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# LETTERS

## Science for laymen

Sir, Articles in *S.R.* are informative, interesting and readable.

A person today cannot understand the world in which he is living unless he understands science. Science has begotten many sciences, and human knowledge has become too vast to be possessed by any one person. So, specialisation has become inevitable. All scientists/specialists should feel that it is their social obligation to spread the knowledge they have gained in specialisation for the benefit of the common man, particularly in a country like ours where 80% population is poor and cannot afford to provide academic education to their children and to themselves. And to this end, the writers of articles in your journal should write in a manner and style intelligible and understandable to a layman. The distressing aspect of the scientists/specialists is that they seem to feel that their knowledge is esoteric, unintelligible or ununderstandable to a layman. I am afraid either scientists are labouring under an inadequate talent to express what they have learnt or suffering from vanity!

I request you to introduce a chapter "Science for the layman" or extend your present chapter" Science for the Young" as "Science for the Young and Laypersons" and provide it with informative and intelligible articles.

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## Protein from petroleum

Sir, Apropos of **Protein from petroleum** by Dr. M. K. Sharma (*S.R.*, May 1976, pp 272-275) I would like to add some more points. But, before coming to these points it would be worthwhile to focus on the work done on single cell protein (SCP) in the CSIR Laboratories of India. Dr. M. K. Sharma has mentioned only the Indian Institute of Petroleum, Dehra Dun, in this regard. while Regional Research Laboratory, Jorhat, has also done a lot of work on single cell protein. Recently, Shri P. K. Barua of the RRL, Jorhat carried out studies on SCP and got his Ph.D under Dr. J.N. Barua; a report of this work has also been published in the *CSIR News*, Sept. 15, 1975 and *Science & Culture* Nov. 1975, Vol. 41, No. 11 in the article *Protein and vitamin concentrate from petroleum hydrocarbon.* Single cell protein not only serves as a rich source of protein but also of vitamins. In India, it is possible to produce about 0.12 million tonnes of pure protein by diverting only 5 % of the internally derived crude petroleum. Dr. J. N. Barua *et al*, of RRL, Jorhat have given detailed information about petroleum hydrocarbon utilizing bacteria which was published in *J. Scient. Ind. Res.*, *Vol* 34, No. 11, Nov. 1975, pp 614-624.

SCP is basically composed of proteins, fats, carbohydrates, ash ingredients, water, nucleic acids vitamins and other substances. The specific composition depends on the particular organism and the feed stock on which it grows.

It is however necessary to remove most of the nucleic acids. This post-treatment therefore involves a variety of techniques to solubilize the nucleic acids. Most popular substrates are either normal paraffins or alcohols. Former is lower in cost and gives a higher yield of biomass than alcohol, but it requires additional energy input for oxygen transfer. Alcohols are already partly oxygenated. Paraffins have a higher enthalpy and so an increasing cooling requirement.

In case of feed it is not necessary to remove nucleic acids because they are not harmful to animals. But in the case of human food more than two grams of nucleic acid intake is not suggestive, if reasonable uric acid level is to be maintained to avoid uric acid poisoning and gout. Hydrolysis can reduce the nucleic acid level, which if properly done, will not denature proteins in the SCP and will increase the total protein.

SCP has a PER (protein efficiency ratio) between 2 and 3 compared to 3.00 of caesin. SCP has a high nutritive value than comparable quality soy-protein and hence can have particular utility for fortifying food products.

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## Parity conservation (*S.R.*, March 76)

Sir, I would like to present the most important implications of Madame Wu's experiments which were responsible for the downfall of parity. The experiments provided a solution to the Ozma problem—an experimental method of extracting from nature an unambiguous definition of left and right. All that is necessary is to cool the Co 60 atoms near to absolute zero and line up their nuclear axes with a powerful magnet. Count the number of electrons flung out by the two ends of the axes. The end that flings out more electrons is the end we call 'south'. It is now possible to label the ends of magnetic axes of the field used for lining up the nuclei and this in turn can be used for labelling the ends of a magnetic needle. Put such a needle above a wire in which the current moves away from you. The north pole of the needle will point to the direction we call 'left'. Q solution to the Ozma's problem is obtained.

The fall of the parity was an evidence against the symmetry which was accepted to exist in the physical realm. Q suitable insight into this asymmetry is expressed in these words by the well-known physicist, R. P. Feynman (*Feynman Lectures in Physics*, Vol. 1, Adison Wesley).

Why is nature so nearly symmetrical? No one has any idea. The only thing we might suggest is something like this. There is a gate in Neipo, Japan, described by Japanese as the most beautiful gate in the world. The gate is elaborate with lots of gables and beautiful paintings. But when one closely observes it he sees, in the midst of all these designs, one of the small design elements is carved upside down; otherwise the thing is completely symmetrical. If one asks why, the story is that it was carved upside down so that gods will not be jealous of the perfection of man and get angry with him.

We might like to turn around and think that the true explanation of the near symmetry of nature is this: God made the laws only symmetrical so that we should not be jealous of His perfection.

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Even after agreeing with the first half of the letter, it can be emphasized that the far reaching consequence of the result of the experiment conducted by Madam Wu *et al.* already remained implied in the theory of Lee and Yang. The situation can be explained in the following way: All theories of decay had been constructed under the assumption that parity was conserved. These theories were in reasonable agreement with experience and so it was generally believed that our experience indicates parity conservation in decay interactions. This reminds us of the famous logical error : All horses have four legs; this has four legs, therefore this is a horse. However, it was left to Lee and Yang to show first that experiments which had been done were equally consistent with the nonconservation of partiy. The first experiment designed to detect possible effects of the absence of left-right symmetry in decay interactions was done by Wu *et al.*

From this experiment, it is possible to abandon the hypothesis that the weak interactions were invariant under left-right symmetry. One could now explain the different decays of the now-one particle ($\zeta$, $\theta$=K). As the parity is not conserved in the decay process, the same particle can decay in two different ways into two states of opposite parity. In this way, a new range of experimental possibilities opened up.

As regards the second half of the letter, it must be noted that the advocacy of the idea that God has made near symmetry in nature just to make compromise with us, expresses one's own personal feeling and can have no scientific basis. Moreover, it is not clear why we should be jealous at all. In this context, it is interesting to remember the witty correspondence between Pauli and Weisskopf. 'I do not believe', wrote Pauli to Weisskopf on January 17, 1957, before the results of Wu *et al.* were made public, 'that the Lord is a weak left-hander'. A few days later he wrote again, 'I am shocked not so much by the fact that God is a left-hander, but by the fact that he still appears to be left-right symmetric when expressing himself strongly'.

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### Monopole

Sir, I read the **Eluslve monopole** (*S.R.*, Feb. 1976) with great interest.

I have found that if a magnetised needle is heated at one end, the polarity of the heated end is very much reduced, while the other end retains the polarity. That is, it behaves more or less like a magnet with a single pole. This phenomenon may have something to do with monopole. I will be grateful to have comments of Shri Chakraborty on it.

GURDIP SINGH
*Amritsar*

The problem has a very simple explanation : when we heat one end of a magnetized needle, we first reduce its remanence or magnetic 'hardness', causing it to become demagnetized. However, it will still remain magnetic, but soft.

In the process of heating, as we approach the Curie temperature (about 700°C for steel), ferromagnetism will vanish and the material will behave only weakly paramagnetic. The susceptibility will decrease as the temperature is further raised in proportion to $1/T$, ($T$= absolute temperature), according to the Curie law.

Magnetic flux lines will begin to leak out of the needle before they reach the heated end as shown in Fig.1. Therefore, the needle will develop a distributed magnetic pole instead of one concentrated at the needle point. The unheated end will remain a magnetic pole.

