining of the captor's mouth and, therefore, eject out the prey. This poison has been used by ancient Chinese physicians for treating heart ailments. Chemical analysis shows that the poison contains digitalis-like substances which have been used for treatment of heart disease by European and American physicians. The toxins in the skin of poison arrow frogs (*Dendrobates* and relatives) have long been used by Indians of Central and South America for tipping their darts and arrows. They collect the poison by baking the frog over a fire. The heat forces the poison through the skin which collects like drops of sweat. These drops are collected into a jar. The most deadly poison can be extracted from Colombia's "Kokoi frog", which is only 2.5 cm long. The poison in small doses has medicinal value. It blocks transmission of impulses from nerves to muscles. and is an important chemical for research in neurology.

A frog or toad is truly a farmer's friend, for it consumes an enormous number of insects including injurious beetles. This has been known to sugar planters, who have imported giant South American toad *Bufo marinus* to save sugar plantations. In Puerto Rico, Haiti, Guam, Hawaii and other places, it protects a crop worth more than a billion dollars a year from sugar beetles. Its economic value is much greater in insect-ridden tropical countries like ours. A study of the stomach contents of 144 toads, *Bufo melanostictus* in Cuttack revealed 2736 insects, *i.e.*, 190 insects per toad. These toads had eaten many types of insects including whole cockroaches. An analysis revealed that they eat a considerable number of common pests like ants, flies and beetles (Fig. 1).

Froglegs are eaten in many parts of the world. In general the edible frogs, the North American bull-frog *Rana catesbeiana*, the European *Rana esculenta*, the Indian bullfrog, *Rana tigerina* and the Indian green frog *Rana hexadactyla*, are larger than common frogs. The Indian bull-frog can reach a length of 195 cm (6.5 inches). Valuable foreign exchange is earned by the export of froglegs to Western Countries. *Rana tigerina* is also eaten in some parts of Orissa. Unfortunately unlimited killing has led to the depletion of natural populations in some areas. Needless to say this has affected the ecosystem and has led to an increase in pests like paddy crabs.

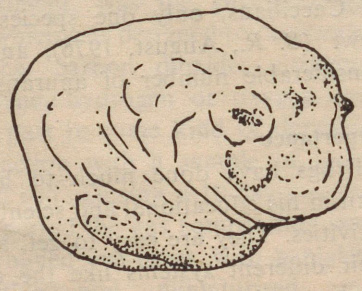

Fig. 2. Cocoon of *Ceratophrys*

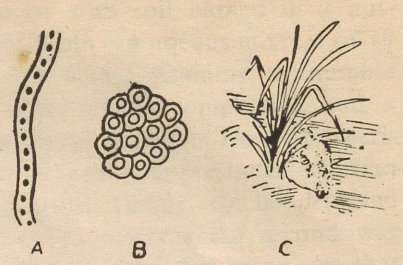

Fig. 3. Representative types of egg clusters
A. Bufo melanostictus; B. Rana cyanophlyctis; C. Rhacophorus maculatus

Last but not the least, many people make a living by catching and supplying frogs to educational and research institutions.

Folklore

Almost every country has its folklore on frogs and toads. In Medieval Europe, frogs and toads were added to the witches' brew to cure all ailments. Priests used frogs and toads in ceremonies. Amphibian motifs are often found on pottery and baskets.

In Indian mythology, frog being a myridion of Indra the God of rain, plays a dominant role in rain making ceremonies. In parts of South India, two boys put a frog into a basket with some neem (margosa) leaves. They tie the basket to the middle of a stick. Supporting this stick on their shoulders, they visit every house in the village singing glories of Indra. It is believed that the louder the noise the captor makes, the better will be the rainfall! In Assam, frogs are wedded in an elaboratecere mony. Apparently this special treatment of the myridion pleases the God of rain. A rather cruel ritual is held in Bihar

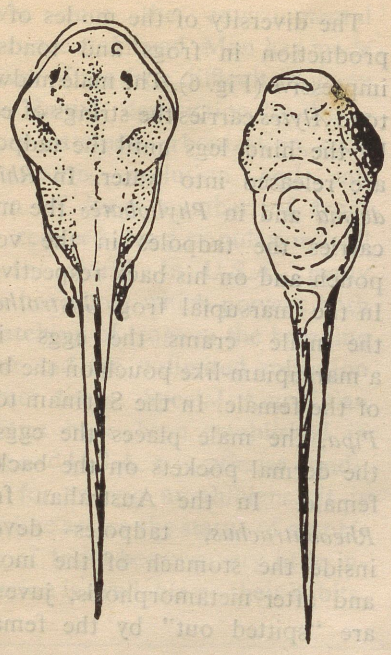

Fig. 4. *Bufo melanostictus* **tadpole (dorsal and ventral view)**

in which frogs are mercilessly tortured in order to draw the attention of Indra who sends rain just to save other frogs from such treatment. In Indian music the note "dhaibata" is named after the sound that the frog makes. In parts of Malaya the bright-coloured tree frog *Rhacophorus dennysi* is venerated by a religious cult, and on holy days one of these frogs is carried in a procession in its own 'sacred' throne.

The myth that toads can give "warts" is baseless. Reports about salamanders originating from fire is simply due to the fact that these amphibians live in hollow logs which are sometimes taken to the fire place. The heat of the fire drives them out. The stories of "rain of frogs" is true. The U.S. Weather Bureau has verified the fact that occasionally contents of a pool along with the frogs and fishes are scooped out by tornadoes and they are deposited some distance away.

Mark Twain has immortalized the extraordinary leaps of some frogs in his famous story. *The Celebrated Jumping Frog of Calaveras County*. An annual jumping contest is held in Calaveras which attracts the townspeople and tourists alike. The current record is held by "Maggie", an American bullfrog which jumped 5 metres (16 ft. 4 in.) in three consecutive leaps. In 1954, the winner, African *Rana oxyrhyncha*, leaped nearly forty-five times its own length in the 'Frogolympics' contest held at at Capetown.

Habits and life history

Amphibians are largely secretive, living under water or hidden in damp places. They cannot regulate their body temperature to any great degree and are mostly nocturnal because nights are cool and humid. Most hibernate during cold winter months. During hot dryer months, some aestivate. In extreme cases, like in *Ceratopprys*, a water conserving cocoon is secreted by the skin gland (Fig. 2).

Although a few of them, like the skipper frog *Rana cyanophlyctis* and the common toad *Bufo melanostictus*, are seen and heard throughout the year, most of them are seen and heard only during breeding season. In Europe and America, breeding takes place in spring and in tropical countries during the monsoons. Apparently, they lead a solitary life. They use a variety of references including odours, land-marks and celestial cues to reach the breeding pond which may involve covering a few kilometres. Their ability to find water is phenomenal. In my laboratory a large container with water is kept in a corner and all the frogs and toads which escape are found in or near the container within a few hours.

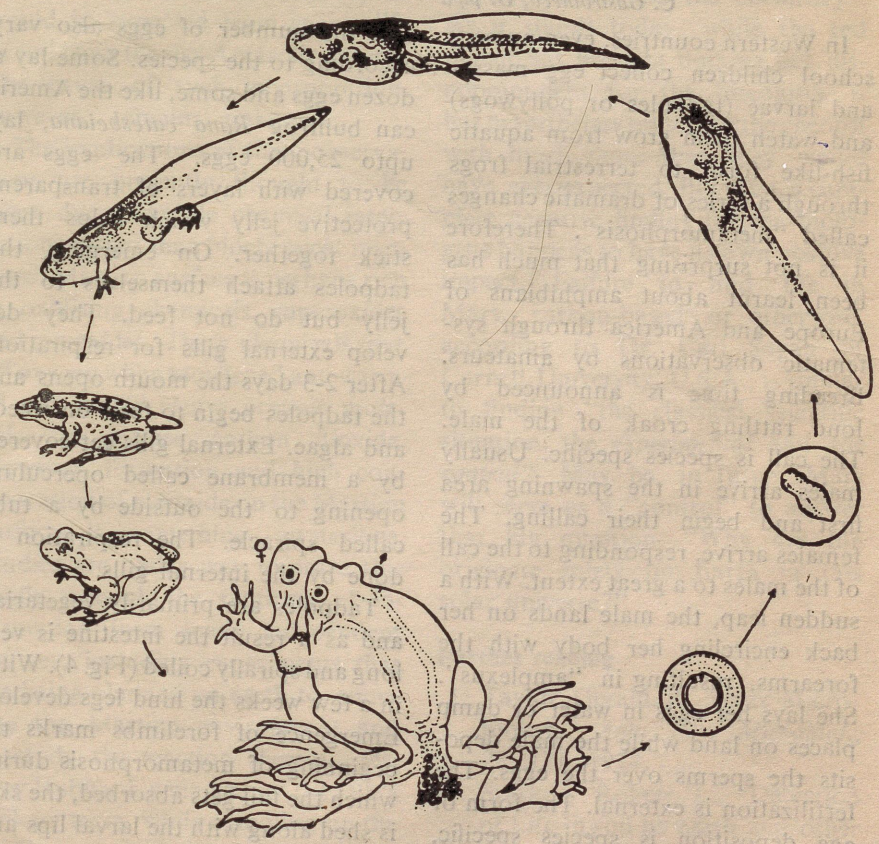

Fig. 5. Life cycle of frog

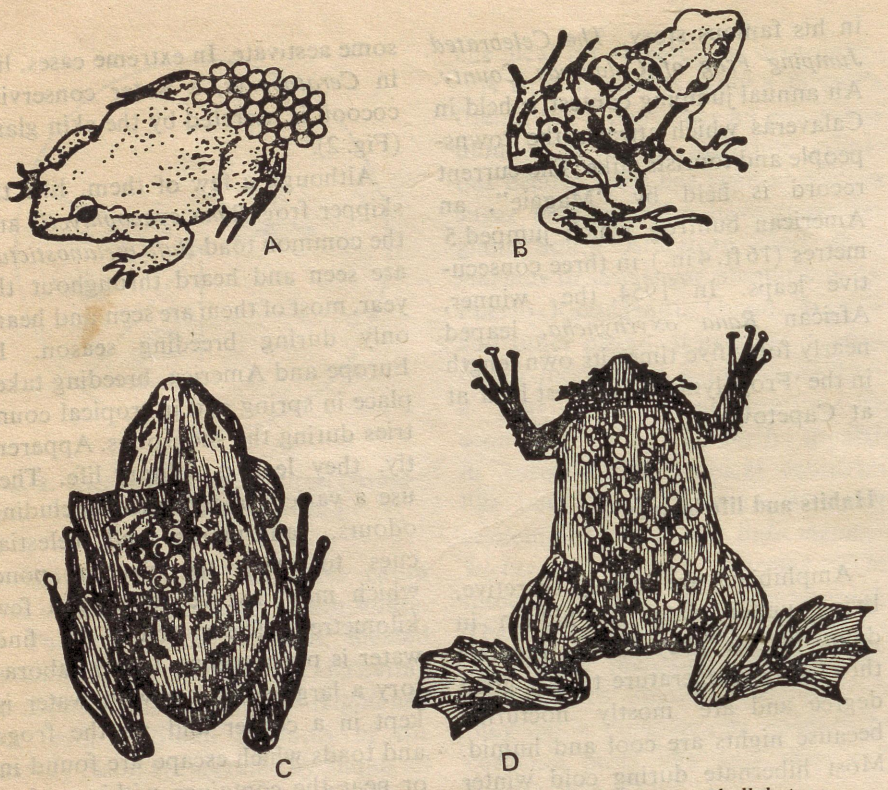

Fig. 6. Parental care in frogs and toads: A. *Alytes*, B. *Phyllobotes*, C. *Gastrotheca*, D. *pipa*

In Western countries, even nursery school children collect egg masses and larvae (tadpoles or pollywogs) and watch them grow from aquatic fish-like form to terrestrial frogs through a series of dramatic changes called "metamorphosis". Therefore it is not surprising that much has been learnt about amphibians of Europe and America through systematic observations by amateurs. Breeding time is announced by loud rattling croak of the male. The call is species specific. Usually males arrive in the spawning area first and begin their calling. The females arrive, responding to the call of the males to a great extent. With a sudden leap, the male lands on her back encircling her body with the forearms, resulting in "amplexus". She lays her eggs in water or damp places on land while the male deposits the sperms over the eggs. The fertilization is external. The form of egg deposition is species specific, some in chains, some in clusters and some in foam nests (Fig. 3). The size and the number of eggs also vary according to the species. Some lay a dozen eggs and some, like the American bullfrog *Rana catesbeiana*, lay upto 25,000 eggs. The eggs are covered with layers of transparent protective jelly which helps them stick together. On emerging, the tadpoles attach themselves to the jelly but do not feed. They develop external gills for respiration. After 2-3 days the mouth opens and the tadpoles begin to feed on weeds and algae. External gills get covered by a membrane called operculum opening to the outside by a tube called spiracle. The respiration is done by the internal gills.

Tadpoles are primarily vegetarian and as a result the intestine is very long and spirally coiled (Fig. 4). Within a few weeks the hind legs develop. Emergence of forelimbs marks the beginning of metamorphosis during which the tail gets absorbed, the skin is shed along with the larval lips and horny jaws leaving a much wider mouth (Fig. 5).

The diversity of the modes of reproduction in frogs and toads is impressive (Fig. 6). The male midwife toad *Alytes* carries the strings of eggs by the hind legs until the tadpoles are released into water. In *Rhinoderma* and in *Phyllobates* the male carries the tadpoles in the vocal pouch and on his back respectively. In the marsupial frog *Gastrotheca*, the male crams the eggs into a marsupium-like pouch on the back of the female. In the Surinam toad, *Pipa*, the male places the eggs in the dermal pockets on the back of female. In the Australian frog, *Rheobatrachus*, tadpoles develop inside the stomach of the mother and after metamorphosis, juveniles are "spitted out" by the females.

Status of amphibians

Until man interferes with the habitat, the wild amphibian lives in harmony with nature. There is no record of any amphibian species being threatened on a large scale by natural disease. Occasionally local populations are destroyed by droughts, out of season freezing or flood. But usually populations

"You have not discovered a new amphibian, Miss Anita. That is only a dead wood floating on the water."

recover once the environmental factors are stabilized. Man has made survival of the frog difficult in many ways. Habitat destruction by drainage programmes, urbanization, road construction, pollution and collection of large number of frogs have reduced frog populations all over the world. In U.S.A., many states have laws which prevent both the catching of frogs in the breeding season and the unlimited collection at other times. Special Amphibian Facilities have been established in Japan and U.S.A. to optimise conditions for raising amphibians. It is difficult to assess the status of amphibians of India because very little information is available on their habits, behaviour and life cycles. There is even disagreement regarding the number of species indigenous to India. A thorough inventory of local amphibians is badly needed. In the midst of our "save the Tiger" or "save the Crocodile" projects where emphasis is on the large, conspicuous and exotic, we are ignoring the existence of our unique amphibians which benefit us in so many ways.

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EXTRATERRESTRIAL LIFE (*Continued from page 506*)

Hope amidst confusion

The first results from the three experiments in the miniaturised biology package reached on August 7, 1976 and the Jet Propulsion Laboratory (JPL) in Pasadena, California, saw one of the most exciting sessions in the search for signs of life on Mars. The initial results were fully consistent with the metabolic activity of microorganism in the Martian soil. This was followed by an extremely puzzling activity displayed by soil samples. The unexpected fast reaction recorded in the second and third experiments took the JPL scientists off their guard. Instead of a slow, steady flow of carbon dioxide released from the radioactive nutrients, there was a rapid gush of gas during the first 10 hours of incubation following nutrient injection which dried up after about 70 hours. Had the earth microbes been in the test system they would have released the gas at a slower rate lasting for perhaps 10 days. In the gas exchange experiment, the equipment detected an evolution of oxygen at an extraordinary rapid rate. The results of the photosynthetic studies also indicate moderate incorporation of radioactive carbon dioxide, as would be expected from sparse life in soil from the dry Antarctic deserts. The cause of such incorporation, however, remains unknown.