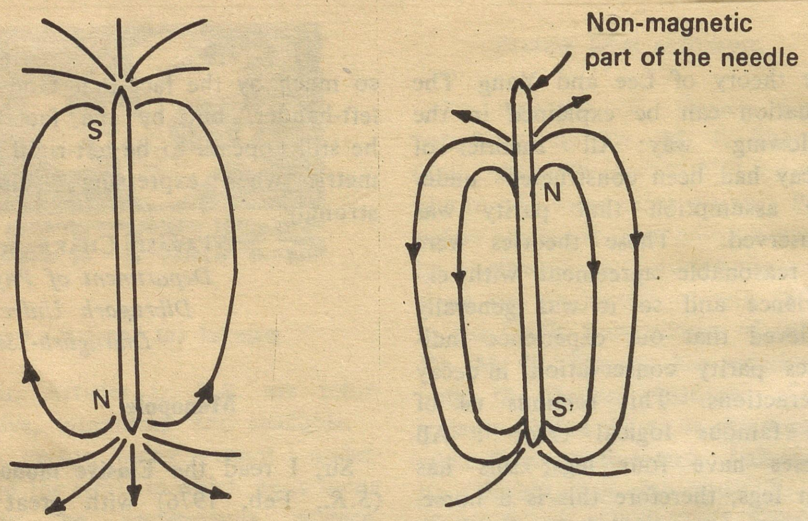


Fig. 1

**Flux lines around magnetized needle under normal conditions**

**Flux lines around magnetised needle when the upper end has been heated to near its Curie temperature (about 700 °C)**

This asymmetry, as explained above, may create the impression of a monopole, since the magnetic attraction for iron flints, for instance, is proportional to the field and field gradient, that is, the density of flux lines and their divergence. The distributed pole will therefore show little attractive effect compared to the concentrated one.

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### Electrical events in heart beat

Sir, Although T. S. Gill's attempt at elucidation of the **Electrical events in the origin of heart beat** is admirable (*S.R.*, April, 1976), it requires some comments. The pacemaker of the heart comprising of the sino-auricular node is situated at the junction of the superior vena cava and the right auricle of the mammalian heart and not simply in the wall of the right atrium. The article states that "At rest the pacemaker cells.... are polarised" implying that these cells have a definite resting state, although a special feature of the pacemaker cells is that they are *never resting*. The maximum transmembrane potential in these cells is around —55 mV as against 1/10 volt (or 100 mV) as suggested by Gill. The $Na^+$ ions rush in when the maximum membrane potential reaches —40 to —45 mV, not 1/600 volt or 1.66 mV as given in the article. This influx of $Na^+$ ions should, however, not be called an electric spark by any stretch of imagination but at best an impulse, as it signifies the beginning of a signal for the cellular functions. Sodium-pump, the energy dependent process for the extrusion of $Na^+$ from the cell interior to restore the cell membrane to its normal state, is not a specific feature of the myocardial cells but takes place in all the living cells. Moreover, it is not yet experimentally proven that the electrical impulse reaching the myocardial cells triggers the breakdown of ATP.

Gill's suggestion that an increased temperature during fever increases the heart rate by increasing the membrane permeability to $Na^+$ ions seems highly speculative. Although it is known from *in vitro* experiments with the atrial pacemaker that an increase in temperature increases its rate of beating, the situation *in vitro*, may be quite different, as a number of other changes during high fever could as well account for the increase in the heart rate. The well-known disturbances in the rhythm of heart beat, for example, arrhythmias and dysrrhythmias are basically due to an alteration in the electrical characteristics of the myocardial cell membrane including those of the pacemaker cells; a lack of co-ordination between the s.a. and a.v. nodes may be one of the many causes, rather than the sole cause, for such disturbances as mentioned in the article. The diagram showing the potential changes at a pacemaker cells is rather out of proportion and requires proper labelling of the different phases of action potential as well as that of the voltage levels. Moreover, the numbers of the open and filled circles representing the $Na^+$ and $K^+$ ions respectively are not constant in each circle indicating the possibility of actual loss or gain of these ions which does not happen in the normal living cells.

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### Heavy metals

Sir, Though excessive concentrations of some heavy metals (*S.R.* May, 1976) are toxic, a fairly large number of enzymes contain metal atoms as integral parts of their structures; they are tightly bound and are necessary for the activity of the protein. Some other enyzmes are activated by the addition of metal ions. Some of the important enzymes which require heavy metals for their normal activity are given below :

| | |
|---|---|
| Copper | .. Tyrosinase, Phenolase, Ascorbate, Oxidase, Tryptophan 2, 3-dioxygenase |

| | | |
|---|---|---|
| Molybdenum | .. | Xanthine oxidase, Nitrate reductase (plants), |
| Iron | .. | Catalase, Peroxidases, Cytochrome enzymes, Homogenitisicase |
| Zinc | .. | Carbonic anhydrase, Lactate dehydrogenase, Carboxypeptidase, etc. |
| Manganese | .. | Arginase, Acetyl CoA carboxylase, etc. |
| Cobalt | .. | Peptidases, Aldolases, ALA synthetase, Transcarboxylase, etc. |

Besides, when selenite is added to experimental rations it affords complete protection against liver necrosis.


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**Protein**

Sir, Solving the much discussed protein problem by obtaining proteins from petroleum is rather fascinating (*S.R.*, May 1976), but to say that the main deficiency in the diet of roughly half the world's population is animal protein is incorrect. Animal protein, though good, is not essential. To say that essential amino acids such as lysine are present only in animal foods is again wrong. Pulses contain a high content of lysine which is limiting in cereals like wheat and rice. Hence a combination of the two gives a favourable amino acid composition. In fact, in these days of shortages, animal food is being largely discouraged by nutritionists all over the world because of its increased cost of production. Apart from petroleum, leaf and mushroom are good potential sources of protein.


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**Pi**

Sir, Dr. S. K. Mukherji has given (*S.R.*, June 1976) the value of $\pi$ upto corrected 20 places of decimal as 3.14159265358979323846. Incidentally this reminds me of the following verse, though not very elegant, which we had picked up in our college days, correct upto as much decimal places :

*Sir, I bear a rhyme excelling*
*In mystic force and magic spelling*
*Celestial spirits elucidate*
*All my own striving can't relate.*


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**Back issues of S.R. wanted**

Sir, I want to buy all the issues of *S.R.* preceding 1973. So, subscribers of *S.R.* interested in selling these back issues of *S.R.* may contact me.


R. Tyagi
*9B-15-VII*
*Bhilainagar-490001 (M.P.)*


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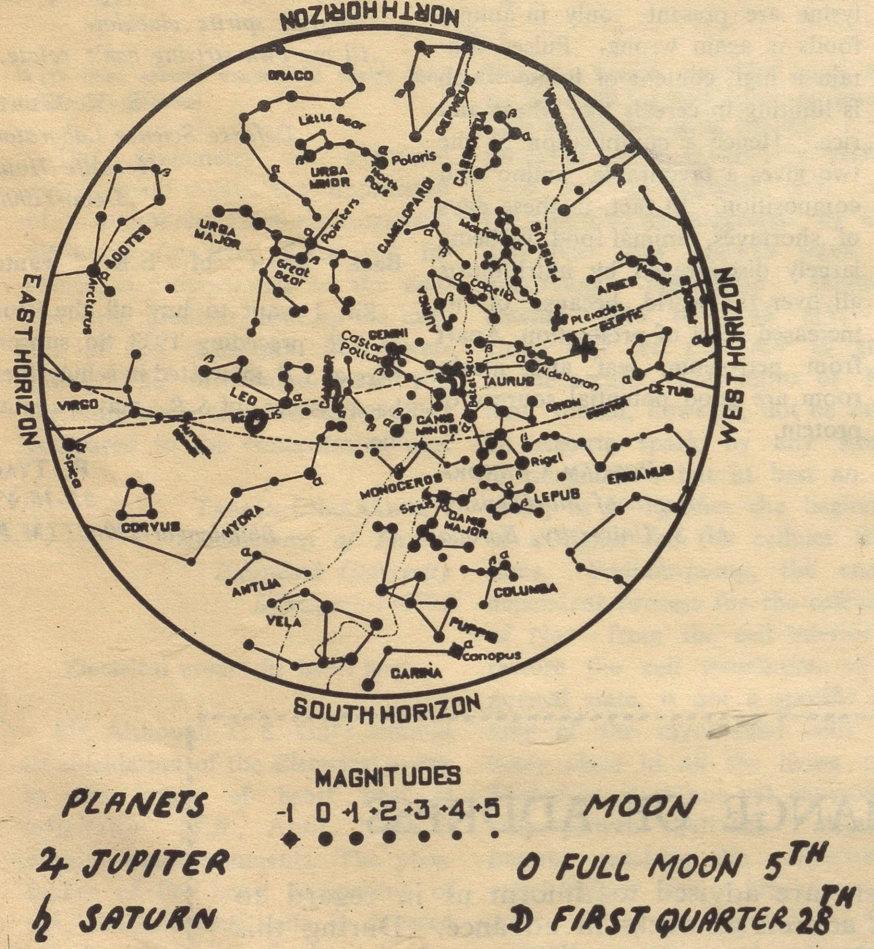
# Planets and their positions

## MARCH 1977




FULL moon occurs on 5th at 10-43 p.m. and new moon on 20th at 0-03 a.m. I.S.T. The moon passes about six degrees south of Saturn on 3rd, about five and a half degrees north of Mars on 17th, eight degrees south of Venus in the evening of 21st, about two degrees south of Jupiter in the night of 24th and again six degrees south of Saturn in the night of 30th. The lunar crescent becomes first visible after the new moon day in the evening of 21st. The moon is at perigee or nearest to the earth on 9th and at apogee or farthest from it on 25th.

The Sun is at the vernal equinox on 20th.

### The planets

*Mercury* (Budha) is too near the sun to be visible during the first three quarters of the month. It is in superior conjunction on 16th. Thereafter, it reappeares as an evening star and sets about an hour after sunset. It passes about eight degrees south of Venus on 28th. It moves from Aquarius (*Kumbha*) to Aries (*Mesha*) through Pisces (*Mina*). Its visual magnitude is about -1.2.

*Venus* (Sukra), an evening star, sets about two and a half hours after sunset during the first half of the month and about one and a half hours after it during the second half. It attains the greatest brilliancy on 1st and become retrograde on 16th. It moves from Pisces (*Mina*) to Aries (*Mesha*) and thence again to Pisces (*Mina*) by retrograde motion. Its visual magnitude varies from-4.3 to-3.5.

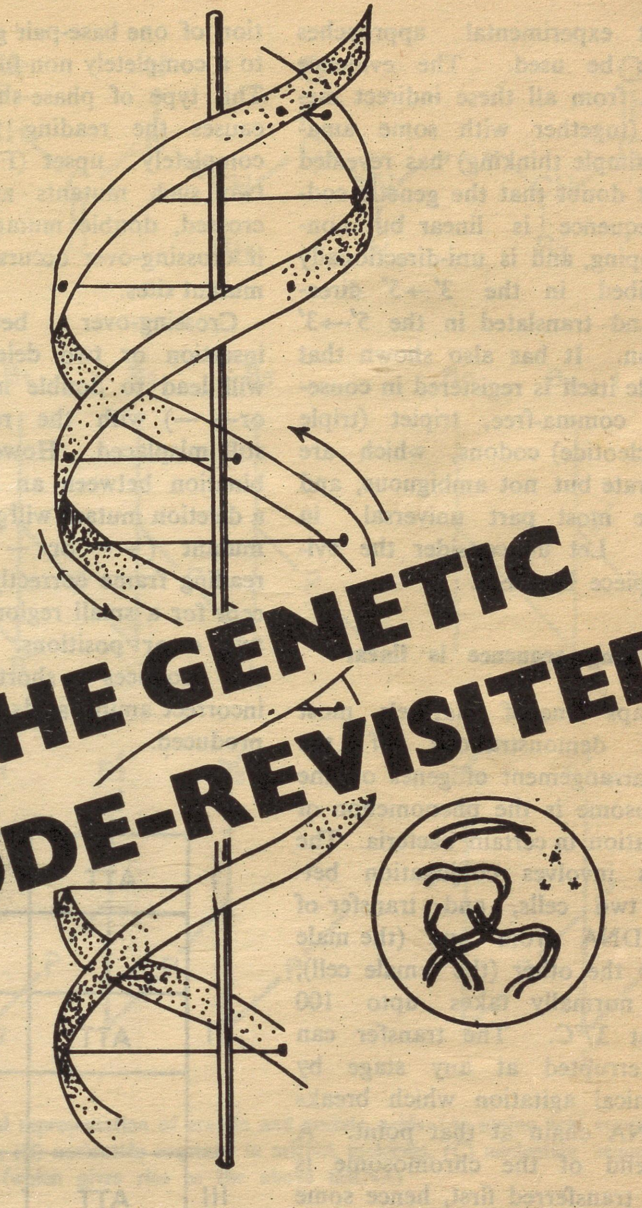
*Mars* (Mangala), visible in the morning sky, rises about one and a half hours before sunrise during the month. It moves from Capricorn (*Makara*) to Aquarius (*Kumbha*). Its visual magnitude is about + 1.4.

*Jupiter* (Brihaspati), visible in the evening sky, sets about one and a half hours before local midnight during the first half of the month and about two hours before it during second half. It is in Taurus (*Vrisha*). Its visible magnitude is about—1.7.

*Saturn* (Sani), visible in the evening sky, sets about two hours before sunrise during the first half of the month and about two and a half hours before it during the second half. It is in Cancer (*Karkata*). Its visual magnitude is about +.0.3.

(*Source*: Nautical Almanac Unit of the Meteorological Office, Alipore, Cal.-27)

**The work on deciphering the genetic code was completed in the last decade. The classical experiments of that era and the revolutionary concepts they produced are reviewed**



# THE GENETIC CODE-REVISITED

## J. PHILIP RYAN

JUST over 100 years ago in 1866, Gregor Mendel made the basic discoveries that established genetics as a science. Some 50 years later, Morgan and others (1915) demonstrated the physical existence of the gene, and its linear arrangement on the chromosome. More recently, Benzer (1961) has clarified the idea of a gene by some brilliant mutational analysis, which permitted the recognition of a unit of function called the cistron. Cistrons are defined as the smallest units of genetic material which can complement each others function. If a diploid cell has two chromosomes which are defective in the same cistron, then it will lack at least one particular function. If, on the other hand, the two chromosomes are defective in different cistrons, then both functions will still be expressed in the cell. In other words, each cistron codes for one complete message—the primary structure of a polypeptide chain. A cistron may be considered as a definite sequence, of from some 1000 to 1500 nucleotide pairs in a DNA-molecule. This nucleotide sequence contains the genetic information required to direct the synthesis of a definite protein molecule. Now, the question to be considered here is how does the cistron code for a particular protein? This is the problem of genetic coding.

The discovery of the structure of the gene was a very gradual process, but once the genetic material was shown to consist of pure nucleic acid the first major step had been taken. All that remained was to decipher the code itself. In theory, a simple and direct comparison of a nucleic acid (cryptogram) and the protein (cleartext) it coded for, should yield the secret of the code. However, this cannot readily be done in practice, so more

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indirect experimental approaches had to be used. The evidence derived from all these indirect methods (together with some amazingly simple thinking) has revealed without doubt that the genetic coding sequence is linear but non-overlapping, and is uni-directionally transcribed in the $3' \rightarrow 5'$ direction and translated in the $5' \rightarrow 3'$ direction. It has also shown that the code itself is registered in consecutive, comma-free, triplet (triple ribonucleotide) codons, which are degenerate but not ambiguous, and for the most part universal in nature. Let us consider the evidence piece by piece.

**The coding sequence is linear**

Perhaps one of Nature's most elegant demonstrations of the linear arrangement of genes on the chromosome is the phenomenon of conjugation in certain bacteria. The process involves conjugation between two cells, and transfer of pure DNA from one (the male cell) to the other (the female cell), which normally takes upto 100 min. at 37°C. The transfer can be interrupted at any stage by mechanical agitation which breaks the DNA chain at that point. A fixed end of the chromosome is always transferred first, hence some of the genes are transferred before others. Chromosome mapping of the transferred genes can thus be studied at various time intervals, and have confirmed the linear arrangement of genes as arrived at by the analysis of recombination frequencies. At a finer level of resolution, the intracistronic coding sequence is also linear.

The mutagenic effects of acridine have been shown to depend on the insertion (+) or deletion (—) of single base-pairs during DNA-replication (Ames and Whitfield, 1966). Insertion or deletion of one base-pair generally leads to a completely non-functional gene. This type of phase-shift mutation causes the reading frame to be completely upset (Fig. 1). When two such mutants are genetically crossed, double mutants may arise if crossing-over occurs between the mutant sites.

Crossing-over between two insertion or two deletion mutants will lead to double mutants (+ + or— —) with the reading frame still misplaced. However, recombination between an insertion and a deletion mutant will yield a double mutant (+ — or — +) with the reading frame correctly aligned, except for a small region between the two error positions. In general, this produces a short sequence of incorrect amino acids in the protein produced.

The fact that single-point insertion or deletion mutants can allow the synthesis of only part of the total protein normally coded for, indicates that the code is read linearly in sequence until the error position is reached. However, the fact that only one end of such molecules can be synthesised from single-point mutations indicates that the code is only read in one direction.