The implications of these observations are presently thought to be more due to subtle chemical interactions rather than biochemical reactions. Martian surface is perhaps rich in oxidising chemicals, superoxides and peroxides. These chemicals give off oxygen when moistened and warmed and would cleave organic molecules to release carbon dioxide. However, formation and high concentration of peroxide on the Martian surface is something mysterious. Studies are under way to solve this riddle through the synthesis of information from many independent sources, including experiments that are being planned on earth to simulate the Martian environment and to study the reaction therein. Dr. Jerry Hubbard, a member of the JPL's biology team, while summing up the existing sentiment among scientists recently remarked "It is easier to think of it all in terms of chemistry rather than biology, even though we do not understand the chemistry". As it stands today, while the red planet has brought nothing but disappointment for the biologists, it has nevertheless presented the chemist with much more than they would have ever expected. But even, a complete negative finding for the biologists happens to have its own positive impact. Failure to find life in Mars, carbon-based or otherwise, according to Dr. Carl Sagan of Cornell University, U.S.A., is similar to finding "the classical scientific situation, the *experimental* and the *control*". May be, in future Mars will serve as a "control" to answer that big question—"Why did life originate solely on Earth in this solar universe?"

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SCIENCE SPECTRUM

Black hole quantized !

ONE of the most mysterious objects in the universe is the black hole. Only indirect evidences are available about its presence and yet on paper it shows itself out prominently with two striking characteristics. One is that no physical laws that we know, for example, laws of gravitation and motion, are valid on its surface! The other is that it is gravitationally so strong that even light cannot escape from its clutches! Till now, therefore, a black hole was literally taken as a black hole. Recent researches, viewing it from quantum mechanical angle, however, attribute to this "space-time" hole colourful possibilities. So much has been speculated about this hypothetical object that it now seems likely to be soon detected and from its study a better understanding of both microcosmos and macrocosmos could be had.

That there are similarities between the properties of a black hole and laws of thermodynamics, that it emits radiation just as an ordinary hot body does, that when it "vanishes" it explodes releasing energy equivalent to many millions of hydrogen bombs—are the possibilities scientists are now talking about. Let us first understand how this "illegitimate" hole is born in the world.

Birth of a black hole

Black hole could readily be called the reincarnation of a star after its death. A star remains alive till its nuclear fuels last. During most of its life it burns hydrogen to form helium—generating heat. The heat expands the gaseous atmosphere of the star keeping in check the gravitational forces trying to "choke" it from all directions. But when the nuclear fuels get exhausted, enough heat is not produced to check the gravitational "choking", and the star begins to collapse—literally. Slowly, as the star collapses, its radius goes on decreasing while its gravity rises. Eventually, the gravity becomes so large that it does not allow even light to escape.

It is a much talked about fact in spaceshots that to get out of the earth's gravitational pull, a spacecraft has to achieve a velocity of 11.2 kms/sec. This is called the escape velocity. For a star, say, of a mass ten times the sun's, the value of this velocity could be 1000 km/sec. When it begins to collapse, with the increase in its gravity, the escape velocity also rises. In the final stage of collapse, when it has reincarnated itself into a black hole, the escape velocity at its surface assumes a value of 300,000 km/sec. Apparently, light, having this velocity, is unable to overcome the gravitational pull of the object and thus hovers about it. Its uppermost wavefront hovers about it at a critical radius (called Schwarzchild radius) of 30 km assuming that the mass of the star is ten times the sun's.

This boundary of black hole, where the last wavefront of light hovers just as the uppermost layer of earth's atmosphere does, is called "Event horizon". So called because upto this horizon no knowledge of the events happening on the black hole could be studied. It is the surface area of event horizon which brings to notice many of the properties recently discovered.

Black hole and thermodynamics

Entropy, we know, is a measure of the degree of disorder in a system. The more there is disorder in a system, the higher is its entropy. Take, for example, two vessels containing two types of molecules, one vessel contains molecules at a degree of disorder or entropy A, and the other B. Connect the two vessels so that they mix. What happens while mixing is that molecules of one type link with those of the other type in a large number of ways. More disorder follows. So when the entropy of the "mixed" molecules is calculated, it is found to be higher than the mathematical entropies of individual molecules, just as two separate noises, one shrill and the other drone, if listened to separately would not appear as much noisy as when listened to together.

Mathematically stated, the above conclusion is somewhat like this. The entropy of (A+B) is greater

than (or equal to) the sum of entropy of A plus entropy of B. Now take the case of black holes. They behave just as the molecules do, in a somewhat different context. It is found that when two black holes merge, or some matter gets itself "absorbed" by a black hole, the event horizon of the product black hole is always higher than the mathematical sum of the individual event horizons of the two. This parallelism between the properties of black hole and the laws of thermodynamics raises some questions and provides insight into the nature of a black hole.

It is further known in thermodynamics that any increase in the entropy of a system, like the "mixed" molecules, is accompanied with a corresponding increase in the energy of the system. In the "mixed" molecules' case, this energy increase can be thought of as the driving force required by the molecules to mix spontaneously. Apparently, the increase in the energy of a system is directly proportional to the increase in entropy. If these two are equated, there comes in a proportionality factor, which is here the temperature of the system. Likewise, this reasoning is followed up in a black hole.

The surface area of event horizon is $\frac{3}{4}\pi$ (Schwarzchild radius)^2. And as Schwarzchild radius is $2GM/c^2$, the surface area of event horizon is proportional to the mass M of the star. So if an increase in the mass of a black hole is equated to the corresponding increase in event horizon, there appears a proportionality factor that links them. This factor is the surface gravity of the black hole at the event horizon.

Now if the event horizon is analogous to entropy, the surface gravity is analogous to temperature. The resemblance between the latter two is further strengthened by the fact that like temperature, which is the same everywhere in a body at thermal equilibrium, the surface gravity of a black hole is the same on all points at its event horizon. Does this mean that the surface area of event horizon could be a sort of entropy of a black hole? In 1972, Jacob D. Bekenstein, of Princeton University, U.S.A., provided the answer.

A black hole has no hair

The sub-heading is not a parody composed by Bekenstein but, quite surprisingly, a theorem, an answer to what the entropy of a black hole could mean.

The more the disorder, the lesser is our ability to know about a system precisely. In other words, as the entropy of a system increases, the more the information about it gets irretrievably lost to us. Entropy of a black hole means just that. Any person believing in reincarnation very well knows that the soul of a person after death gets into another body with the difference that it forgets everything about its previous life. Similar things happen in a black hole with slight changes. A black hole retains only three of its "soul" qualities, namely, mass, angular momentum and electric charge, after the reincarnation and loses everything else about itself. It doesn't "know" whether it had formed out of matter or antimatter, from a spherical shape or highly irregular shape, etc. This degree of information lost, or disorder created, is called the entropy of a black hole. It has been found quantum mechanically to be finite.

Having understood what entropy of a black hole is and having known that it is finite in value, it is easy to infer that such a body has to have a finite, other than absolute zero, temperature. And as entropy of a black hole is proportional to its event horizon, the temperature of the black hole is proportional to its surface gravity. In a state of thermal equilibrium a black hole therefore should emit radiations. From the classical point of view this is not possible, and that is why Bekenstein theorem for some time received no notice until S. W. Hawking, of University of Cambridge, U.K., (*Scientific American*, January 1977) showed this phenomenon to be happening in reality—mathematically, of course. His calculations led him to believe that a black hole does emit radiation like an ordinary hot body and its temperature does depend upon its surface gravity. But how does all this happen ? This "business" is explained in the seemingly bizzare quantum mechanical manner.

Radiation and explosion

That pairs of virtual particles and antiparticles, whose existence has been indirectly observed, are being continuously filling the space is a well-known fact. These particles within a very short time materialise in space out of "nothing", separate, and then annihilate each other to vanish to "nowhere". Take, for instance, such a pair of particles being produced in the vicinity of a black hole. One of them is attracted and thus "absorbed" by the black hole. The other, if it is left out, escapes to infinity. It is this latter particle that appears to emanate from the black hole as radiation. Or, an anti-particle, i.e., a particle travelling backwards in time, falling into a black hole could be taken as the one coming out of it but travelling backwards in time. If it gets scattered gravitationally, where it was originally produced, it travels forward in time, as it were being radiated out of the black hole.

Just as we have potential barriers a round atomic nuclei, a black hole, too, has one. The influencing strength of this barrier is proportional to its size. The larger a black hole, the stronger is the barrier, lesser thus is the number of particles able to tunnel, quantum mechanically, through it as they do through nuclei. And when lesser is the radiation emitted by a body, the lower

is the temperature of the body. Estimations tell that a black hole with a mass equivalent to sun's has an insignificant, cold temperature of ten-millionth of a degree above absolute zero. On the other hand, a black hole with a mass equal to that of a mountain, say, a billion tons, has a temperature of 120 billion degree K. Such a small sized black hole, of the order of 10^{-18}, would radiate energy equivalent to 6,000 megawatt, the output of six large nuclear reactors! So the existence of a large black hole would not be, because of absence of any tangible radiation, detected, while that of a small one would be far easier to detect.

It is apparent that a large black hole in time would "disintegrate" into a small black hole because of the radiation however minute it may be, and it would finally blow up. This blow up may be better termed as an explosion, because a black hole would blow up releasing millions of megaton of hydrogen bomb energy. The black hole explosion, it is now claimed, will prove to be an effective tool in probing into fields of particle physics and cosmology.

How much powerful a black hole explosion would be, it is now established, would depend on the different number of species of elementary particles in existence. As contemporary theories differ, one claims all particles to be made up of six different kinds of quarks (a basic particle), and other says there are infinite number of elementary particles—observation of a black hole explosion would tell which theory is correct. In fact, there is no other test to probe into the matter.

Telling about big bang

It is claimed that, though only within the last few decades we have come to realise, quite hypothetically, the presence of black holes, they have existed in the universe since it was formed. We now know that "Big Bang" occurred and formed the universe. In other words, a highly compressed region of dense material exploded with a bang to produce the universe. Fragments of material got scattered in all directions, some of which were so dense that they immediately collapsed to form minute black holes, called specifically "primordial black holes". Having small masses, they radiate copiously to be easily detectable. Statistical probability tells that such a black hole might be lurking somewhere about the orbit of planet Pluto. Having the knowledge of when the universe was formed and knowing what time a black hole takes to explode, it has been estimated that primordial black hole must be at present emitting hard γ-rays with an energy of 100 million eV. This clue would certainly enable us to trace it out. As an intriguing possibility, could not be the recently detected cosmic γ-rays (*S. R.*, June 1977), whose origin is still debated, the emissions of such a black hole in our vicinity? The *Cygnus X*-1 X-rays source, which is presently considered to be containing a black hole, also needs constant vigil for such signs. Further, as a black hole explosion is in characteristics similar to the Big Bang, much could be gauzed from its study about the formation of the universe. Is it possible that like black holes, matter first collapsed and then with a bang exploded to form the universe?

DILIP M. SALWI

Uranus and its six satellites

ORDERWISE uranus is the seventh major planet from the sun; the other six are Mercury, Venus, Earth, Mars, Jupiter and Saturn. It is revolving round the sun at an average distance of 2880 million Km, or in other words 19.182 astronomical units. One astronomical unit is equal to the mean distance between the earth and the sun. This is 148.6 million Km. The symbol for the planet is H. Uranus was the first planet to be discovered by telescopic observations. Not known to ancients, it was discovered by William Herschel on March 13, 1781. He thought it was a comet.

The planet is visible without a telescope, but appears as a very faint star. Earlier astronomers like Flamsteed, Lemonnier and Tobias Mayer had observed it as early as 1756 and thought it to be a faint star.

The discovery marked the commencement of series of brilliant discoveries which adorned the astronomical career of William Herschel. The orbit of Uranus is a flat ellipse. Its rotation about its axis is very fast, the day of Uranus is of 10 hours and 49 minutes. The revolution about the sun is very slow taking 84 years or, more accurately 30,685 days.

Six satellites revolve about Uranus in the equatorial plane which is tilted at such an angle to the ecliptic plane (the plane containing centre of the sun and the planet) that the satellites appear to revolve in a retrograde sense, i.e., they appear to rise in West and set in East. The two outer satellites are Titania (U III) and Oberon (U IV), diameter about 1,000 km. The next two Ariel (U I) and Umbriel (U II) are 700 km in diameter, while Miranda (U V) the fifth satellite is only 300 km in diameter.

The first two satellites were dis-

covered by Herschel in January 1787, the third and fourth in 1851 by William Lassel at Malta and the fifth and then innermost satellite was discovered 97 years later by G. R. Kuiper in 1948.

The sixth satellite or a group of four extremely small satellites was discovered on March 10, 1977 by J. C. Bhattacharjee and Kuppuswami of the Kavaloor observatory of the Indian Institute of Astrophysics, Bangalore. According to them the new satellite is about 30 km in diameter and is the innermost satellite of Uranus. The observations were carried out with the help of 102 cm telescope at the Institute.

American astronomers led by Elliot do not agree with the findings of Indian scientists. They have detected a band of four satellites and not just one.

The observations of Uranus were carried out by Indians and American astronomers at the same time and by using a similar method called "Occultation".The Americans worked in an airborne observatory about 12,500 metres above the earth's surface. The aircraft flew over the Southern Indian Ocean when satellites were sighted on March 10, 1977.

The Indian and American scientists inferred the presence of a new object or objects around Uranus by using the occultation method. This involves measuring the intensity of light coming from a star beyond the planet Uranus. Indian astronomers found that the starlight suddenly began to grow dim indicating that some object had crossed the path of starlight. Since their calculations showed that neither the planet Uranus nor its five known satellites could have caused the occultation, they attributed the dimming of light to the presence of an unknown satellite.

American astronomers also found dimming and brightening of the starlight. But the pattern repeated four times indicating that it could have been caused by the quick movement of four satellites. They suspect that Uranus has a band of satellites close to it or a system of rings like Saturn. Until now Saturn was the only planet in the solar system known to be encircled by rings of space particles.

The new satellite is about 30 km in diameter and has a period of 10 hours. The sixth satellite of Uranus is yet to be named. The U VI cannot be seen even with a telescope as it is too small and too close to Uranus. Small satellites of the size of U VI were seen before only around the planets Mars and Jupiter. Astronomers have concluded that these extremely small satellites may be captured asteroids, as there is a region of minor planets called asteroids between Mars and Jupiter.

However, the present discovery of a small satellite at such a vast distance from the asteroidal belt is very interesting. It is very difficult, if not impossible, to capture asteroids from such a long distance.

The satellites bear the same relationship to planets as the planets bear to sun. The formation of a system of satellites may have a process similar to the formation of planets around the sun. It is also interesting to note that even though there are a number of major satellites around planets, no satellite is found to revolve around any other satellite. There are, of course, man-made satellites around our only satellite, the moon.

The satellites of the planets give the mass of the planet around which they revolve accurately. The mass of the planet can be estimated from a measurement of the distance from the planet and the orbital period. They also give information about the nature of the planets and the formation as well as evolution of the solar system. The tiny satellites of Uranus discovered by Indian and American astronomers are expected to add to our understanding of the mysteries of the solar system.

It is very difficult to detect small satellites such as the ones discovered, more so if they are at a far off distance as Uranus. Many small satellites were discovered in long exposure photographs of the sky taken for entirely different purposes.

According to M. K. Venu Bappu, Director of the Institute, and the only astronomer in India to discover a comet, the two observations of Indian and American astronomers are absolutely complementary to each other. He says that the discovery of a single satellite by Indians and a band of satellites by Americans was completely unexpected. Both the discoveries were made independently at about the same time and by similar techniques of measurement. The credit should be assigned jointly to Indians and Americans. An observatory in South Africa has confirmed the observations carried out by Indians as well as Americans.

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What is electrophoresis?

ELECTROPHORESIS is one of the most important methods used for separation of substances of different ionic properties. The term 'electrophoresis' derived from Greek means "borne by electricity." Alexander Reuss (1897), a Russian physicist, was one of the earliest

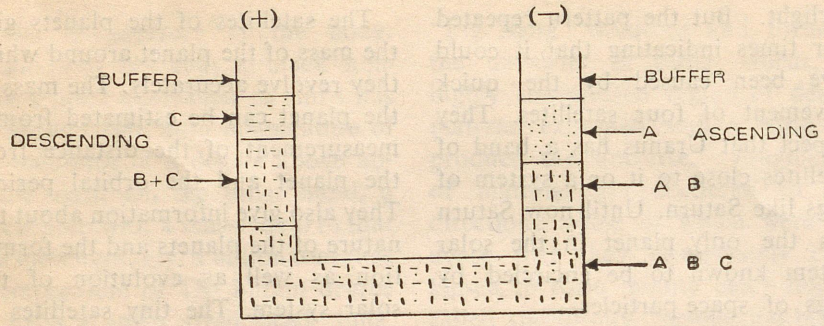

Fig. 1

investigators who studied the principles of electrophoresis. He observed the movement of colloidal clay particles when electricity was passed through a glass tube containing clay and water. Since then a host of workers developed the theory and methods of electrophoresis for applying it to laboratory problems. This technique has been extensively applied to the separation of some biological macromolecules since 1899.

The rate of migration of a molecule in an electric field is largely dependent on the net charge; the rate of electrophoretic migration will depend on the pH in the same manner as does the degree of ionization. In other words, in a mixture of proteins, each protein with its characteristic surface electrical charge will respond to an applied electrical potential in a different and characteristic manner at a given pH. The wide choice of pH and its effect on the electrical charges on a protein molecule lends great versatility to the technique of electrophoresis and allows a critical evaluation of the number of components in a protein. Although the absolute rate of migration is essentially contingent on the net charge, the shape and size of the molecule also influence the rate of migration.

The procedures

The two fundamentally distinct electrophoretic procedures are: (a) electrophoresis in free solution, and (b) electrophoresis on supporting media (filter paper, starch, polyacrylamide gels). Microscopic electrophoresis (a type of electrophoresis in free solution) involves direct observation and measurement of migration of particles in a solution or suspension contained in a glass tube placed horizontally on the stage of a microscope. The method as such is applicable to blood cells, protozoa, bacteria and colloidal particles. Moving boundary electrophoresis (another type of free electrophoresis), which involves measuring the movement of the boundary of a mass of particles, has brought in a new era of biochemical research in the past 30 years. This method owes its development to the pains-taking research of Arne Wilhelm Kaurin Tiselius of Sweden who was awarded Nobel Prize in 1948. The material to be studied is placed in a U-tube (Tiselius apparatus). On top of the protein solution, in the two arms of the U-tube, is carefully layered a buffer solution so that there is a sharp boundary between the two solutions. An electric current is passed through the solutions by means of a positive electrode (anode) inserted in one arm of the tube, and a negative electrode (cathode) in the other. The entire U-tube is immersed in a bath maintained at a constant temperature near 0° C in order to minimize convection currents produced by heat generated by passage of electric current, and to prevent heat coagulation of sensitive proteins. Consider homogeneous protein solution having three components A, B, and C. If the components A, B, and C carry charges of the same net sign (positive or negative) but of different magnitudes (or numbers), the components will migrate at different rates and separate themselves. If the magnitude of electric charge is in the order A, B, C, the components will separate as explained below.

The faster moving component A will be present in the pure form in the ascending boundary, whereas C will be present in the pure form in the descending boundary; however, B will be mixed with A or C.

The measurement of the movement of the boundary was first augmented by the development of Schlieren optics—a method based essentially on the fact that at a boundary between two transparent materials

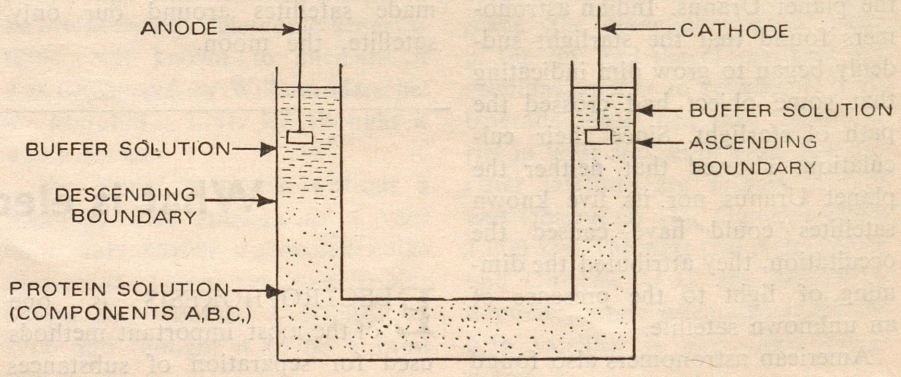

Fig. 2

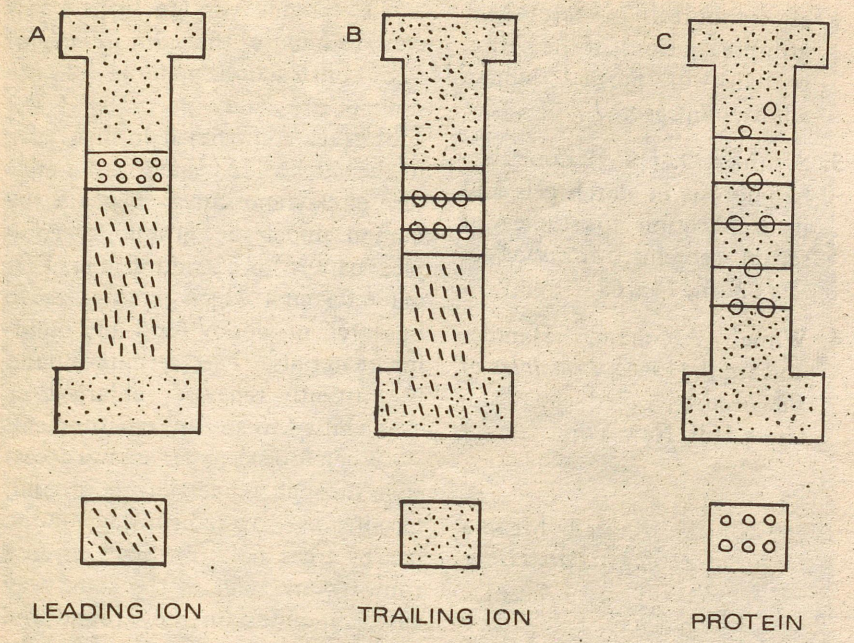

Fig. 3

of different density the light rays are so refracted as to produce "shadows" which indicate the location of refraction. "Schlieren Scanning Device" was introduced by Lewis G. Longsworth (Rockefeller Institute, U.S.A.) in 1939, which gave a more comprehensive picture in the form of "peaks and valleys", each peak representing the position of a boundary in the moving column and the area under the peak representing the concentration of the chemical fraction responsible for the area under the curve. With pure substances, only a single symmetrical peak was obtained (in the form of a bell-shaped curve); multiple peaks and asymmetrical curves indicated mixtures.

A basic equation defining electrophoretic mobility (μ) in terms of the moving boundary is :

$$\frac{dx}{dt} = \mu E$$

dx=distance travelled in time dt under influence of electric field E (distance in dimension of cm).

dt=in seconds

E=volts/cm

The most important problem in electrophoresis, as mentioned above, is the dissipation of heat generated by the passage of current; not only are most biological substances thermolabile, but unequal heating produces conversion currents in free solution resulting in uneven migration boundaries.

Disc gel electrophoresis

Since electrophoretic mobility in free solution at a given pH is a function of the net charge density on the protein molecule, several molecules of different shape and size may exhibit the similar electrophoretic mobility. If, however, electrophoresis is carried out in a medium that is provided with microscopic pores, the size and shape of the protein molecule become important factors. In this case, large molecules of high electrophoretic mobility may trail behind the smaller molecules of lesser electrophoretic mobility. In 1955, O. Smithies of the Univesity of Toronto (Canada) developed methods for molecular sieve electrophoresis. He observed the additional resolving power provided by the sieving capacity of starch gels. This phenomenon led to the use of polyacrylamide gels.

Polyacrylamide gels show distinct advantages as an electrophoretic medium. 1. They are obtainable in highly purified form; 2. their pore size can be adjusted over a wide range by varying the monomer concentration; 3. they are transparent over the range of visible light; 4. the gels are relatively inert chemically because their lattices are formed by carbon-carbon bonds with pendent amide groups with few or no ionic side groups; and 5. they are easy to handle and are fairly rigid in nature. Taking these factors into consideration, these polymers provide flexibility not available in the starch gel technique. In "disc" electrophoresis the system is not uniform in pH, buffer species and concentration and gel porosity. The salient characteristics of the technique reside in the controlled variation of the gel pore size for the purpose of increasing the resolution of ions based on dimensional differences, and provide an electrophoretic step for concentrating the sample ions into a narrow starting zone prior to electrophoretic separation.

The polyacrylamide gel column is composed of two layers. The small-pore, lower gel is the part in which electrophoretic separation occurs. This gel functions as a seiving device as well as an anti-convection medium. The seiving phenomenon comes about as a result of the differences in frictional drag of moving molecules of different sizes. The large-pore, upper gel functions to concentrate electrophoretically the sample ions. This spacer gel stacks the various ionic components of the original sample into contiguous zones in the order of their relative mobilities. This, thereby, decreases diffusion and increases resolution.

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The polarity of the electrodes in the two buffer basins is arranged so that the ions migrate toward the small-pore gel. After voltage has been applied, the gel is removed and stained with a protein-binding stain. Unbound stain is removed by washing or by electrophoresis, thus leaving the various stain-bound proteins in clearly definable bands.

Further reading

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Termite mound and ground water exploration

TERMITES, popularly known as white ants, are a part of the extensive fauna that exists throughout the tropical and in most of the warm temperate countries. Their estimated number of species is 2,000. Food of termites is mainly wood and woody tissues of plants, so they cause immense damage to buildings, furniture, clothes and crops. Further, in some regions, they build small mounds of soil which prove serious obstacles to agricultural and civil engineering projects. Efforts have been made to eradicate them or immunise articles against their attack.

However, there are some beneficial effects of termites too. The soils of their mounds are used for making ovens, bricks, and pottery; for plastering walls, surfacing roads, pavements, and tennis courts. Termites are used as food in certain parts of the world because they form a useful source of animal protein.

Termites live in soil. For some, the habitat is a network of chambers made below the ground with little or no indication of their presence on the surface. Others build conspicuous mounds varying from a few cms to more than 9m in height. The construction material of the mounds are sandy particles of the subsurface soil carried in their jaws to the site and cemented with a mixture of clay and saliva. Beneath the mound, under the ground, a complex pattern of corridors (Fig. 1) is made through which termites move in search of woody food and building materials. The termite mound is constantly renewed, enlarged, or even shifted to suit the environment.

When food supplies are not accessible through tunnels in the ground, termites use covered runways on the nearby trees (Fig. 2). Such covered runways are built in the same way as the mounds on the ground and constitute an extension of the mound construction. The colour, texture of the soil, and the architecture of the termite mound vary widely and depend upon: (1) the nature of the subsoil; (2) climate, and rainfall; and, (3) the behaviour of the particular species of the termite.

The interior of a termite mound consists of a number of chambers and

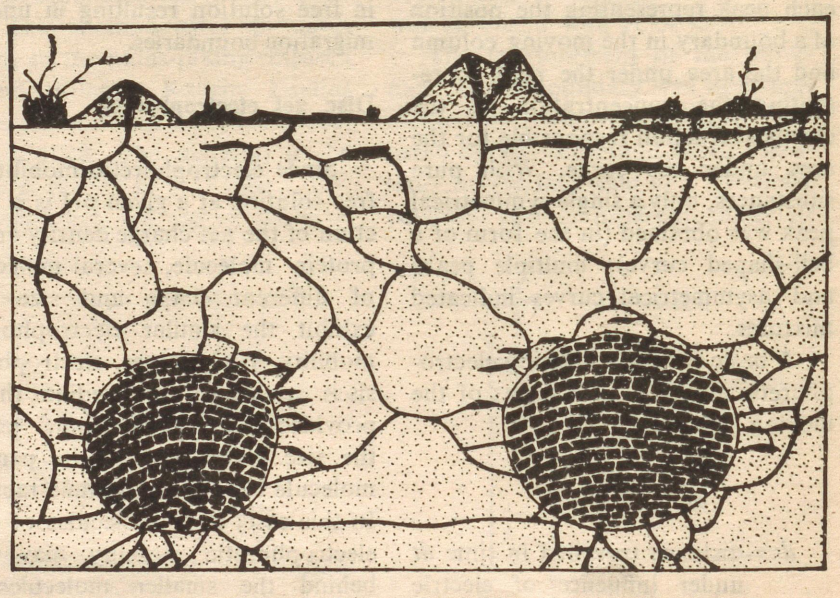

Fig. 1

Fig. 2

partitions to provide an elaborate system of ventillation to meet the requirements of their microclimate.

As has already been pointed out, the termite mounds represent an equilibrium of three forces—behaviour, material, and climate. A species, which is restricted in its distribution to a particular ecological zone where environmental factors such as soil and climate are relatively uniform, builds mounds of uniform shape. On the other hand, a species occurring in a wider range of habitats builds mounds of variable appearances. The architectural style of a termite mound is of great significance in environmental science which, from ecological point of view, deals with the sum of all external conditions and influences affecting the life and development of organisms.

In certain regions, the land is covered with a thick and featureless blanket of soil. In such places, prospecting for minerals is difficult due to scarcity of bed rock exposures. Geochemical prospecting, involving trace element analysis of the surface soil or such metals as nickel (Ni), molybdenum (Mo), and tungsten (W), indicate the probability of their presence in the parent rocks occurring below the soil. The soils of the larger termite mounds, with their large proportion of unweathered subsoil, are a helpful clue in the exploration of economically important mineral deposits.

The most important use of the termite mound is in ground water exploration. In this connection, reference to the ancient Hindu Literature, *Brihat Samhita* by Varahamihira (A.D. 505-587) is highly significant. The Sanskrit text of *Brihat Samhita* deals with astronomy, astrology, and various other sciences. Its 54th Chapter entitled *Dakargalam* deals with the ground water exploration with a multidisciplinary approach involving various disciplines in earth sciences and life sciences. It describes termite mounds together with certain plant species as hydrologic indicators.

Termites are susceptible to desiccation. Therefore, maintenance of high humidity in the termite mound is an essential requirement for the survival of most species of termites, especially those living in arid and semi-arid regions. Active transport of water is one of the important mechanisms contributing to humidity control of the termite mound. A. Buillon (1970) of U.S.S.R, has pointed out that free water in the soil and from the water table, even when it is very deep, is one of the sources of water used by the African termites. Also, the connection of the termite mound, through its subterranean 'galleries', with the ground water source has been demonstrated by other workers.

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The mysterious scattering layer

ECHO sounding machines have been employed for measuring the depths of oceans instead of the conventional lead and line method since the Second World War. Sound waves sent out from the echo sounder reflect back after striking the ocean bottom. A continuous record of the depth is maintained as the survey ship moves along. This method of charting the ocean depths appeared simple and free from any trouble at first. Soon the charts began to show profiles of depths shallower than real. The mystery further deepened when this false bottom was found to migrate up and down. It became evident that something scattered the sounds at depths. Its existence spread for thousands of kms and was recorded in the Altantic, the Pacific and the Indian Oceans. This layer of doubtful existence was soon named the Deep Scattering Layer or D. S. L. in short.

Deep Scattering Layer mystified biologists for a while. The living creatures are abundant only upto a depth of about 200 metres where minute plants of the plankton can synthesise food from sunlight. Population density of living creatures below this depth tends to decrease. The Deep Scattering Layer presented the possibility of enormous quantities of living marine resource ready to be tapped. However, the exact nature of resource could not be established for a long time. Nets and remote control cameras operated at these depths could not provide definite clues. Finally scientists descended the ocean depths in pressure resistant equipments (bathyscape) to observe organisms responsible for scattering the sounds directly. Dense concentrations of floating jelly fishes (siphonophores), swarms of shrimps and small lantern fishes in huge shoals greeted the diving scientists at different depths. The mystery of the Deep Scattering Layer was solved from a biological point of view.

In Indian waters the D. S. L. is known to occur at depths varying from 700 metres to 900 metres. The living populations at these depths are small prawn-like euphausiids, midwater fishes and shoaling cephalopods. A detailed study of the D. S. L. is required for further assessment of populations available for future exploitation.

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Hormones influence animal behaviour

STEROID hormones play an important role in physiological regulations in animals. They are secreted by adrenal cortex or by gonads and are potent substances. Steroids from adrenal cortex help regulate utilization of electrolytes such as sodium and potassium in the body. In addition, adrenocortical hormones also affect the mood of an animal. Similarly, gonadal steroids which primarily act on tissues associated with sexual functions like those of vagina, uterus, breast and the oviducts in female, and the prostate, seminal vesicle in males, also play an important role in sexual behaviour. We will discuss some observed effects of gonadal steroids on animal behaviour.