**The coding sequence is non-overlapping and comma-free**

Simple base-pair switches or substitutions often lead to what are termed "leaky" genes, which have some activity. Nitrous acid has the mutagenic property of promoting the transitions: Adenine$\rightarrow$ Hypoxanthine (which pairs like

| | i | ii | iii | iv | v |
|---|---|---|---|---|---|
| I | ATT | GCA | ACC | CAT | CAT |
| | | | | | |
| II | ATT | GCA | $\boxed{H}$CC | CAT | CAT |
| | | | | − | |
| III | ATT | GCA | ACC | ATC | ATC |
| | | | + | | |
| IV | ATT | GCA | CAC | CCA | TCA |
| | − | | + | | |
| V | ATG | CAA | CAC | CAT | CAT |

**Fig. 1. The effect of various mutations on the sequence of nucleotides: I. a normal sequence of DNA, II. a base-switch mutation, converting adenine to hypoxanthine (which pairs like guanine). Amino acid in the iii position is switched from tryptophan to argenine III. a deletion mutation, which upsets all amino acids after the iii position, IV. an insertion mutation which upsets all amino acids after the ii position, V. a single deletion and insertion mutation, which upsets only the three amino acids in positions i, ii and iii respectively.**

Guanine), and Cytosine→Uracil (which pairs like Adenine). Single substitutions invariably cause only one amino acid in the original polypeptide sequence to be changed. Many proteins of widely differing functions are now known to exist in several forms. Families of such proteins, with only one or two differing amino acids, include human haemoglobin, TMV (tobacco mozaic virus) coat protein, and the isozymes (iso-enzymes) of tryptophane synthetase from *E. coli*. The evolution of proteins, possibly caused by simple mutations at single base-pairs, can be traced in this way, cytochrome c being the classical example. If the coding sequence was overlapping then each base transition should be expected to cause more than one amino acid error, simply because (as we shall see) more than one base is necessary to specify each amino acid. But this is never found to occur in practice.

In contrast, it is concelvable that the code could contain a space between each signal or word. Such commas could assist in the reading process to correctly align the active codons. However, this device is unnecessary and has not been adopted in the genetic code.

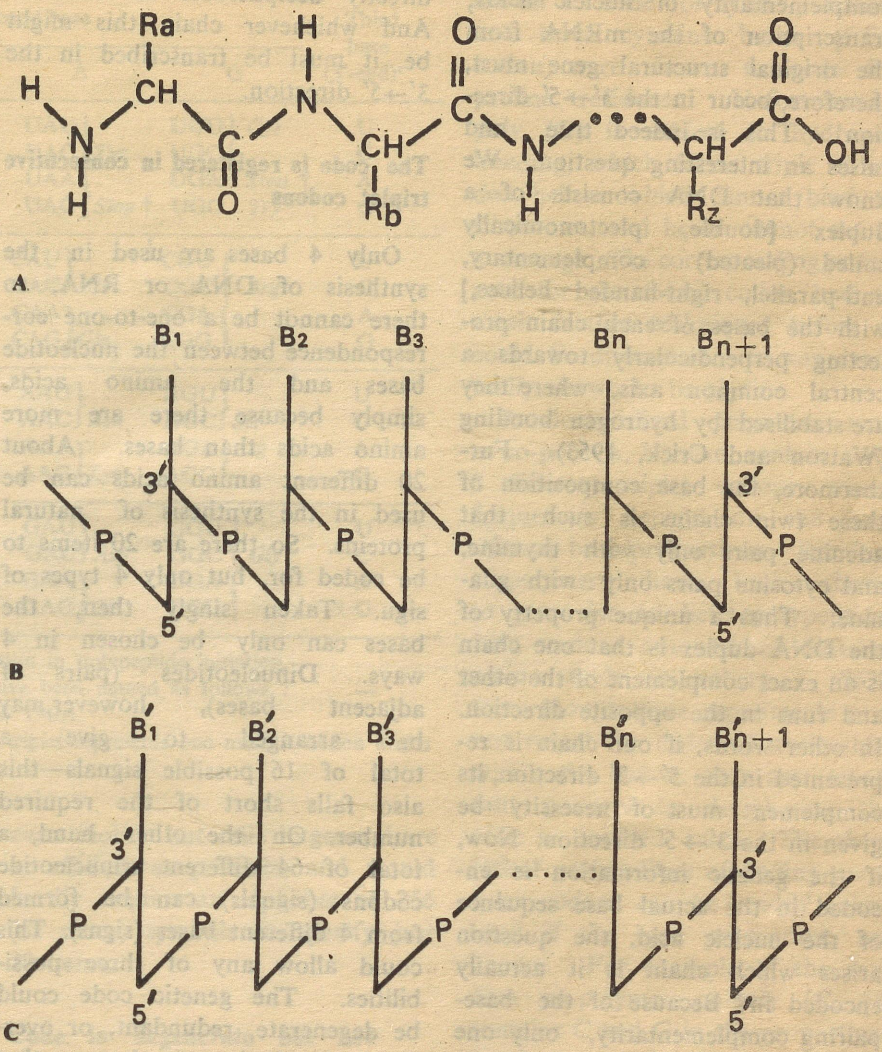

**Fig. 2. General representation of protein and nucleic acids: (A) amino acid sequence in a protein molecule, (B) nucleotide sequence in mRNA molecule, (C) nucleotide sequence in a DNA molecule (which gives rise to the above mRNA)**

### The coding sequence is unidirectional

We are accustomed to reading English from left to right across a page. The Chinese is read from right to left. These are matters of convention. However, in proteins and nucleic acids there is a fundamental difference in the chemistry of alignment when reading in different directions. In the usual convention, protein sequences are written with their free amino ($NH_2$—) on the left and the corresponding free carboxyl (—COOH) group on the right. Nucleic acids, however, are normally written with the 5′— carbon of ribose (or deoxyribose) sugar on the left, and the 3′ — carbon on the right. These structures are illustrated in Fig. 2. The question is, are these directions compatible?

A single stranded co-polymer (synthetic mRNA) consisting of a repeating AAA-sequence and ending with an AAC-triplet at the 3′-terminus was tested *in vitro* to clarify this problem. The co-polymer was found to code for peptides consisting of repeating lysyl-residues and usually ending with an asparagyl-residue. This unique residue always occurred at the free carboxyl-terminal of the chain. It was concluded that the genetic information is translated unidirectionally in the 5′→3′ direction (conventionally read from left to right). In other words, the codon on the left of the mRNA sequence always codes for the N-terminal amino acid, and its opposite partner on the right codes for the C-terminal one. It was sheer good luck that the directions in which these two molecules are usually represented, correspond directly with each other! In other words, the two sequences are co-linear.

So, translation from mRNA to protein occurs in the 5′→3′ direction but, because of the inherent complementarity of nucleic acids; transcription of the mRNA from the original structural gene must, therefore, occur in the $3' \rightarrow 5'$ direction! This is indeed true and raises an interesting question. We know that DNA consists of a duplex [double, plectonomically coiled (pleated) complementary, anti-parallel, right-handed helices,] with the bases of each chain projecting perpendicularly towards a central common axis, where they are stabilised by hydrogen bonding (Watson and Crick, 1953). Furthermore, the base composition of these twin chains is such that adenine pairs only with thymine, and cytosine pairs only with guanine. Thus a unique property of the DNA duplex is that one chain is an exact complement of the other and runs in the opposite direction. In other words, if one chain is represented in the $5' \rightarrow 3'$ direction, its complement must of necessity be given in the $3' \rightarrow 5'$ direction. Now, if the genetic information is encoded in the actual base sequence of the nucleic acid, the question arises which chain is it actually encoded in? Because of the base-pairing complementarity, only one sequence can give rise to a functional mRNA. The other sequence can, of course, give rise to a dud mRNA which may even code for a non-functional protein, and in fact often does so *in vitro*. But, *in vivo*, the cell, being economical, limits the process of transcription to the functional sequence only. Incidentally, (and, indeed, because of the one-to-one base pairing rules) each DNA chain must in fact carry exactly the same amount of genetic information. This is obvious when it is considered that each chain gives rise to an exact copy of the other during the replication process. However, while the amount of information may be the same quantitatively speaking in both DNA chains, it is so encoded that only one of these chains is directly decipherable in the cell. And whichever chain this might be, it must be transcribed in the $3' \rightarrow 5'$ direction.

### The code is registered in consecutive triplet codons

Only 4 bases are used in the synthesis of DNA or RNA, so there cannot be a one-to-one correspondence between the nucleotide bases and the amino acids, simply because there are more amino acids than bases. About 20 different amino acids can be used in the synthesis of natural proteins. So there are 20 items to be coded for, but only 4 types of sign. Taken singly then, the bases can only be chosen in 4 ways. Dinucleotides (pairs of adjacent bases), however, may be arranged to give a total of 16 possible signals—this also falls short of the required number. On the other hand, a total of 64 different trinucleotide codons (signals) can be formed from 4 different bases (signs). This could allow any of three possibilities. The genetic code could be degenerate, redundant, or overlapping! It is now known that the code is, in fact, degenerate, having upto 6 synonymous triplet codons for some amino acids. Indeed, all of the 64 codons have their assigned meanings, hence the code is not at all redundant. Nor, indeed, is it overlapping, as we have seen (although, theoretically it is possible to devise such a code; admittedly with some necessary constraints on the allowable sequences of amino acids). The code is also comma-free, in the sense that the codons are arranged in consecutive triplets, In other words, none of the bases are employed as codon spacers.

In a sequential code which is non-overlapping and comma-free another problem arises, that of correctly registering the codons. At first it was thought that the triplet code might be redundant rather than degenerate. Indeed, it is possible to devise a redundant code for the 20 amino acids, leaving 44 nonsense triplets. But while this is a clever ploy it lacks evolutionary flexibility, and has the inherent danger that most mutations would be lethal. Nature is found to be more cautious, in that the mRNA message is read (registered) in consecutive triplets starting from the 5′-end of the molecule (often starting at a polypeptide initiator codon) and proceeding to the other end (unless a polypeptide terminator codon intervenes). Although it is better at doing this *in vivo* than *in vitro*, but this is understandable!

It was Gamow (1954), who first suggested that each codon probably consists of three successive bases. All the evidence since that time has supported this idea. Crick (1962), and many others, in experiments with the B cistron of the r II region of the $T_4$ bacteriophage, have shown that the triplet codon is indeed the most likely. It was found possible to obtain functional genes with three closely spaced (not necessarily adjacent) insertions (+ + +), or deletions (— — —), or with one insertion and deletion in the same gene (+ — or — +). All other single, double, or triple combinations were defective. Even four such single-point mutations in a single gene gave a non-functional gene (except in cases where there were two insertions and two dele-tions). The conclusion is obvious.

Further evidence for the triplet codon is derived from the fact that homo-polypeptides can be synthesised from ordered polyribonucleotides, such as co-poly (UUC), which consists of repeating UUC-triplets. It is possible to register three different codons in this co-polymer,

**Table 1. The genetic code dictionary**

| First base (5'-end) | Second base U | | C | | A | | G | | Third base (3'-end) |
|---|---|---|---|---|---|---|---|---|---|
| | UUU | | UCU | | UAU | | UGU | *Cys* | U |
| | UUC | *Phe* | UCC | *Ser* | UAC | *Tyr* | UGC | | C |
| U | UUA | | UCA | | UAA | | UGA | *Stop* † | A |
| | UUG | *Leu* | UCG | | UAG | *Stop* † | UGG | *Try* | G |
| | CUU | | CCU | | CAU | | CGU | | U |
| | CUC | *Leu* | CCC | | CAC | *His* | CGC | *Arg* | C |
| C | CUA | | CCA | *Pro* | CAA | | CGA | | A |
| | CUG | | CCG | | CAG | *Gln* | CGG | | G |
| | AUU | | ACU | | AAU | | AGU | | U |
| | AUC | *Ile* | ACC | | AAC | *Asn* | AGC | *Ser* | C |
| A | AUA | | ACA | *Thr* | AAA | | AGA | *Arg* | A |
| | AUG* | *Met* | ACG | | AAG | *Lys* | AGG | | G |
| | GUU | | GCU | | GAU | | GGU | | U |
| | GUC | | GCC | | GAC | *Asp* | GGC | *Gly* | C |
| G | GUA | *Val* | GCA | *Ala* | GAA | | GGA | | A |
| | GUG* | | GCG | | GAG | *Glu* | GGG | | G |

*These codons are also known to function in polypeptide initiation.
†The polypeptide terminating codons have been named as follows : Amber, UAG; Ochre, UAA; and Opal UGA.
Full details are given in the text. Each triplet represents one mRNA codon and is written in the conventional 5'→3' direction.

namely UUC, UCU or CUU. Indeed, co-poly (UUC) is found to code for polyphenylalanine, polyserine, and polyleucine, *in vitro*. It does not, however, code for heteropolymers of these three amino acids, which is evidence to show that the coding is comma-free.

On the other hand, the random co-polymer of U and C, in the same 2:1 proportions, is found to code for a random heteropolypeptide consisting of the 4 amino acids: phenylalanine, serine, leucine and proline in the proportions 4 : 2 : 2 : 1, respectively. Each amino acid in this particular example has, in fact, two synonymous triplet codons because of the degeneracy of the code (Table 1). The relative frequency of each codon and hence amino acid, depends on the base composition. A worked example is given in the next section.

Of course, it is conceivable that cells could have evolved codons consisting of 4 consecutive bases (or even more): but cells in general are as efficient as possible, and would hardly require an alphabet of 256 (or more) symbols to specify just 20 items.

## Code is degenerate but not ambiguous

The fact that there are 64 codons and only 20 amino acids raises the question whether all the possible signals are used or not. The first synthetic polyribonucleotide discovered to have mRNA activity was poly(U), a homopolymer of uracil bases. Nirenberg and Matthaei (1961), found that it could exclusively select phenylalanine residues. This discovery revealed the codon for phenylalanine. Whenever a sequence containing three uracil bases was registered (UUU codon) in the mRNA sequence it could be predicted that phenylalanine would be incorporated into the protein chain. Similarly three adenine bases (AAA codon) were shown to code for lysine residues, and three cytosine bases (CCC codon) were shown to code for proline residues. Unfortunately, poly (G) is subject to hydrogen bonding, which forms triple stranded helices which cannot bind to ribosomes, and hence cannot act as a message. The corresponding amino acid for the GGG codon had to await further techniques before it could be discovered. It was eventually shown to be glycine.

Random mixed polymers, such as co-poly (A, U) can contain upto 8 different triplet codons, whose frequencies depend on the constituent base proportions. Random co-polymers have been shown to give rise to heteropolypeptides with various amounts of different amino acids (Nirenberg, 1963). Even though these experiments cannot reveal the order of nucleotides within the codon, they are important pointers in deciphering the code in doubtful cases. The theoretical probabilities of finding particular codons can be readily calculated if the base proportions are known. For example, if the random co-polymer co-poly (C, G) contains C and G in the proportions 3 : 7 (i.e., 30% C and 70% G), then the probability of occurrence of, say, the GCG-codon will be given simply by the product $0.7 \times 0.3 \times 0.7 = 0.147$. In other words, approx. 15% of the codons can be expected to consist of the GCG-triplet. Now this codon is specific for alanine. But, the GCC-codon has also been found to code for alanine, and this codon will occur (by the same reasoning) some 6% of the time. So, in general, alanine can be expected to occur some 21% of the time in the heteropolypeptide coded for by co-poly (C, G) ; (3:7). Various other possibilities are worth computing, with reference to Table 1.

Khorana and others (1966) developed synthetic but regular co-polymers. Co-poly (UG) for example, which consists of the sequence-U-G-U-G-U-G-U-G-U-G-U-G, was found to direct the synthesis of the regular heteropolypeptide -cys-val-cys-val-, and thus confirmed that the cys-codon was UGU, and the val-codon was GUG. Numerous examples were investigated in this way.

On the other hand, Nirenberg and Leader (1964), showed that the binding of various triribonucleotides to isolated ribosomes was sufficient to promote the attachment of particular tRNA molecules (which are specific carriers for the 20 different amino acids). All 64 triplets were tested in this way, and about 50 of them gave unambiguous results. The actual method involved passing the mixture over a nitrocellulose filter which retained the ribosomes and any attached molecules. Therefore, all but one type of tRNA passed through the filter, and with them all the corresponding amino acids. The remaining amino acid could then be detected.

The results were all in agreement, whatever the method of investigation used, and very quickly all the codon assignments were worked out as shown in Table 1. Of these 61 codons are used to specify the 20 amino acids. The remaining 3 are actually used as polypeptide chain terminators (stop signals). These have been nick-named (on the bases of mutation studies) as follows: Amber (UAG-codon), Ochre (UAA-codon), and Opal (UGA-codon), respectively.