Removal of gonads in males (castration) seriously affects sexual behaviour in all vertebrates, although a sexually experienced animal may enjoy some aspects of sexual behaviour for long even after castration. However, castration before puberty has a profound effect on the sexual behaviour. For example, in pre-puberty castrated rat, penile intromission does not occur though the animal may display some related behaviour such as running around a female and even jumping on her. Several such examples can be cited about male hamsters, guinea pigs and cats. A monkey becomes sexually impotent 4 or 5 months after castration. All the lost masculine characters can again be restored by androgen treatment. Castration in females eliminates estrous cycle and sexual receptivity which can be restored by administering estradiol. Steroid hormones have also been shown to be effective in regulating the parental behaviour in some animals. In night heron, in which parental activities are performed jointly by the male and the female, testosterone, but not the estradiol, was found to initiate nest-building in both sexes.

The question left to be answered is : How do steroid hormones affect animal behaviour ?

Extensive investigations have revealed that all behavioural effects of steroidal hormones are mediated by brain. It is now well established that sex hormones directly influence sexual differentiation in brain by affecting the pattern of nerve connections, and the organizations of nerve circuits in specific parts of the brain during embryonic and early post-natal life. For example, if a male rat is castrated at birth, the sexual differentiation of nerve circuits in brain fails to take place and the brain retains "female" pattern. Similarly, administration of testosterone to a newborn female evokes a "male" pattern of brain because

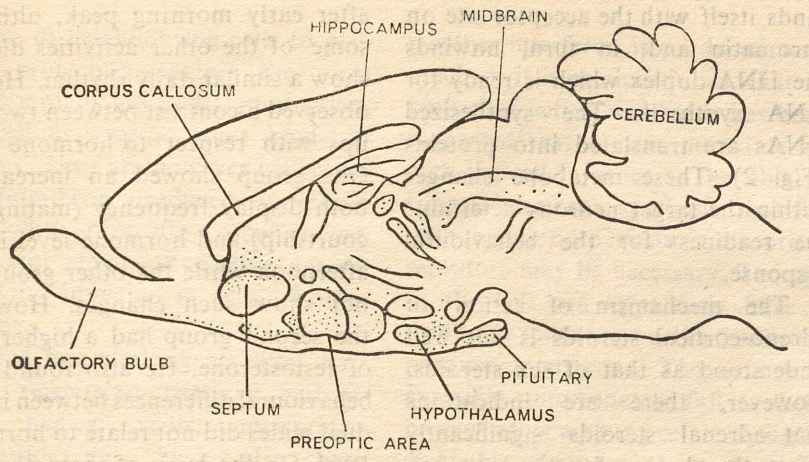

Fig. 1. Dotted areas show incorporation of tritiated estradiol

administered testosterone is readily converted intracellularly into estradiol. However, sex hormones cannot modify the nerve circuits in the adult animal but can influence the circuit's functional efficiency and, in turn, control the behaviour.

Professor Arnold A. Berthold (1949) of the University of Göttingen has suggested that gonadal steroids directly influence the brain functions. He found that castrated roosters no longer crowd, fought or exhibited sexual behaviour. These symptoms were however restored when testes were transplanted into abdominal cavity of castrated roosters. On the basis of this experiment, Arnold concluded that behavioural signals from testis reach the brain through the blood and not through the nerves. The findings of Arnold were confirmed by Ronald J. Barfield (1969) of Rutgers University. Professor Bruce S. McEwen and his co-workers of Rockefeller University have located different specific steroidal-hormone-sensitive regions in the brain. Donald W. Pfaff of Rockefeller University and Walter E. Stumpf of the University of North Carolina

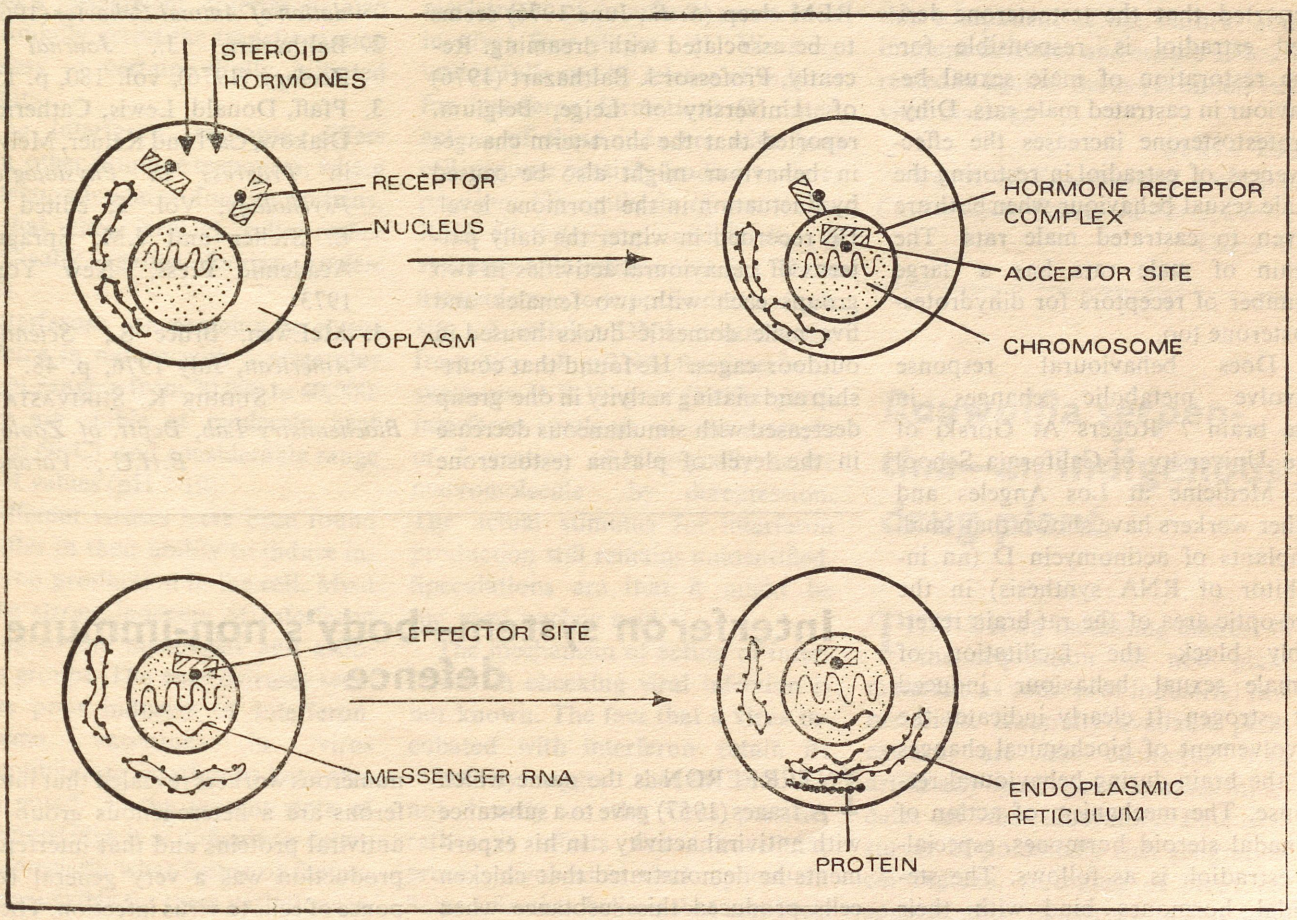

Fig. 2. Mechanism of action of steroid hormones

found the highest density of estrogen concentrating cells in the pre-optic area of the brain, the hypothalamus and its adjacent area, and the amygdala in the brain of castrated female rats with the aid of autoradiography technique (Fig. 1). Pfaff and Joan I. Morrel also observed a similar pattern of distribution of estradiol-specific area in the brain of fishes, amphibians, birds and mammals. These specific regions of the brain are loaded with receptor proteins which can bind with estradiol. It is now well proved that testosterone can be enzymatically converted into estradiol and dihydrotestosterone. Enzyme responsible for this is present in all the steroidal hormone sensitive regions of the brain of a male rat except in the pituitary.

Larry Christensen and his colleagues of Michigan State University reported that the testosterone derived estradiol is responsible for the restoration of male sexual behaviour in castrated male rats. Dihydrotestosterone increases the effectiveness of estradiol in restoring the male sexual behaviour when both are given to castrated male rats. The brain of male rats has a large number of receptors for dihydrotestosterone too.

Does behavioural response involve metabolic changes in the brain ? Rogers A. Gorski of the University of California School of Medicine at Los Angeles and other workers have shown that small implants of actinomycin D (an inhibitor of RNA synthesis) in the pre-optic area of the rat brain reversibly block the facilitation of female sexual behaviour induced by estrogen. It clearly indicates the involvement of biochemical changes in the brain during behavioural response. The mechanism of action of gonadal steroid hormones, especially estradiol, is as follows. The steroidal hormones bind with their specific receptors and form hormone-receptor complex. This complex binds itself with the acceptor site on chromatin and, in turn, unwinds the DNA duplex which is ready for RNA synthesis. The synthesized RNAs are translated into proteins (Fig. 2). These metabolic changes within the target neurons determine the readiness for the behavioural response.

The mechanism of action of adreno-cortical steroids is not well understood as that of sex steroids. However, there are indications that adrenal steroids significantly affect the brain functions as revealed by the presence of receptor proteins in the hippocampus and septum regions of the brain. When adrenal steroids were administered into human volunteers, they profoundly affected the rapid eye movement (REM) of the volunteers characterizing a certain state of sleep. REM sleep (*S. R.*, June 1976) seems to be associated with dreaming. Recently, Professor J. Balthazart (1976) of University of Leige, Belgium, reported that the short-term changes in behaviour might also be caused by fluctuation in the hormone level. He recorded in winter the daily patterns of behavioural activities in two groups each with two females and five male domestic ducks housed in outdoor cages. He found that courtship and mating activity in one group decreased with simultaneous decrease in the level of plasma testosterone after early morning peak, although some of the other activities did not show a similar daily rhythm. He also observed a contrast between two groups with respect to hormone level. One group showed an increase in both display frequency (mating and courtship) and hormone level in the afternoon while the other group did not show such changes. However, the second group had a higher level of testosterone. He also found that behavioural differences between individual males did not relate to hormone level. On the basis of these observations, Balthazart gave an intriguing explanation for a mechanism of short-term changes in behavioural activities. But still it has to be shown that the changes in hormone level cause the behavioural changes rather than the other way round.

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2. Balthazart, J., *Journal of Zoology* (1976), vol. 180, p. 155.
3. Pfaff, Donald, Lewis, Catherino, Diakow, Carl and Keiner, Melvyn in *Progress in Physiological Psychology*, Vol. 5, edited by E. Steller and J.M. Sprague, Academic Press, New York, 1973
4. McEwen, Bruce S., *Scientific American*, July 1976, p. 48.

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Interferon system—body's non-immune defence

INTERFERON is the name which A.Isaacs (1957) gave to a substance with antiviral activity . In his experiments he demonstrated that chicken cells produced this susbtance when exposed to heat inactivated influenza virus. Subsequent investigations by numerous workers revealed that interferons are a heterogenous group of antiviral proteins and that interferon production was a very general response of cells to virus infection. These substances are released in the cell infected with a virus which then

diffuse to neighbouring cells to provide protection against the virus which initially induced its production, as well as against other kinds of viruses. They are however cell specific. Interferon produced in mouse cells while protecting other mouse cells will remain ineffective against any viral infection in cells of other species.

Some non-viral agents like bacteria, rickettsiae, bacterial endotoxins, nucleic acids, nucleotides, nucleosides etc. have also been claimed to be inducers of interferon-like inhibitors. As these substances have not yet been adequately characterized, their precise classification is uncertain.

It is now generally believed that viral infections are held in check in animals as a result of this special defence mechanism. Interferons also profoundly arrest the transformation process in certain virally initiated tumors.

The interferon response differs from other immune responses, where protection is against foreign proteins, in that they protect cells rather specifically against foreign nucleic acids.

Interferons are proteins or glycoproteins in nature with a molecular weight ranging from 20,000 to 40,000. They are stable at moderate heat (about 60°C) and considerable range of pH values (pH 2-10).

Different viruses have been found to differ in their ability to induce interferon production in the cell. Most of the strong inducers of interferon belong to the myxovirus and arbovirus groups. The enteroviruses seem to be poor inducers of interferon. Extreme variations in virus susceptibility to interferons have also been noted. At the present state of our knowledge it is difficult to determine precisely what factor or factors are responsible for these variations in virus-interferon responses. Apart from the virus, the cell seems to be an equally important determinant of whether interferon is produced, how much of it is produced and what its biological action will be. It has been suggested that a virus must interact with the cell in order to be able to trigger interferon synthesis, and for such reaction to occur appropriate receptors may be necessary. The age of the cell can apparently have a profound influence on the ability to produce interferons. The evidences available unfortunately fail to establish whether a young cell is basically incapable of producing interferon or its failure to do so is because it gets killed before it is ready to synthesize the substance. Cells of the reticulo-endothelial system have been shown to have an important role in interferon production.

Studies of numerous scientists put together seem to suggest that the mechanism of interferon production involves four stages : (1) Virus invasion followed by release of inducer for interferon formation; (2) interaction of these inducers with host cell genome possibly leading to derepression; (3) synthesis of messenger RNA for interferon, and finally (4) synthesis of interferon proteins. There are evidences to suppose that a single site on cellular DNA controls the formation of mRNA for interferon synthesis. R.R.Wagner (1963)regards interferon synthesis as an example of formation of biologically active macromolecule by derepression. The actual stimulus for interferon production still remains unidentified. Speculations are that it might be the viral nucleic acid.

The mechanism of action of interferons in checking viral infection is not known. The fact that a virus incubated with interferon retain its infectivity suggest that the action is not directly on the virus particle, rather it affects the intracellular process involved in viral replication. Some scientists believe that synthesis of viral nucleic acid, or more possibly protein, is affected.

The facts that interferons are essentially non-toxic and are tolerated by animals to a great extent and that its inhibitory action is on a wide range of unrelated viruses have aroused considerable interest on the subject. There is hope of the possible application of interferons as "broad spectrum antiviral drug" in the near future. Local application of interferon has been shown to protect eyes, skin, peritoneum, respiratory tract and other sites against viruses in a number of animal experiments. Interferons are also capable of preventing malignant transformation of cell by oncogenic viruses and are known to selectively destroy virally initiated cancer cells.

Past experimental evidences, along with researches in progress in the field, might open up new lines for successful clinical application of this component of our natural non-immune defences and ensure effective remedies against the as yet undefeated viral diseases.

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Rauwolfia serpentina—an indigenous drug plant

THERE is an increasing interest in the acquisition of new plant materials as sources of industrial raw materials. Naturally available plant extracts are less economic than artificially synthesized complex molecules of the laboratory. Extensive survey of potentially rich geographical regions, screening of plant resources, their conservation and utilisation is noteworthy. Scientists say, "A more elaborate analysis of the pharmacology of the plant shall

R. serpentina

bring out the truth of its mysterious manifold action." *Rauwolfia serpentina*, Benth., the wonder plant of antiquity, is the source of an alkaloid known as reserpine. It has aroused great interest for its hypotensive and tranquillizing principle. Roots of the plant are the source material from which the alkaloid is extracted.

Origin and morphology

The nativity of this medicinal plant is not clearly known. The root of *R. serpentina* has been much valued in India as well as in the Malayan peninsula from ancient times as an antidote to the bite of poisonous reptiles, stings of insects and also as a psychoactive material.

The plant is indigenous to Maharashtra, Gujarat, Tamil Nadu, Kerala, Karnataka, Punjab, Bihar, Orissa, West Bengal and Assam is an inhabitant of moist regions with rainfall range of 175 cm-375 cm a year and altitude upto 1300 metres. It belongs to the family Apocyanaceae (Vern.: Bengali and Hindi : Chotachand, Chundrika; Kannada : Amalpodi, Garudpathal; Marathi: Moogsavel, Sapasan; Oriya: Patalgaruda; Bihar: Dhanbarna; Sanskrit: Sarpagandha, Chundrika; Tamil: Eiyakundu; Telugu: Patalgandhi, Patalgarud).