All the amino acids except methionine and tryptophan (which are believed to be evolutionary late-comers) are selected for by more than one codon, with the synonymous codons differing mainly in the 3′-terminal nucleotide. Even the stop signal is degenerate! The existence of these synonyms (upto 6 for some amino acids) does not necessarily mean that the code is randomly degenerate, nor indeed does it imply a lack of specificity. It is possible that some codons are only specific for certain tRNA molecules (if not different amino acids). *E. coli*, for example, contains two types of tRNA for transporting leucine, one of which only recognises the UUC-codon. However, it is now known that many tRNA molecules can recognise several codons, often with differing affinities. But, this observation itself is suggestive. Again, when the nucleotide sequence of various tRNA molecules became known, it was shown that only the first two bases of each mRNA codon were fully specific for the corresponding tRNA anticodon. A certain latitude was allowed in pairing at the third position. This became known as the Wobble Hypothesis (Crick, 1966), and helped to clarify many formerly puzzling effects It particularly explained why the synonymous codons are found in the same 'box' of the table (see Table 1.).

But even if we allow that the code is degenerate (even in an unqualified way), it is by no means ambiguous. Ambiguity can arise in messages when the noise-to-signal ratio becomes high. The analogy of noise may occur even at the molecular level of the genetic landscape. The presence of high concentrations of such simple cations as $Mg^{++}$ and $NH_4^+$ causes mis-reading of various condon assignments. Under such conditions, the UUU-codon can select a little leu-tRNA as well as its normal phe-tRNA. Even the initiator codon, if present, can be suppressed by high $Mg^{++}$ levels and this can cause the reading frame to be upset. Antibiotics, such as streptomycin, also cause mis-reading. Even certain genes in the cell can cause reading mistakes (sometimes to advantage!). For example, there are suppressor genes which insert specific amino acids at various terminator codons. Now, if such codons arose by mutation in the first place at some point in an important cistronic message, then the second mistake can be used to rectify the first. Thus a certain amount of background noise even at the genetic level may be of evolutionary advantage as a buffer against the unpredictable visisitudes of even some single-point substitutions. However, under conditions *in vivo* the code is almost certainly unambiguous, and is translated in error-free messages of perfect fidelity. At the same time it should be noted that many small peptides such as glutathione (and -glutamyl-cysteinyl-glycine), and even some antibiotics such as the decapeptide Gramcidin S., in *B. brevis*, are produced without the aid of genetic coding.

Two apparent exceptions to the unambiguous nature of the genetic code are shown by the met-codon (AUG), and the val-codon (GUG). These can also serve as polypeptide chain initiating signals. In *E. coli* and yeast, the AUG-codon is found to initiate protein synthesis by coding for N-formyl-methionine. This step also helps to register all the subsequent codons. Indeed, there is evidence that the AUG-codon can determine the reading frame even when it does not actually occur on the 5′—terminal of a synthetic co-polymer. It is believed that completed polypeptides are subsequently hydrolysed to remove the N-formyl-methionine residue (and possibly even other amino acids as well), or at least the formyl-group. Again, the direction of translation can be confirmed by using co-polymers with an AUG (initiator) triplet at one end and an UAA (terminator) triplet at the other with assorted bases in between. In higher organisms (some animals), GUG appears to function as an

## DNA SEQUENCING: A NEW METHOD

HOW is the information coded in those parts of DNA that are not structural genes? To find an answer, one has to determine the nucleotide sequences of these regions.

The RNA sequencing method, however cannot be applied because of three reasons. Firstly, the radioactive labelling of specific DNA segments *in vivo* is not known. Secondly, there are no known DNA degrading enzymes that may cleave at specific bases. Lastly, even if such enzymes were found, they would cut the DNA molecule into so many pieces which would be difficult to separate.

Until recently, sequencing of nucleotide only in a very few short DNA segments was known, but this method could not be utilised for many naturally occurring DNA segments.

In the last two years, simple methods to determine the DNA sequencing have been developed. One of the techniques uses restriction enzymes obtained from bacteria. Each restriction enzyme recognizes a specific DNA sequence and cuts the DNA at that sequence. According to R. Roberts of Cold Spring Harbour Laboratories, U.S.A., out of 300 bacterial strains he analysed, one third produced restriction enzymes. Nearly 45 enzymes of separate specificities have been found out. Once short DNA segments are obtained, it is easy to label them radioactively (*Science*, Vol. 192, 14 May 1976).

N. B.

alternative polypeptide initiator codon signal. But, here again, the term ambiguity is inappropriate for the apparent duplicity of codon function, because terminal and internal codons may differ in function, and at least in the case of the AUG-codon there are again two distinct tRNA species; one which is specific for N-formylmethionine, and the other for methionine itself!

### The code is universal

Although the code is universal in principle, it may nevertheless contain some regional dialects. Preference for certain synonyms of the degenerate assignments is one possibility. Indeed, we have seen how this may even apply to the initiating and terminating signals as well. An elegant experiment illustrating the relative response of different tRNA species derived from widely divergent organisms such as *E. coli* (bacteria), *Xenopus laevis* (amphibia),a nd —uinea pig (mammalia), was carried out by Nirenberg and his colleagues (1966). Some synonymous codons were equally popular templates with tRNA, whatever its source; whereas in other cases the codons were only active with the tRNA from one but not the other sources. However, tRNA from different tissues (such as liver and muscle) in the same species always gave the same response.

Other points in favour of the universal nature of the genetic code derive from the great uniformity of the primary structures (amino acid sequences) of homologous proteins, such as cytochrome c, from divergent species (which could reflect a common phylogenetic origin). Again, DNA (hence mRNA) with a high guanine and cytosine content is usually found to give rise to proteins which are rich in alanine, argenine, and glycine; but poor in isoleucine, lysine and phenylalanine. If the code is universal, a comparison of the corresponding codon-assignments for these amino acids (Table 1) should be sufficient to explain this observation. Finally, any mutation which could result in altered codon assignments would almost certainly be lethal; because it would actually change the nature (if not the amount) of the coded genetic information, and result in nothing but "scrambled" proteins, if indeed any at all! So perhaps it is pertinent to conclude here, with a quotation from Nirenberg (1966), who contributed so much to breaking the genetic code :

"The remarkable similarity in codon base sequences recognised by bacterial, amphibian, and mammalian tRNA suggest that most, if not all, forms of life on this planet use almost the same genetic language and that the language has been used possibly with few major changes, for at least 500 million years".

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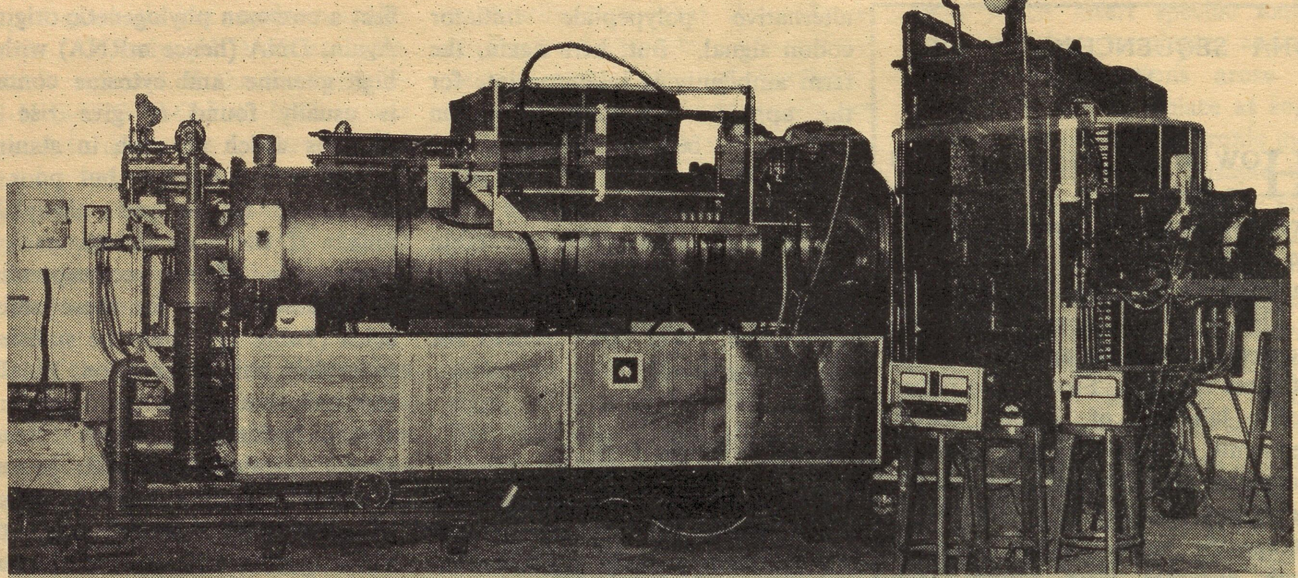

# Cyclotrons: The machines of Nuclear physics

**The "atom smashing" machines, originally invented for nuclear research, are now finding extensive use in production of radio isotopes and in many other fields such as medicine and material science**

NARESH KUMAR

EVER since the discovery of nucleus in an atom, scientists have been interested in knowing the structure of nuclei, and of the forces which hold the nuclear particles together. The nucleus is a small entity of the order of $10^{-12}$ to $10^{-13}$ cm, and as such it cannot be seen even under the most powerful microscope. To "look into" the nucleus one has to think of some indirect methods. The one which seemed the most appropriate was somehow to "break" the nucleus into fragments, and to speculate about it from the nature and the directions of its outgoing components.