It is a pretty, glabrous undershrub, 30-60 cm high with bright green, shining, opposite and 3-4 nately whorled, oblong or ovate membranous leaves, 7.5-15.5 cm long. Its small, white flowers have pink tubes in terminal peduncle.

Mention may also be made of two other species found in India namely *R. canascence*, L. and *R. densiflora*, Benth., for their useful alkaloids.

Chemical composition

As an authentic drug in the indigenous system of medicine, major workers of India and abroad have focussed their attention on roots, the main source of active principles. A detailed account is given in Table 1. The alkaloid reserpine currently

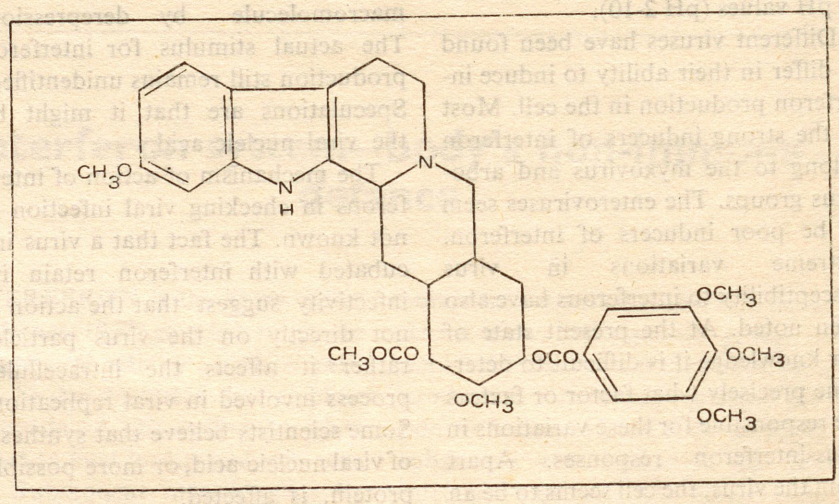


Fig. 2

Table 1. List of alkaloids detected and their properties

Alkaloid groups isolated	Locality	Source	Alkaloid contents	Physical properties
1. Two types of alkaloid alongwith resin and starch	—	Root	1% of the root	
2. Five types of alkaloids under two groups	—	Root		
A. *Ajmaline group*				White crystalline weak bases
(a) Ajmaline ($C_{20}H_{26}O_2N_2$)			0.1%	m.p. 158-160°C.
(b) Ajmalinine ($C_{20}H_{23}O_4N$)			0.05%	m.p. 180-181°C.
(c) Ajmalicine			0.02%	m.p. 250-252°C.
B. *Serpentine group*				Bright yellow crystalline strong bases
(a) Serpentine ($C_{21}H_{23}O_4N$)			0.08%	m.p. 153-154°C.
(b) Serpentinine			0.08%	m.p. 263-65°C.
3. Three alkaloids	—	Root		m.p. 160°C.
(a) Rauwolfine ($C_{21}H_{26}O_2N_2$)				
(b) Isorauwolfine				—
(c) Alkaloid of the type ajmaline				—
4. Alkaloids of different groups				
(a) Ajmaline, ajmalinine, and ajmalicine groups	Bihar	Root	—	White crystalline bases
(b) Serpentine and serpentinine groups	Bihar	Root	—	Bright yellow crystalline bases
(c) New ajmaline group, little ajmaline and ajmalicine	Dehra Dun	Root	—	—
(d) Isoajmaline and neoajmaline	Dehra Dun	Root bark	0.1%	m.p. 264-260°C.
(e) Isoajmaline and neoajmaline	Dehra Dun	Root	0.1% &1%	m. p. 205-207°C.
5. Total alkaloids	—	Root	1.21%—1.36%	—
6. Rauwofine ($C_{19}H_{26}O_2N_2$)	—	Root	—	m.p. 235°C.—236°C.
7. Reserpine	—	Root	—	m.p. 202°C.—203°C. crystalline form
8. Total alkaloid	—	Root	1.7%—2.7%	—
9. Total alkaloid	Dehra Dun	Root of 2 years diploid plant	1.54%	—
-do-	Dehra Dun	Root of 2 years tetraploid plant	2.28%	—
-do-	Rishikesh	Root of 3 years diploid plant	2.28%	—
10. Total alkaloid	Bihar	Root	0.956%—2.72%	—
11. Total alkaloid	Rishikesh (U.P.)	Root	2.6%	—
	Rangoon (W.B.)	Root	2%	—
	Dehra Dun (U.P.)	Root	1.8%	—
	Calcutta (W.B.)	Root	1.35%	—

isolated (Fig. 2) has become commercially feasible for its psychoactive principles.

Besides the alkaloid contents, some other substances like resin, starch, potassium carbonate, silicate, phosphate, maganese, iron, phytosterol ($C_{25}H_{44}O_2$), oleic acid and unsaturated alcohols are also present. A long term research of about five decades provides the clue for extensive survey of potentially rich geographical regions for screening superior variety with a rich content of reserpine.

Alkaloid consumption in India

Alkaloid consumption in India is gradually increasing due to its higher commercial exploitation. A. Dutta and coworkers recommended from Calcutta (*Ind. Jour. Pharm*, 54, 1947) a standardised alcoholic extract containing about 0.5% of alkaloid for clinical trials. This extract or tincture manufactured by different commercial firms was used by the medical profession in India for the treatment of hyperpiesis and maniacal type of insanity. There is also a large scale production of reserpine by extraction from natural source as well as by biosynthesis from many pharmaceutical firms in our country.

Cultivation and ecophysiological studies

The plant *R. serpentina* occurs widely in nature in various habitats. Considerable variation in the alkaloid contents and consequently potencies of *R. serpentina* roots have been reported from time to time. The highest alkaloid contents is found at the end of the season when the fruits are ripe. At pre-flowering stage in the month of March, roots have the lowest alkaloid content and it increases till the end of the season. R. Dhar at Regional Research Laboratory, Jammu (*Proc. Ind. Ac. Sci.*,

1965) reported that there were considerable variations in the alkaloid content of four geographical races of *R. serpentina*.

R. C. Biswas (*Sci. and Cult.*, 1969, 1970) while working at Central Botanical Garden, Calcutta, reported an increase in the root alkaloids under defloration treatments with and without nitrogenous fertilizer to the deflorated samples. Such defloration procedure may be employed for commercial cultivation of *R. serpentina*.

Table 2. Pharmacological action of alkaloids

Alkaloid treatments	Experimental animals	Effect
1. Extracts of serpentine groups injected intravenously	Cats	Effective stimulation marked
2. Total alkaloid contents and serpentine groups	Guinea pig	Lowering the carotid blood pressure, depresses the cardiac musculature, produces spleenic contraction, stimulate respiration and increases peristalysis of intestine
3. -do-	Cats	Lowering the blood pressure
4. Alkaloid extract from roots	Cerebrate and spinal animals under experimental hypertension.	Stimulatory effect on nervous system followed by depression
5. Reserpine	Rabbits and dogs	Animals put to sleep
6. Reserpine	Man	Effective tranquillizing action during hypertension

Pharmacological action

The plant has attracted considerable attention not only in India but also in Europe and America and much work is being done on pharmacological action of different alkaloids in it.

The ajmaline group (Table 1) is a general depressant to the heart, respiration and nerves, and the serpentine group (Table 1) paralyses respiration and depresses nervous system but stimulates heart. These observations are based on experiments carried out on frogs and are not applicable in toto higher animals. Fresh reserpine is a strong and long duration central sedative. Small doses (0.01 mg/kg) administered intravenously to rabbits and (1 mg/kg) orally to dogs put the animals to sleep (Table 2). The drug is not an irritant when taken by mouth or when introduced into the system by hypodermic or intramuscular injection.

Sedative responses

Recently reserpine has gained popularity as a specific drug for treatment of in sanity as it possesses marked sedative properties. Powdered roots produce a good sedative effect. J. C. Gupta and coworkers (*Ind. Med. Gaz.*, 547, 1943) have treated fifteen types of mental patients, like organic psychosis, chronic-epilepsy and effective reaction types. All patients were suffering from insomnia and showed considerable mental agitation. After treatment patients behaved normally and there was considerable improvement in those suffering from mental disorders. Epilepsy was controlled and there was stimula tion of alimentary system. Appetite also improved.

Treatment of hypertension

Powered roots taken (20 gm to 30 gm) twice daily decrease blood pressure within a week. Reserpine is also valued as a major tranquilliser and is used in treatment of hypertension. The doses are: in psychiatric states 1 mg to 5 mg daily in divided doses; in the treatment of hypertension, 500 mg daily.

Drug interaction

There is an increasing interest in the study of interaction of *R. serpentina* with other drugs. K. Nadkarni (*Indian Materia Medica, 1*: 1050, 1954) reported use of *Aristolochia indica*, L. with *R. serpentina*, Benth. against cholera and found that the patients were cured. In treatment of colic, one part of the root with two parts of *Holarrhena antidysenterica*, Wall. and three parts of *Jatropha curcas*, L. in milk is given. *R. serpentina* root with *Andrographis paniculata*, Nees., *Zingiber officinale*, L. and black salt is prescribed against fever.

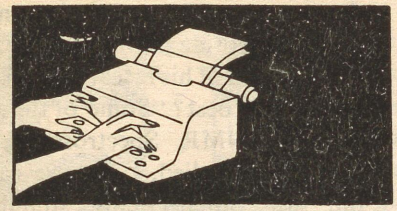
Ayurvedic use

Decoction of the root is used to increase uterine contraction and quicker expulsion of the foetus. Root is used as a remedy against poisonous snake bites and stings of insects. It is also a valuable remedy in dysentery and painful bowel complaints.

Current research programmes

Now steps are being taken by the Regional Research Laboratories at Jammu, Bhubaneswar and research workers of other organisations for a detailed survey of the

(*Continued on page 494*)



NEWS & NOTES

The neutron bomb

TWENTY FIVE years after the first hydrogen bomb was exploded in 1952 comes the news of the testing of a 'neutron bomb' by the United States. The new device, developed after 20 years of research, is in fact the first major breakthrough in nuclear weapons development since the H-bomb. It is said to be highly effective in killing the enemy personnel but cause little damage to buildings and other structures. Also, there is no radioactive fallout.

From the information available so far, the neutron bomb is most likely a new type of small-sized hydrogen bomb. The conventional hydrogen bomb uses a moderate-sized uranium or plutonium fission device to trigger off the thermo-nuclear fusion reaction. This is necessary because the fusion of hydrogen nuclei needs extremely high temperatures, of the order of a few million degrees centigrade. And so far such temperatures could not be produced by chemical explosives like T.N.T. One result of using a uranium or plutonium trigger was that although hydrogen fusion itself does not produce much radio-activity, the bomb produced radio-active fallout due to fission debris. Besides, since the fission reaction needs a minimum quantity of the fissile material, the H-bomb could not be built smaller than a certain size. This posed problems of its delivery and deployment. These difficulties seem to have been overcome in the neutron bomb by using a non-fission type of trigger. While exact details are not known, it is likely that the trigger temperature is attained by using electromagnetic heating or high-power pulsed laser, or even shock waves.

Once the need of a critical size is done away with, the bomb can be built in any size, suitable for use in tactical warfare. It can then be carried by the ground troops also.

Since no fissile material is used, a neutron bomb does not produce any radioactive fallout. But it does give out intense bursts of high-energy neutrons and gamma rays which are lethal to any living being. But the low blast energy would cause little damage to buildings and structures. So it would be possible for the attacking force to occupy and use enemy territory in relative safety.

BIMAN BASU

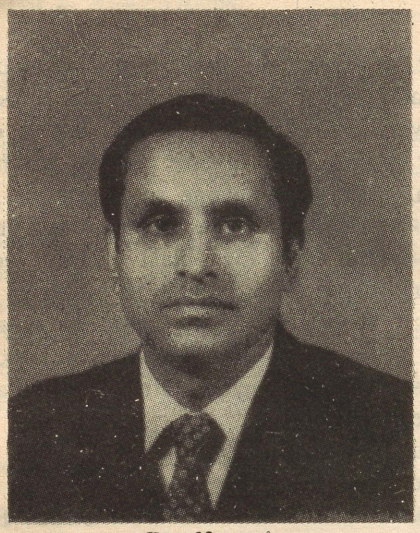
An Interview

Dr. K. Nagarajan

A few years back a brilliant physicist, having just returned from abroad, said in an article on educational system in India published in a leading daily that, "even our Ph.D. students are superficially interested in their subject". Is it a fault of our students or educational system? Most blame the latter. But after having listened to Dr. Kuppuswamy Nagarajan, the 1974 S. S. Bhatnagar Prize winner in chemical sciences, on this perennial problem, I felt there is a need to consider a third, yet un-cared-for factor.

It is the encouragement and patronage a teacher or researcher gives to his students. If the student-teacher relationship is informal, and a student is given free hand to indulge in his pursuits, and talented ones are spotted and given special attention and facilities, what could stop them from materialising into talented scientists? "Catch them young" is the phrase our scientists should remember. Dr. Nagarajan says that it is the ability of the American education system "to spot and encourage talent at an early stage of a student's career that contributes a lot to its success." He gave an illuminating example.

"In 1959-60 when I was at California Institute of Technology as a post-doctoral researcher in the tenth year of my career," he reminisced "an undergraduate was attached to my professor, J. D. Roberts, on a summer assignment. He was trained to use the sophisticated Nuclear Magnetic Resonance (NMR) spectrometer, and soon he not only mastered its electronics but also became proficient enough to grasp and wield its theoretical potentials. I am sure that he had a brilliant graduate and postgraduate career subsequently. Such patronage can go a long way in mobilizing young talent in our country." Dr. Nagarajan attributes his own successful career to the encouragement he got from his father and many teachers.



Dr. Nagarajan

Born on September 15, 1930, at Sirupalai, Tamil Nadu, in the family of a school teacher, Dr. Nagarajan had a brilliant career since his childhood. He is one of the seven sons of the family, so his big family always lived off a shoe string budget. But for the assistance he received from Prof. K. Swaminathan, Professor of English at Presidency College, and the late Prof. K. Subrahmanyam, he "might have been forced to take up a clerical job." He took up the honours course in chemistry as it was then considered to be an "achievement". Later, on meeting Prof. T. R. Govindachari, of Presidency College, Madras, he decided to pursue research in organic chemistry at the same college.

Presently working as a group leader in Pharma Synthetic Chemistry Division of CIBA-GEIGY Research Centre, Bombay, Dr. Nagarajan is a Fellow of many national and foreign academies and associations. He has done research at many internationally renowned institutes and has 120 publications and several patents to his credit. His work is in the field of medicinal chemistry.

Dr. Nagarajan has synthesized a large number of new compounds, most of them heterocycles, for screening for antifertility, antiparasitic, antibacterial, antitubercular, antiviral and antidiabetic activities and also for effect on the cardiovascular and central nervous system. He developed a new and simple synthesis of dibenzoxazepine ring which helped the development of a clinically useful antidepressant.

Medical chemistry fascinates Dr. Nagarajan. It is a "satisfying" field for him as "positive results are capable of being of direct use in making of drugs". In fact he has played an important role in the elucidation of structures of several plants of medical importance. Also, he has been involved in the determination of the structure of the complex aminosugar nucleoside antibiotic, amicetin.

What part of his research work does he consider best? "Some of the applications of NMR Spectroscopy," Dr. Nagarajan replied, "that we carried out was intellectually stimulating and satisfying. This was not so much a matter of fluke as one of design. An important offshoot of this work was that we could obtain NMR evidence for the presence of allylic strain in some complex molecules. This strain concept had been propounded for cyclohexene in U.S. some years earlier. It was satisfying for us to have our NMR results confirmed by X-rays studies of Prof. G. Kartha."

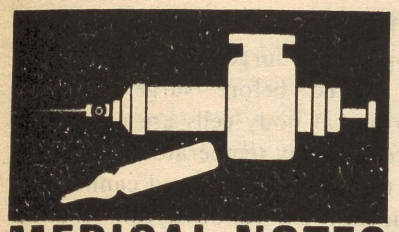
To popularise science Dr. Nagarajan suggests that talks on various subjects be given to high school and undergraduate students by "people who practise science and live with it". In this way, he says, "the lectures will have a note of authencity and greater effectiveness than those given by their teachers."

Married to Padmalochana, a noted Bharathanatyam artiste and vocalist (karnatak music), Dr. Nagarajan has one daughter and one son.

DILIP M. SALWI

CORRIGENDUM

In Fig. 2, page 350 (*S.R.*, June 77), *read* 100 kilojoules *for* 100 kilograms



MEDICAL NOTES

Microwaves in medical service

THE use of microwaves in communication systems is well known. In developed countries research is in progress to exploit microwaves to solve energy problems. They have a role to play in medical and social needs of man as well.

The electromagnetic fields in the spectrum between 1 MHz (1 mega hertz=10^6 cycles per second), and 100 GHz (1 Giga hertz=10^9 cycles per second) are biologically significant. They can be readily transmitted through, absorbed, and reflected at biological tissue boundaries in varying degrees. These properties can produce medically beneficial effects or do biological damage. The frequency range in which people are most interested today is in the microwave spectrum of 300 MHz to 10,000 MHz. Tissues of man in this frequency range have a good absorption properties.

The idea of using microwaves for therapy originated in Germany in 1938 and 1939 when H. E. Hollman discussed the possible application of radio waves of 25 cm wavelength for therapeutics. He predicted that these waves could be used to heat deep tissues without excessive heating of the skin. In 1939, A. Hemingway and K.W. Stenstrom, in the United States, suggested the use of higher frequency radiation for this purpose. But during World War II, the biomedical research related with microwaves, to dispel the fears of possible ill effects of electromagnetic radiation upon personnel connected with radar work, gained more interest. As a consequence, a number of medical applications of microwaves have come to light.

Medical applications

The medical applications of microwaves can be classified into two areas : (1) therapeutic : heating of tissues, and (2) diagnostic. The former includes the most historic application, diathermy, and newer applications including rewarming of refrigerated whole blood, thawing of frozen human organs, production of differential hyperthermia (elevated body temperature) in cancer treatment, rapidly reversing a patient's hypothermic state (low body temperature) in open heart surgery, and the transmission of microwave pulses into nervous tissues for stimulating nerves. The latter may be used to block pain signals and also in some cases for the improvement of neuromuscular functions. Diagnostic applications include measurements to assess properties and conditions of certain biological tissues and to assess significant parameters such as blood volume and respiratory volume changes.

Diathermy

Diathermy is a technique used for providing therapeutic heating in tissues. Physical forms of energy such as ultrasound, electro-magnetic shortwaves, or microwaves are converted into heat after being transmitted to deep tissues and fatty layers beneath the skin. The beneficial effect of the diathermy in inflammation is that better heating leads to relief from pain. Figs. 1 and 2 show shortwave diathermy application system and fields in layered human tissues. The applicators used with commercially available 2450 MHz diathermy apparatus are shown

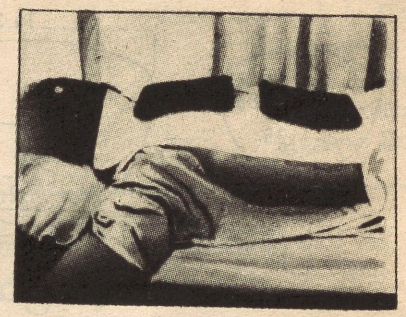


Fig. 1. Short-wave diathermy application with condenser pads to back with spacing between skin and electrodes provided by layers of terry cloth

in Fig. 3. These applicators are basically a special type of antennae. Diathermy is now successfully used in the treatment of the diseases of muscles and bones, such as rheumatoid arthritis, fibrositis, myositis tendinitis. The heating of tissue induces muscular relaxation, so it may be used for the relief from muscular spasm. Another advantage of microwave diathermy is that the patient is free to move away from the director and is free from pads, cables, and toweling commonly used in shortwave diathermy.

Differential hyperthermia in cancer treatment

Research on application of microwave heating of body tissues for the treatment of cancer is now in progress in various laboratories of the world. Microwaves are used to heat the cancerous or tumour area

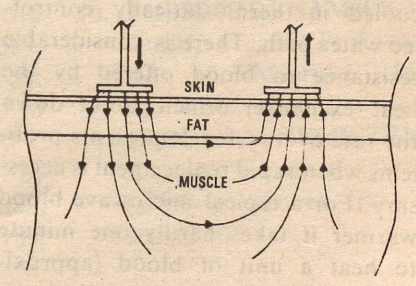


Fig. 2. Cross sectional sketch showing fields in layered tissue exposed to shortwave diathermy capacitor type electrodes

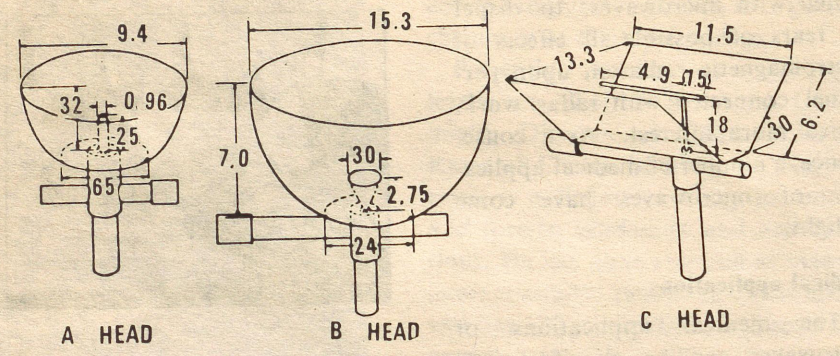


Fig. 3. Applicators used with commercially available 2450 MHz diathermy apparatus

selectively and uniformly at a very high temperature (hyperthermia), while the remainder of the body is maintained in a hypothermic condition (the temperature below normal body temperature), that is, 25° C below normal body temperature. A toxic anti-cancer drug is then administered to the subject. The cooler tissues absorb very little of the drug while the tumor absorbs a significant amount of it. Recent experiments on mice indicate that 75 per cent of the tumors disappear after 4 to 5 hours of treatment.

Warming of human blood

To prevent lowering of heat and body temperature below normal (hypothermia), the refrigerated bank blood is warmed from its 4°C—6°C storage temperature to body tempearture before introduction in the body. In the past, this was done by passing the blood through a long, small-core plastic tubing cooled in thermostatically controlled water bath. There is considerable resistance to blood offered by the heat exchanger which slows down the rate of transfer. It presents problems when rapid replacement is necessary. For a typical microwave blood warmer it takes hardly one minute to heat a unit of blood (approximately 500 ml) in its original plastic container from 4°C—6°C to 35°C. This warmed blood can then be rapidly administered to the patient. The unit is warmed by rotating it in a microwave cavity driven by a 2450 MHz 1000 watts magnetron. Extensive laboratory tests indicate no deleterious effect on the blood and its transfer to patient indicates no abnormal effects.

Rapid elimination of hypothermia

A standard technique used in open heart surgery is to reduce the body temperature to induce a hypothermic state prior to surgery. Hypothermia slows down the mechanism of metabolism (series of chemical changes in the living body to maintain life) so that nutrients and oxygen requirements are reduced sufficiently to allow the heart to be stopped for surgery. Surface cooling is desired before surgery as the peripheral body cells are cooled before the body temperature is reduced to the point when blood cannot provide nutrients and oxygen. For rewarming after surgery, core heating is desirable so that blood has sufficient temperature to allow proper metabolism prior to the rewarming of the peripheral cells. Peripheral cells require oxygen and nutrients at a level that the blood cannot provide due to the lower body core temperature. Core heating is possible in case of adults and large children by pumping blood through heat exchangers. This process takes along time and so restricts the total time required for surgery. Heating cannot be used in case of infants below a certain size due to the physical limitation of the apparatus. Microwaves offer a method to achieve core heating rapidly for a patient of any size by selectively heating certain portions of the body.

Rapid thawing of frozen tissues

It is known that an increase in the survival of biological materials

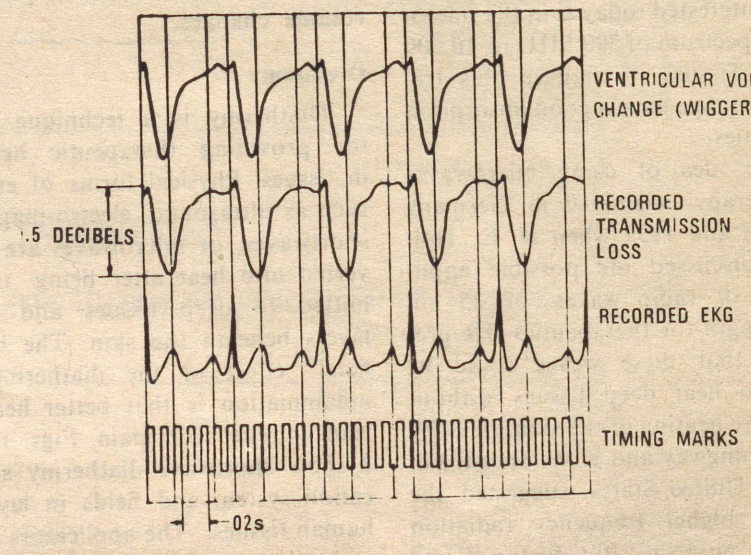


Fig. 4. Comparison of cardiac-ventricular volume change with recorded microwave transmission loss through chest cavity

is related with rapid thawing rates. Microwaves are capable of thawing human organs or other biomaterials such as semen. With proper development of microwave applicators, thawing rates upto 10 times faster than present can be achieved.

Diagnostic studies

In late 1960s Y. E. Moskalenko of U. S. S. R. suggested methods for assessing changes in reflected and transmitted microwave energy which are caused by significant parameters such as blood or respiratory volume changes. Their feasibility has been confirmed by A. W. Guy of U. S. A. by passing microwave beam through human chest. Fig. 4 illustrates that the variation of microwave loss is proportional to the ventricular volume changes in the heart. The potentialities of this approach appear favourable. Recently, J. C. Lin of Wayne State University has also reported the use of microwaves in respiratory measurements.

It is true that microwaves produce severe ill-effects on human beings, but only when a man is exposed to high power microwaves. To avoid them however, safety standards should be observed.

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Sialin peptide may reduce tooth decay

A recent discovery by Dr. Israel Kleinberg of the State University at Stony Brook suggested a new and natural approach to the control and prevention of cavities. The discovery is based on a substance named sialin. Basically, sialin is a small peptide comprised of only a few amino acids. It is a component of saliva that counteracts the acid produced by the bacteria in the mouth, the cause of tooth decay. In fact, the substance is the body's mechanism to protect the teeth, but it is overwhelmed by an excess of sugar in the diet. Dr. Kleinberg, Chairman of the Department of Oral Biology of Dental Medicine, and coworkers have synthesized the substance in the laboratory so it could be commercially produced. Efforts are being made to find the most appropriate vehicle for raising the level of sialin in the saliva. The possibilities include a rinse, chewing gum, toothpaste or candies.

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BOOKS RECEIVED

1. **A DICTIONARY OF CHROMATOGRAPHY** by Ronald C. Denny *Macmillan Press Ltd.*, London, Representatives in India : 2/10, Ansari Road, New Delhi-110002, Pp. 191, £15.00
2. **A FIRST COURSE IN APPLIED ELECTRONICS** by W. Gosling, *Macmillan Press Ltd.*, (same as above), Pp. 162, Price not indicated
3. **TRIVENI Science, Democracy and Socialism** by A. Rahman, *Indian Institute of Advanced Study*, Simla-171005, Pp. 111, Rs. 22.50
4. **MICROBIAL AND MOLECULAR GENETICS** by J. R. Finchman. *Hodder & Stoughton*, London, Representative in India: *BI Publications*, 359, Dr. D. N. Road, Bombay-400023, Pp. 150, Rs. 36 (£ 2.25)
5. **INTRODUCTION TO ECOLOGY** by R. Dajoz, *Hodder and Stoughton* (Same as above) Pp. 416, Rs. 71.20 (£ 4.25),
6. **MICROBIAL PLANT PATHOLOGY** by P. J. Whitney, *Hutchinson*, London, Representative in India : *BI Publications*, 359, Dr. D. N. Road Bombay. 400023, Pp. 160, Rs. 47.20 (£ 2.95)
7. **BIOLOGY OF INSECTS** by C. P. Friedlander, *Hutchinson, London* (as above), Pp. 189, Rs. 47.20 (£ 2.95)
8. **FRESH WATER BIOLOGY** by L. G. Willoughby (same as above), Pp. 167, Rs. 47.20 (£ 2.95)
9. **PRINCIPLES OF CHEMISTRY** by A. N. Sharma and Y. P. Jigyasu, *Kalyani Publishers*, Available at *Lyall Book Depot* Chaura Bazar, Ludhiana-141008, Pp. 783 Rs. 25.00
10. **THERMODYNAMICS** by J. N. Gurtu, *Pragati Prakashan*, P. B. No. 62, Meerut-1, Pp. 292, Rs. 14.50.
11. **ELECTROCHEMISTRY** by J.N. Gurutu, *Pragati Prakashan*, (same as above), Pp. 232, Rs. Rs. 12.60

SCIENCE FOR THE YOUNG

Chemistry creates a wonder world

LIFE as we know it would be strikingly different without chemistry. Chemists along with other scientists have made it possible for us to have conveniences and luxuries unknown to the kings a generation ago. The paper on which this magazine is printed, the permanent quick-drying ink used in its printing, the metal used in the type and the reproduction of illustrations are all the result of chemical processes.

An understanding of chemistry is essential in many professions. Whether you are a doctor, a grocer or a housewife—you have a chemist part also in you. A doctor uses lots of chemicals produced by chemists and a knowldege of their properties and physiological action is necessary for their judicious usage. Likewise, a housewife should not mistake sodium bicarbonate for common salt in her kitchen.

In the laboratories chemists experiment with many materials, sometimes using complicated apparatus for producing a seemingly endless new products to satisfy our needs. Among these products are the sulpha drugs, penicillin, streptomycin, bakelite, lucite, rayon, nylon, dacron and the silicones, to name a few.

You need not think that only great chemists can carry out chemical reactions. You are also capable of doing complicated chemical reactions. When you strike a match, or boil potato, or wash your hands with soap and water, you are producing chemical changes. Of course, you can clean your hands without being a chemist. But a bar of clean-smelling soap is a result of thousands of experiments by chemists.

You can do other kinds of excellent chemistry. This morning you combined calcium with carbondioxide to form calcium carbonate when you drank milk. In other words, the milk has been changed into bone material in your body. Similarly you may have separated proteins into amino acids to form other types of proteins when you ate an egg which is now on the way to becoming a part of your muscles.

To most people, the label chemistry is largely associated with the production of somewhat simple chemicals—sulphuric acid, ammonia, ethylene, glycol and similar inorganic and organic chemicals. A much smaller number of people, when pressed, might add a few more materials that are also chemical such as plastics and resins, synthetic rubber and fibres, drugs, soaps and detergents, cosmetics and toiletries, paints and varnishes, and fertilisers and pesticides. There are about a dozen categories of chemical and chemical products comprising the output of what is more formally known as the 'Chemical and allied products industry'. At the same time, many other manufacturing industries that are not normally thought of as chemical have a considerable dependence on chemistry.

Chemistry by definition deals with the molecular transformations that matter undergoes and, hence, the activities that occur in the industries dealing with ferrous and non-ferrous metals, petroleum, food, coal and coke, pulp and paper, stone, clay and glass, and electronic equipment should also be included in the treatment of chemistry.

Now, can you name a few objects you come across daily, which do not have a connection, either direct or indirect, with the chemist or his field of specialization ? You find it a tough job, because what all you say form the subject matter of chemistry. In fact, the universe, so to say, is the realm of chemists' activity. Such a view of the pervasiveness of chemistry is not offered with the thought of improperly aggrandizing chemistry beyond its limit. Chemistry is considered to embrace the practice of industrial chemistry and chemical engineering as well as chemical research and development and the academic preparations of professional manpower. Moreover, the practice of chemistry in industry reaches far beyond research and development into production, inspection and testing, sales and purchase and many other areas.