In 1919, Ernest Rutherford (U.K.) reported the first successful disintegration of a nitrogen nucleus with naturally occurring alpha particles (nuclei of helium atoms) of 5 to 8 MeV energy (1 MeV=$1.6 \times 10^{-6}$ erg) from thorium. The energies of these naturally occurring alphas were far in excess of the energies available otherwise in the laboratory. To perform disintegration experiments efficiently and in a controlled manner, physicists for the first time realised the need for artificial sources of high-energy particles. These sources, now called the particle accelerators, are machines for producing high-speed particles. The energy of a particle of mass $m$ accelerated to a velocity $v$ (low, compared to the velocity of light) is given by $\frac{1}{2} mv^2$. Particles accelerated by these machines are used as projectiles to bombard the nuclei targets.

Today accelerators are an indispensable tool of nuclear research. Their installation and running costs are enormously high. Some, like the linear accelerators, are so big that they are kilometers long.

### Invention

The development of particle accelerators began in late 1920s. The first invented by J. D. Cockcroft and E.T.S. Walton at the Cavendish Laboratory, Cambridge, was an electrostatic accelerator in which charged particles were accelerated by a strong electric field. In 1932 this machine was the first to "split" a lithium

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nucleus with artificially accelerated protons of about 400 keV energy (1 keV$=10^{-3}$ MeV). The velocity of a proton (hydrogen ion) of 1 MeV energy is 14 million m/sec.

As electrostatic accelerators suffered from the defect of insulation breakdown at high voltages, machines which could accelerate particles in numerous small steps of low voltages were needed. One such machine, called the cyclotron (earlier named the magnetic resonance accelerator), was conceived in 1929 by Ernest O. Lawrence at the University of California, Berkeley (U.S.A.). In 1932 this machine was used by Lawrence and M. Stanley Livingston to disintegrate a nucleus with protons of 1.2 MeV, the highest energy then available in the laboratory. Lawrence was awarded the 1939 Nobel Prize in Physics for the invention of cyclotron.

Cyclotrons, which later formed the basis of a whole series of cyclic accelerators, were developed at a tremendous speed, their size growing bigger with the increasing need of more high energy particles. Their number in the world is now well over a few hundred. It is only in the last decade or so that their use in other branches of physics and science has been extensively explored.

**Principle**

A cyclotron consists of two hollow semi-circular metallic boxes $D_1$ and $D_2$ (Fig. 1), usually called the "dees" because of their shape. These dees are placed in an evacuated chamber C which is fixed within the pole faces of an electromagnet. The magnetic field, which acts perpendicular to the plane of the dees is uniform in the centre, but decreases slightly as one moves away from it. The dees are connected to a high frequency oscillator to provide them with a high frequency alternating potential. The dees then act as electrodes. When one dee is positive, the other becomes negative, and vice versa.

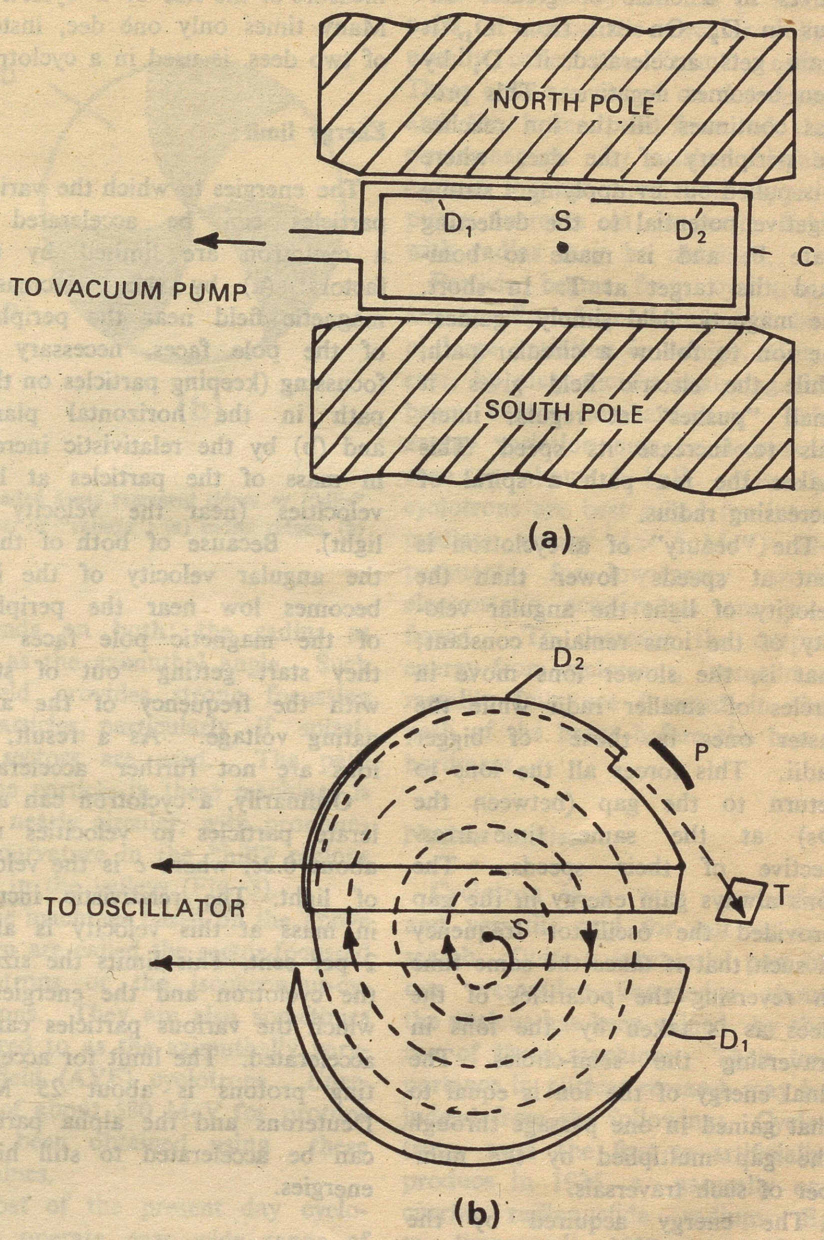



**Fig. 1. Principle of cyclotron: (a) vertical view of the main part of the machine, (b) path of the particle within the dees**

Positive ions are produced in the ion source S placed near the midpoint of the gap between the dees. If at the time of formation of a particular ion the dee $D_1$ is negative, the ion gets accelerated towards it. Once inside $D_1$, it moves in a circular path under the influence of the magnetic field quite unaffected by the electric field. If at the time of its exit from $D_1$ the oscillator reverses the polarity of $D_2$ making it negative, the ion again gets accelerated in going from $D_1$ to $D_2$. As a result the ion gains kinetic energy, which increases its speed. It then moves in a circle of greater radius in $D_2$. On exit from $D_1$, it again gets accelerated if $D_1$ by then becomes negative. This process continues till the ion reaches the periphery of the dees where it is pulled out by applying a strong negative potential to the deflecting plate P, and is made to bombard the target at T. In short, the magnetic field simply "guides" the ion to follow a circular path, while the electric field gives it small "pushes" at regular intervals to increase its speed. This makes the ion path a spiral of increasing radius.