While emphasising the pervasiveness of chemistry, it has to be re-

membered that no scientific discipline is really independent of all others. Any given scientific or engineering talent must be complemented by other skills and many of the accomplishments of chemistry have resulted from the work performed by persons trained in other disciplines.

Chemists' accomplishments

All around you are the marvellous and useful works of chemists. Your food, your clothing and your home—just about everything you use—have been made possible by chemists. Chemists learnt to change wood into paper, and lumps of coal and grains of salt into white silky cloth. The storage battery in your car and the soap in your soap box contain important chemicals. Chemists also manufacture synthetic fibers, plastics, vitamin pills, foam-rubber, television tubes, coloured balloons, unbreakable records, solvents, dyes, cosmetics, paints, toothbrushes, detergents, insecticides and so on.

Methods and materials

It is very interesting to have a glimpse of a chemist's work and to see what methods and materials he uses. A chemist's materials are everywhere and in every thing. Everything in the world is of interest to him. He tries to understand what it is made of and how it can be used. Bit by bit, over hundreds of years chemists have found out more and more about the atoms and molecules as well as the elements and compounds of the world.

Chemists have always been puzzled at the changes matter undergoes under particular conditions. They are very much surprised at the formation of completely new materials with properties altogether different from those of the starting materials. For example, early chemists found that when sodium wire burns in chlorine gas, common salt is formed. Sodium is a highly reactive metal and chlorine is a poisonous gas. But their combination results in an entirely new and non-poisonous materials, finding an essential place in the kitchen.

Chemists call such changes chemical reactions. During a chemical reaction, a new product (common salt in this example) is formed when two or more materials (sodium and chlorine) react together. Chemists are not satisfied just by finding the use for the new product. They are interested more in understanding the way the change has taken place, and now we have a fairly good understanding of the mechanism of chemical changes; thanks to the accumulation of facts and principles by chemists over the years.

A chemist is curious about almost everything. One wants to know the chemistry of a rose, while another might be interested in a rotting waste material. There are millions of materials in the world—wood, plaster, clouds, water, salt, iron, clay, feathers—the list is endless. Is it possible to understand what each and every thing is made of, how they are useful and how they can be changed? The clue lies in the fact that molecules are made of smaller particles called atoms. Although there are millions of different kinds of molecules, there are only a few more than hundred different kinds of atoms. Each atom (also called an element) is carefully studied by scientists and is given a name—oxygen, hydrogen, silver, gold are a few of them.

But then, most of the things we know are not simple elements but combinations of elements. Common salt is a combination of sodium and chlorine, while water contains hydrogen and oxygen. Such combinations are called compounds. A compound is quite different in its properties from the elements of which it is made, as is seen in the case of common salt. Another example of a compound is sugar. It is made of carbon, a black solid and hydrogen and oxygen which are gases. None of the three elements is either white or sweet as sugar.

Chemists imitate nature

Nature has a fantastic skill to produce things. Look at the array of beautiful colours of the fruits and flowers in your garden. The plants and trees could produce these things with the water and manure you give them, with the help of sunlight. When Wöhler (a German scientist) made an organic compound from an inorganic raw material in 1823, the idea that only living things could produce organic substances through life processes was proved false. You will wonder that some of the greatest advances in science have come from the elimination of false ideas and theories and Wöhler's discovery is an excellent example. It led to attempts to make other known organic substances. Many of these efforts were successful. One synthesis led to others and now snythetists can prepare many of the naturally occurring materials.

Nature does not always provide man with pure substances. Mostly they are mixtures and often the components have to be separated before use for effective applications. Certain preparations made from plants, like poppies and coca, have long been known to kill pain when ingested by human beings. The plants contain the pain-killing substances morphine and cocaine along with several other substances. With the passage of time, chemists learnt to isolate

these substances from plants. Thus, one of the tasks of chemists is to investigate the molecular composition of such naturally occurring mixtures and separate them into pure substances. Analysts and analytical chemists do such job. Modern analytical and separation chemistry has advanced so much that even the most difficult analysis/separation can be carried out within a reasonably short time.

When organic chemists realized the importance and usefulness of natural products like wood, petroleum and coal, they tried to understand how the molecules of these products are constructed. After many years of painstaking research, they realized that the molecules of all natural organic materials that are strong, elastic, insoluble and melt at high temperatures have one essential feature in common—giant size. The giant molecules are composed of large numbers of smaller units connected end-to-end like coaches in a train. For example, each molecule of cellulose (the substance that gives rigidity and strength to plants) is made of strings of glucose molecules and each molecule of natural rubber is made of strings of isoprene units. The simple units are called monomers while the strings of monomers are called polymers. The way the monomers are connected to form the chain-like polymer decides the properties of the polymer—whether it will be flexible like rubber or rigid like plastics and textile fibers.

Chemists excell nature

It is one thing to use materials readymade in nature. But it is quite different to design and build special materials in the laboratory. Thus, a chemist's main task lies in the production of new substances not found in nature or occurring rarely. The knowledge gained by polymer chemists about the structures and properties of polymers has enabled them to design new molecules that would behave just as they wanted them to. We now have a variety of synthetic fibers, plastics and rubbers, each with properties the chemist intended it to have.

Polyethylene is a familiar man-made polymer. Squeeze bottles, toys, water pipes, food wrapping and electrical insulation are only a few of its applications. Likewise, butyl-rubber is an important synthetic rubber. Being much superior to natural rubber, it is widely used for automobile inner tubes. Fibers like nylon, rubbers like butyl rubber and plastics like polyethylene are only a few of the interesting and useful polymers that chemists have discovered.

There was a rapid progress in the manufacture of new substances in 19th century and the trend towards substituting man-made materials for natural ones is on the increase. Nowadays chemistry provides us with shoes and clothing and the time is not far off when it will start replacing the natural foods with the synthetics from petroleum products. A layman might be sceptical of such an idea. But a simple example might remove all his doubts. Which do you think would make a better perfume, lilies of the valley or a lump of coal. The answer is coal. It is very difficult to extract the essence of the flower because it is very delicate, but chemists could produce from coal a fine perfume with the scent of the flower. Other perfumes like Jasmine scent is prepared from phenylethyl alcohol and musk from xylene. These perfumes can also be derived from coal.

There has been considerable progress in the synthesis of food products. As a result, synthetic chemical compounds have found application in natural foodstuffs to give them attractive appearance, consistency, smell and taste. In addition, certain vitamins and aminoacids are synthesized commercially. It will not be long before synthetic proteins, fats and carbohydrates become competitive with natural products if the chemists find out simple and economic processes for their synthesis.

Think for a moment of photosynthesis, the process by which water and carbon dioxide combine in a green plant to form sugar. If this can be carried out artificially on a large scale, we shall be able to set up factories to mass produce food. This would be possible when chemists thoroughly understand the mechanism of photosynthesis.

Consider the problems of human or plant diseases. The way in which a medicine (a drug or a pesticide) works depends on the structure of its molecules. As the connection between molecular structures of living things and their function becomes better known, we shall be able to make better drugs, fertilisers and pesticides. Scientists are now trying to understand and imitate the giant polymers in plants and animals. Future developments in health care and agricultural production are closely connected with the development in understanding the chemistry of life. We have seen chemists successfully developing superior grade materials (like artificial rubber and synthetic fibers) which nature would envy. One day chemists might be successful in synthesizing a superior race of human beings!

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Your nose knows more than you know

A mother knows the smell of her own baby so well that even blindfolded she can pick it out of a nursery full of infants. The baby, in turn, knows the smell of its mother and probably, its father. Wives, however, cannot distinguish the smell of their husbands' hair from that of an old dachschund!

Dr. Orville Chapman of the University of California, Los Angeles, became interested in odour perception while working with a student entomologist. Together they discovered that insects and other species communicate with each other via chemicals called pheromones. For insects, pheromones not only constitute an odour language, but it is their best way of obtaining information about the outside world. Other animals rely less heavily on their sense of smell, with dogs about one million times less sensitive than insects, and man, at the lowest end of the scale, a million times less sensitive than dogs. Even with reduction, odour perception is operating all the time at a subconscious level, evoking an emotional reaction rather than an idea as sight does. The olfactory nerve is connected with the most primitive part of the brain; the message it sends—unlike a visual signal—is not filtered through the intellect. Communication from a skunk, for instance, is direct and persuasive. It is not something to mull over. Think of new-mown hay, and sight-smell, and touch-memory are all experienced at once.

Memories evoked

Deja vu, the sudden feeling of familiarity in an unfamiliar place, is believed to be the result of an unperceived odour evoking an old memory. If this is so, psychiatrists could capitalize on it by using odours to unlock a patient's blocked memories. In addition, an odour which suggested peace and security might be used to relieve anxiety. The odour of breast milk, the first smell associated with falling asleep, might develop into a replacement for sleeping pills.

Among most animals, a certain pheromone in a particular strength must be present before mating can take place. The implications of this in human terms are sensational. A drop of human aphrodisiac pheromone, would ensure the continuation of the human species. It is certain that humans are attracted to each other, even now, for unexplained reasons, some just sensed. It is known that perspiration from physical exertion is inoffensive and probably has an aphrodisiacal effect. Perspiration produced by tension, however, is always immediately offensive.

Link with immune system

"There is something here no one understands, and I have some reservations about understanding it." Dr. Chapman says cautiously. Within the body, he believes, the immune system communicates by chemicals shaped like the pheromones of odour language. Small fat molecules—lipids—control the function of certain organs and systems. The ratio of these lipids may be each person's chemical fingerprints—his identity—or the balance that his immune system seeks to maintain. When a foreign substance upsets this characteristic balance, the immune system gathers to fight it, often, scientists believe, destroying early tumours before they are medically recognizable.

What attracts the immune system to the tumour and what turns the tide, causing the body to accept and allow a tumour to grow to lethal proportions, is something worth investigating. It is probably the lipids shaped like and structurally related to the pheromones of odour language.

From memories of fresh hay to the body's immunity, it is plain that odours play a subtle and important part in our lives. Just how important, scientists are only beginning to recognize.

"Those volatile lipids, those pheromones, may manipulate us in any number of ways—from curing cancer to explaining that funny thing called love."

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Do it at home

Inexpensive fire alarm

HERE is a project that is both simple and inexpensive. It costs less than Rs. 20 and is easy to construct. The entire project can be built in an hour.

The thermistor

The thermistor is a small slab of semiconductor whose resistance decreases as the temperature of the semiconductor slab increases. When the thermistor is heated the number of charge carriers increases, thus decreasing the overall resistance, and, as a result the current through it increases.

How it works

Look at the circuit (Fig. 1) and imagine the thermistor (T) removed and the gap bridged by a wire. This is the configuration of an oscillator, a circuit which will produce an audible tone in the speaker (S). With the cold thermistor wired in, the base bias falls below the minimum required for oscillation. However, when the thermistor becomes warm, its resistance drops sufficiently and the required value of base bias is established. This starts oscillations and the alarm tone is heard in the speaker. Unlike circuits using relays, this circuit does not have the disadvantage of requiring resetting after having tripped once. However, relays could be used to trigger visual alarms or other electronic alarm circuits.

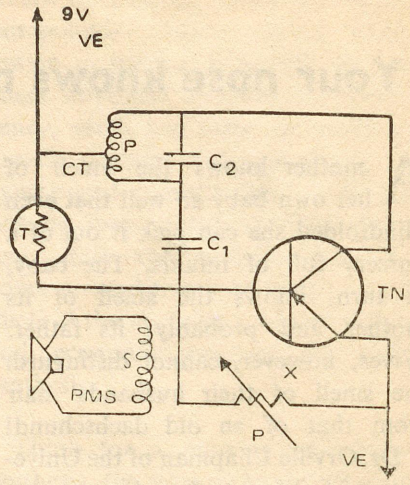

Fig. 1

Components

Transistor(TN)—AC128....1 no.
Capacitors C_1—0.1 mfd 16 wvdc
C_2—0.22 mfd 16 wvdc
Potentiometer(X)—500 K ohm log 1 watt
Thermistor(T)—DLZ100 or DLY100
Transformer—Output, matching AC 128 to 8 ohm load
Speaker(S)—8 ohms, PM, any normal size.
Battery—9 volt

Construction hints

The components can be easily mounted on a 5-tag board. Keep the transistor(TN) cool using a heat sink. In continuous operation the transistor warms up. Any small metal sheet tightly clipped to the can of the transistor will do.

Testing

Check connections and battery polarity. Adjust the potentiometer for maximum resistance and decrease it slowly keeping the thermistor at the temperature at which the alarm should sound. Stop as soon as the tone is loud enough to be heard. Cool the thermistor, the tone should disappear. Now check if the circuit is working correctly by taking the thermistor to a source of heat. The alarm should sound.

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Clues (*Continued from page 537*)

tion; used for culinary (pertaining to cookery) purposes also.
2. A herbaceous twiner (*Papilionaceae*) with white and blue flowers. Action: laxative and diuretic.
3. An annual herb (*Umbelliferae*). Its fruit or its volatile essential oil content is carminative, diuretic and stimulant; used for culinary purposes also.
4. An annual or perennial herb or shrub (*Solanaceae*). Its fruit, yielding a pungent principle, acts as local irritant and general stimulant; used in curries and pickling.
5. An annual herb (*Umbelliferae*) whose fruit, yielding an essential oil, is carminative and stimulant; used as a condiment.
6. An annual herb (*Urticaceae*). Flowers or fruit tops are used for their resin content. Action; intoxicating and sedative.
7. A large shrub (*Asclepiadaceae*) whose roots, leaves and flowers are used. Action is on the heart. A digestive.
8. A tree (*Rubiaceae*). Dried bark is used. Its alkaloid is used in the treatment of malaria.

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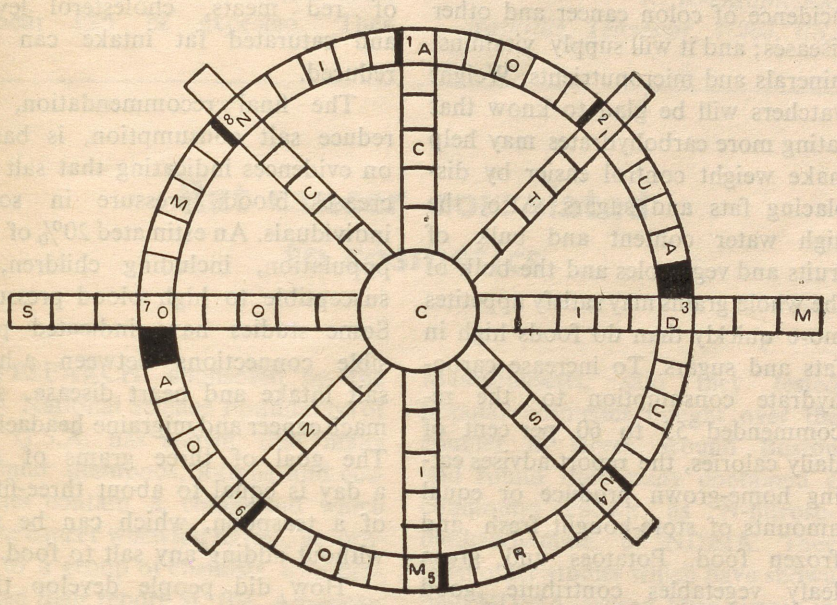
Science Wheelword Puzzle (Medicinal plants)



NOTE: The reader is required to fill in the botanical name (generic name) of the conncerned medicinal plant.

CLUES

The rim (Clockwise)

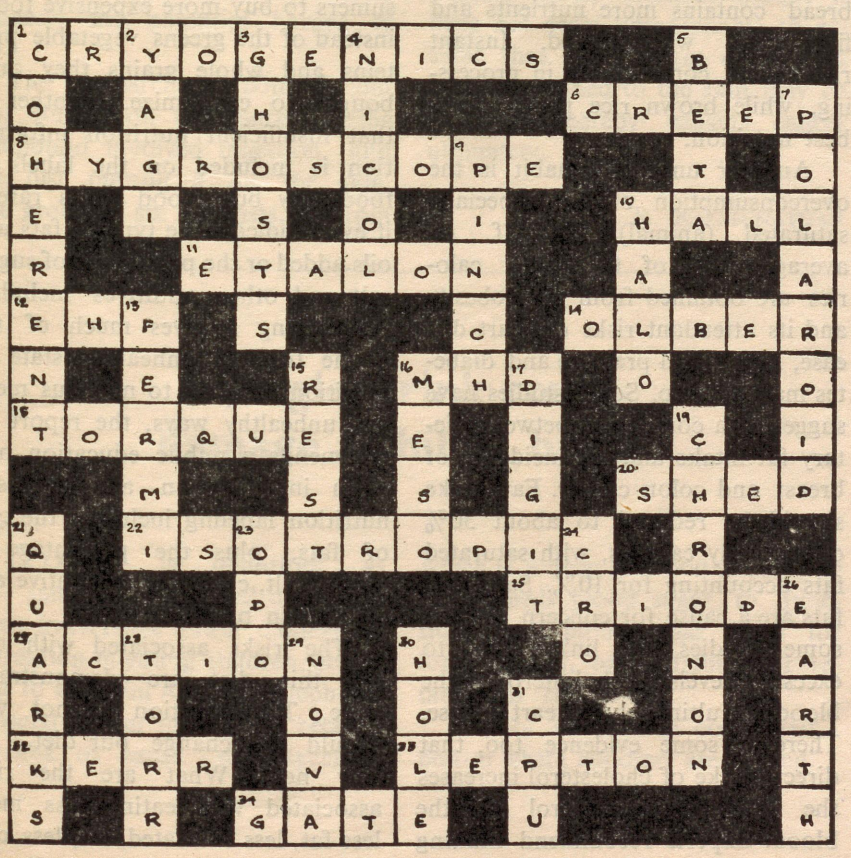
1. A herb (*Solanaceae*) whose dried leaves and tops are used to extract an alkaloid having mydriatic (abnormal dilation of the pupil) action.
2. A herb (*Compositae*) known for its essential oil and bitter principle content of the rhizome and roots.
3. The dried leaves and flowering tops of this herb (*Solanaceae*) are used for their naroctic and antispasmodic action.
4. A shurb (*Anonaceae*) which yields a sweet, scented essential oil from its roots.
5. A sensitive shrub (*Leguminoseae*) whose roots and leaves exhibit carminative and resolvent action.
6. Roots and flowers of this shrub (*Rubiaceae*) are sedative in action and are stomachic tonic.
7. A strongly scented herb (*Labiatae*). Its shoot possesses carminative and stimulant effect.
8. A shrub (*Apocynaceae*) whose roots (bitter principles) and leaves (an alkaloid) are medicinally important. The root extract is diuretic and a cardiac tonic.

The spokes (names begin from centre, C)

1. A herb (*Zingiberaceae*) with tuberous root stocks. Tubers and rhizomes are used for carminative and stimulant ac-

(*Continued on page 536*)

Crossword Puzzle (Solved)



Solution to crossword puzzle published in July 1977 issue

FOR HER

Diets - do's and dont's

OUR eating habits have changed drastically since the beginning of the century, when carbohydrates (sugars and starches) were the main source of food energy. Sugar has replaced complex carbohydrates—fruits, vegetables and whole grains—in popularity, mainly because people started consuming large amounts of soft drinks. This increased use of sugar may have some serious consequences. The most immediate effect is that sugar, offering little nutritional value, is replacing foods high in nutrients. Not only does this deprive the body of nutrients. According to a report published in the U.S.A, sugar calories may increase the body's requirement for certain vitamins. Sugar also has been implicated in the incidence of diabetes in genetically susceptible persons and in widespread tooth decay. Although sugar now contributes about 40 per cent of the calories in the average American diet, the report recommends cutting sugar intake down to 15 per cent by eliminating soft drinks and baked foods while using more fruits and vegetables.

The increased consumption of whole grains may have several good results; it may reduce the risk of heart disease by lowering the levels of fat and cholesterol in the blood; it may help treat diabetes; it may provide more natural fiber to the diet, which some researchers believe will reduce the incidence of colon cancer and other diseases; and it will supply vitamins, minerals and micronutrients. Weight watchers will be glad to know that eating more carbohydrates may help make weight control easier by displacing fats and sugars. Also, the high water content and bulk of fruits and vegetables and the bulk of the whole grains may satisfy appetites more quickly than do foods high in fats and sugars. To increase carbohydrate consumption to the recommended 55 to 60 per cent of daily calories, the report advises eating home-grown produce or equal amounts of store-bought fresh and frozen food. Potatoes and green leafy vegetables contribute good amounts of nutrients and fiber. Highly processed foods should be avoided. The less processed whole wheat bread contains more nutrients and fiber than white bread. Instant rice suffers considerably in processing, while brown rice provides the best nutrition.

Another unhealthy habit is the overconsumption of fat, especially saturated (animal) fat. If on average 40% of the daily calories are obtained from fats, obesity and its attendant risks of heart disease, high blood pressure and diabetes may develop. Some studies have suggested a correlation between dietary fat intake and the incidence of breast and colon cancer. Fat intake should be reduced to about 30% of the daily calories, with saturated fats accounting for 10%. Saturated fats are a cause for concern because some studies have linked them to excessive levels of cholesterol in the blood and ultimately to heart disease. There is some evidence too, that direct intake of cholesterol increases the level of cholesterol in the blood. Experts recommend limiting cholesterol to about 300 milligrams per day (one egg contains about 250 milligrams). By eating more vegetable proteins such as legumes and more fish and poultry instead of red meats, cholesterol levels and saturated fat intake can be reduced.

The final recommendation, to reduce salt consumption, is based on evidences indicating that salt increases blood pressure in some individuals. An estimated 20% of the population, including children, is susceptible to high blood pressure. Some studies have indicated possible connections between a high salt intake and heart disease, stomach cancer and migraine headaches. The goal of three grams of salt a day is equal to about three-fifths of a teaspoon, which can be met without adding any salt to food.

How did people develop their poor eating habits? The report mentions several factors: One is that rise in incomes has permitted consumers to buy more expensive foods instead of the greens vegetable proteins and whole grains they once bought to economize. Another is that insufficient nutrition information is included on the labels of food they buy. Food labels rarely, if ever, indicate the type of fats and oils added or the percentage of sugar, salt and other additives included. Advertising receives much of the blame for the unhealthy state of nutrition. In order to make us mend our unhealthy ways, the report recommends a public education program in nutrition and extensive nutrition labeling including the type of fats, plus the percentage of sugar, salt, cholesterol, additive and calories in products.

The risks associated with eating this diet are demonstrably large. The question is not why should we change our diet, but why not? What are the risks associated with eating less meat, less fat, less saturated, fat, less cholesterol, less sugar less salt, and

more fruits, vegetables, unsaturated fat and cereal products especially whole grain cereals? There are none that can be identified and important benefit can be expected. Then why not change? The sooner the better!

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Nashville, Tennessee, 37203, USA

Rat cancer correlated to cosmetics

RESEARCH sponsored by the National Science Foundation of the U.S.A. has shown that many popular shampoos, lotions and cosmetics contain a compound which cause cancer when fed to rats, according to a group of chemists who presented their report at the American Chemical Society convention, recently held at New Orleans. It is not possible at the present time to assess properly the potential hazard to man.

The researchers pointed out that studies on the cancer-causing compound involved ingestion, and not just putting it on the skin. The group of six scientists, all from Massachusetts, said they tested popular cosmetics bought over the counter at stores around Boston and found that many contained a compound known as N-nitroso-diethanolamine, or NDEIA. They cited other studies which have shown that NDEIA caused liver cancer in rats that ate it. They said that since the cosmetics contained a super-wetting agent, triethanolamine, it does not seem unreasonable to assume that a significant amount of NDEIA applied to the skin may be absorbed, thereby causing cancer ultimately.

R. RAGHUNATHAN

A single drink could damage a child's brain

ALCOHOL in quantities as small as one mixed drink can cause irreversible brain damage or retardation in young children, according to Dr. Will Alemeir. Alcohol is a special danger to children because it tends to cause hypoglycemia, which is a drop in blood sugar. The brain needs blood sugar to function, so if blood sugar drops for long enough, brain damage or retardation can occur.

Alcohol should be considered a poison where children are around. A four year old boy was taken to emergency, after accidental uptake of a small amount of wine. The child was at once woozy and then had convulsions. Pediatricians checked the child's blood sugar content and it was 10, the usual range being near 70 . The child was immediately given glucose intravenously, which is the treatment for hypoglycemia and within minutes the child woke up and next morning he was fine. Of each of the 6-8 cases reported to have drunk alcohol for one reason or other, 2-3 had a drop in blood sugar. Very small amounts of alcohol makes a child vulnerable to hypoglycemia. But children under the age of 10 would be most seriously affected; just one can of beer could affect the intelligence and motor areas of the body.

Parents may not know how dangerous hypoglycemia is. The child does not have to drink alcohol to have this condition. Just one occasion of very low blood sugar can cause permanent damage unless the child receives medical attention in an hour or two. Early signs of a drop in blood sugar are anxiousness sweating and nervousness. Without any treatment unconciousness or seizures might develop. An old home remedy for bringing down fever the use of alcohol is being questioned by doctors. Some people sponge off feverous children with alcohol and water. If this is done in a small closed room the child could breathe enough fumes to cause hypoglycemia. If the child was on other medication, the intake of alcohol could be twice as dangerous. Many doctors now agree that alcohol should be kept far away from the reach of children.

R. RAGHUNATHAN

Science in Industry

Dental amalgam alloy

THE National Metallurgical Laboratory (NML), Jamshedpur, has developed a process for the production of a dental amalgam alloy for filling up the cavity of decayed teeth. The estimated demand for this alloy is 4000 to 5000 kg per year and this is met partly by imports.

In the NML process, raw materials in the purest form are melted in a furnace, and the melt is stirred thoroughly before pouring. Pouring is done in mould. The ingot is then homogenized, processed for obtaining proper particle size followed by suitable heat-treatment. All the raw materials required are available indigenously.

The main equipment required are: melting furnace, crucible, ingot moulds, shaping machine, annealing furnace, and cold flat rolling mill. All the equipment, except for cold flat rolling mill, are available indigenously.

Laboratory-scale investigations have been completed. A successful clinical service trial was conducted at the Tata Main Hospital.

The material was tested as per the standard specification and was found to conform fully to IS: 4704-1968, BS : 2938-1957 and to that of the American Dental Association, 1934.

The suggested capacity of an economic unit is 3000 kg of alloy per year. The estimated capital investment for such a plant (based on 2 shift operations in a day and with 300 working days in a year) is Rs. 13.35 lakh, and the cost of production per kilogram is about Rs. 1400.

Portland cement coating for steel

THE Central Electrochemical Research Institute (CECRI), Karaikudi, has developed a protective coating based on portland cement which provides good protection to structural steel in a salt-laden atmosphere. The coating provides, in particular, adequate protection to steel reinforcement rods both during storage at site and when embedded in concrete and helps increase the durability of the reinforced concrete structures exposed to corrosive atmospheres. The specific advantage of this coating is that it does not adversely affect the bonding between steel and concrete. Large-scale trial and demonstration has shown that the coating procedure is quite feasible under field conditions.

Besides on reinforcement rods, the coating finds useful and cheap application on steel sheets (corrugated), angles, poles and pipes. Compared to organic coatings, this coating is cheaper.

Portland cement, inhibitor solution and water glass are the main raw materials required for the manufacture of the coating, and all these are available indigenously.

The total investment for setting up a plant capable of producing the coating for protection of 1000 tonnes of steel reinforcement rods is estimated at Rs. 80,000 (comprising Rs. 30,000 as fixed capital on plant and Rs. 50,000 as working capital).

BOOK REVIEWS

EARLY SOLAR PHYSICS by A. J. Meadows, *Pergamon Press*, Headington Hill Hall, Oxford OX3 OBW, England, Pp. 312, $ 13.

HOW ideas evolve is an interesting subject in itself. The process is similar to evolution of species but on a smaller time scale. Every scientist who adds something to existing knowledge thinks he has taken a "big step ahead" but when seen as a whole his work seems a drop in the ocean. Only the invention of a tool or discovery of an effect are the major milestones which, like mutations in a species, bring revolutionary changes in the evolution of a subject. The story told of how a subject evolved, therefore, not only is an experience for a researcher in the field to take to heart but also could prove to be an amusing story of interest to any scientist or for that matter a layman. There are, however, a few books of this type and the book under review is one among them. It deals with solar physics.

Why the need for such a book on solar physics? The author doesn't say anything except that to "provide some insight into the changes and developments" in the subject. In the opinion of this reviewer it is to teach astronomers and astrophysicists some 'lessons'—for which, in fact, history is meant. For instance, the history of development of solar physics, as narrated in this book, tells how once highly accepted theories had in time met their death. Could it be possible that what today we take for granted, for instance, that sun produces its energy due to thermonuclear reactions, would turn out to be absurd tomorrow? The present controversial theory that the sun is generating so much energy due to a black hole it contains might be an accepted theory tomorrow. All this is possible. Likewise, the entire subject of astronomy and astrophysics might one day need overhauling due to a fundamental discovery or invention. In short, one should not take anything for granted or only accept the prevailing "fashionable" beliefs. Indeed, such a book is a welcome for researchers of as mysterious a subject as the universe.

The book is divided into two parts: the first deals with the historic development of ideas and the second is a list of noteworthy papers which duly figure in the part I. Starting with very silly ideas the early astronomers had when interest about sun had just been created, the book covers the development of ideas only till the beginning of the present century. The emphasis is on the period 1850 to 1900, called new astronomy by the author, in which solar spectroscopy brought revolutionary changes in the understanding of sun. The next turn was, according to the author, the coming of 'New Era in solar physics' which began when in 1913 Neil Bohr proposed a workable theory of atomic spectra. Here, with some discussion the historical part ends. Suiting to the title, this much history seems enough, though with the discovery of radio sun in 1942 a new chapter has begun in the further understanding of solar physics.

This historical account in Part I, besides giving the dialogues of scientists wherever necessary to emphasize a discovery, also gives author's interpretation of why a particular scientist, because of the milieu he was in, thought or argued as he did. The papers reproduced in Part II not only tell the difference between how they were written then and now but also will teach a budding researcher how to forward to one's arguments. The book is otherwise a scholarly work and is meant for researchers or those who wish to acquire the bent of mind needed in research. To be frank, a layman would not find anything of his interest in this book notwithstanding the fact that it is written in a simple and easily understandable manner. This is mainly because of two reasons. First, it doesn't contain any sparkle of amusement or thrill; the treatment is rather heavy. Secondly, why should he be interested in old concepts when to know the latest in science is his aim?

DILIP M. SALWI

HUMAN POPULATIONS by David Hay, *Penguin Books Ltd.*, England, Indian Representative: *Penguin Overseas Ltd.*, 706, Eros Apartment, 56, Nehru Place, New Delhi-110024, Pp. 96, £ 2.75.

HUMAN population continues to be a topic of discussions, writings, debates, conferences, symposia and what have you! Which is as it should be. Man has realized as never before that his survival is being threatened by the multiplication of his own species.

In about 900 years from now, if the present rate of growth of human population continues, the entire land and sea will be covered by a continuous 2000 storey building to house every man. And 900 years is not far away. Already there are countries which are groaning under the weight of bulging human populations. Bangladesh, South East Asia and China are examples. Why the human population is growing fast, the social and economic factors contributing to it and the present state of human commu-

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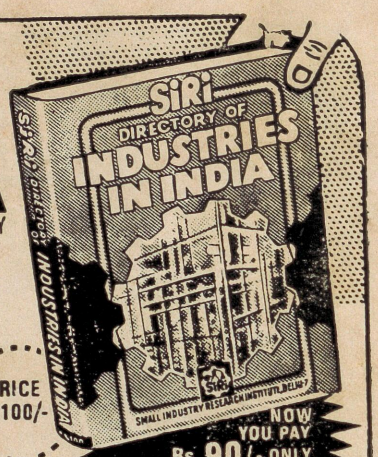

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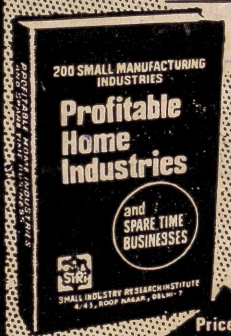

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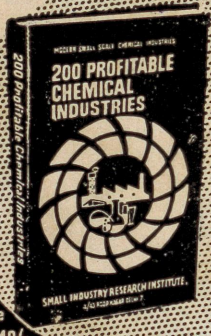

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