The "beauty" of a cyclotron is that at speeds lower than the velocity of light the angular velocity of the ions remains constant; that is, the slower ions move in circles of smaller radii while the faster ones in those of bigger radii. This forces all the ions to return to the gap (between the Ds) at the same time irrespective of their speeds. The ions always gain energy in the gap provided the oscillator frequency is such that it takes the same time in reversing the polarities of the dees as is taken by the ions in traversing the semi-circles. The final energy of the ion is equal to that gained in one passage through the gap multiplied by the number of such traversals.

The energy acquired by the particles in a cyclotron is independent of the dee voltage. When voltage is small, the particles make large number of turns before reaching the periphery ; when voltage is high, the number of turns is small.

Only charged particles like protons, deuterons, alphas, ions of light and heavy elements can be accelerated in a cyclotron, as an electric field can exert force only on the charged particles.

The diameter of the magnetic pole faces is often used as a measure of the size of a cyclotron. Many times only one dee, instead of two dees, is used in a cyclotron.

**Energy limit**

The energies to which the various particles can be accelerated in a cyclotron are limited by two factors: (a) by the decreasing magnetic field near the periphery of the pole faces, necessary for focussing (keeping particles on their path in the horizontal plane); and (b) by the relativistic increase in mass of the particles at high velocities (near the velocity of light). Because of both of these, the angular velocity of the ions becomes low near the periphery of the magnetic pole faces and they start getting "out of step" with the frequency of the alternating voltage. As a result, the ions are not further accelerated.

Ordinarily, a cyclotron can accelerate particles to velocities upto about $0.2c$, where $c$ is the velocity of light. The relativistic increase in mass at this velocity is about 2 per cent. This limits the size of the cyclotron and the energies to which the various particles can be accelerated. The limit for accelerating protons is about 25 MeV. Deuterons and the alpha particles can be accelerated to still higher energies.

**Modifications**

For many nuclear experiments we need particles of a few tens of MeV of energy. So sometimes the attainable particle energies from an ordinary cyclotron pose a serious limitation. To push up these energies two different techniques have been devised. They depend on compensating for the decrease in angular velocity of the particles at high speeds (near the periphery of the dees). In the first technique, the frequency of the accelerating voltage is continuously decreased from some maximum to a minimum value, as the particles move away from the centre of the machine. In the second, the intensity of the magnetic field is continuously increased from the centre towards the periphery of the magnetic pole faces (keeping a fixed frequency for the accelerating voltage). With the increasing magnetic field, the particles feel stronger bending forces and move in circles of smaller radii. The shortened paths compensate for the decreased angular velocity at high speeds.

The cyclotrons based on the first modification are called the synchro-cyclotrons or the frequency modulated (FM) cyclotrons. These machines do not produce particles in a continuous stream, but in small 'bursts". Energies of about 750 MeV for protons have been obtained using these machines. The FM cyclotrons are usually used in high-energy (elementary particle physics) research.

In connection with the second modification, it was observed by H. A. Bethe and M. E. Rose of U.S.A. that a field which increases as we move away from the centre of the machine has a defocussing action in the vertical direction and so cannot be used in an accelerator. Because of the vertical defocussing, the particles move up or down and get lost in the walls of the dees. In 1938 L. H. Thomas (U.S.A.) suggested a way out. Incidentally, however, his suggestion was not put to test for over a decade due to the development of synchro-cyclotrons. The first two small model machines based on Thomas's idea were constructed at Berkeley in 1952. But the real interest was taken in these machines only after 1955 when E.O. Lawrence reported about them at the "Atoms for peace" conference in Geneva.

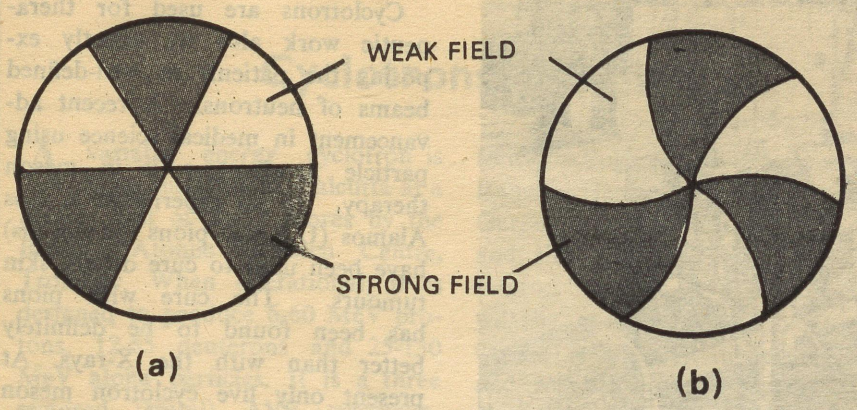



**Fig. 2. Pole faces of sector-focussed cyclotron. Shaded areas represent ridges or "hills" while unshaded areas represent empty spaces or "valleys"; (a) radial ridges, (b) spiral ridges**

In machines based on Thomas's idea, the magnetic pole faces are not flat but fastened with iron slabs either in the radial direction or spiraling outward in gentle curves (Fig. 2). These slabs, called sectors or ridges, have gaps of empty space in between of about the same size. As the pole gap between the ridges is small, the magnetic field is stronger there compared to the one in the "valley" regions. This gives alternating regions of strong and weak magnetic fields. The magnetic field depends on both: the radius as well as the azimuthal angle. Such a field provides strong focussing of particles, particularly if spiraling sectors are used. The path of the particle in these machines is only nearly circular, with pronounced curvature in the "hill" regions than in the valleys (Fig. 3).

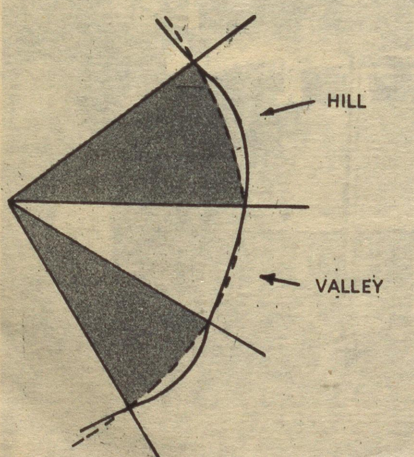



**Fig. 3. Trajectory of a particle in an isochronous cyclotron. Circular path, for reference, is shown by a shaded line**

The machines based on the above design are called the sector-focussed cyclotrons or the isochronous-cyclotrons. They are also sometimes referred to as the azimuthally varying field (AVF) cyclotrons. Energies of about 580 MeV for protons have been obtained using these machines.

Most of the present day cyclotrons operate over wide range of oscillator frequency and can, therefore, accelerate particles to a desired range of energies (of course, upto a maximum possible from the machine in question). These cyclotrons are then also called the variable energy cyclotrons (VEC). In them, the strength of the magnetic field is also varied to make the particles return to the gap "in step" with the frequency of the oscillator.

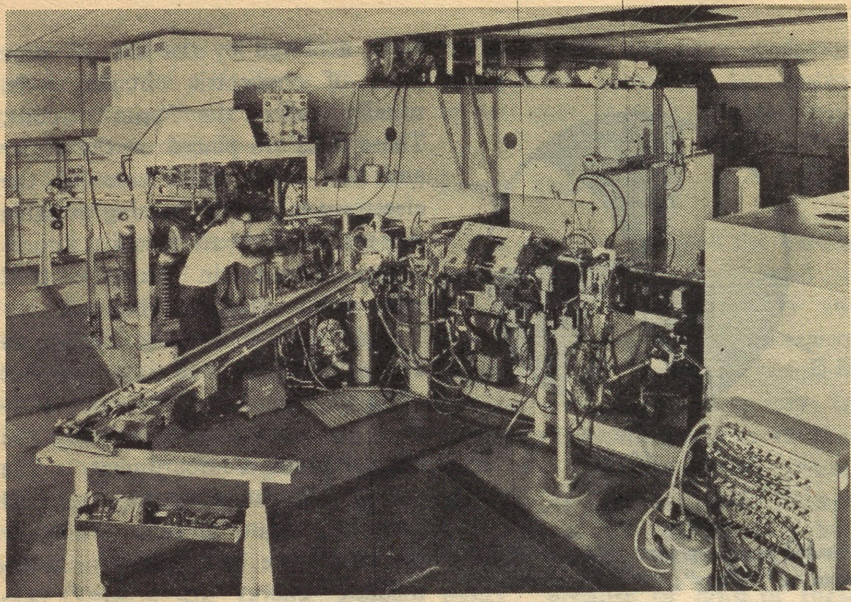
The increase in magnetic field from the centre to the periphery of the magnet in an AVF cyclotron is often achieved by the use of some pairs of concentric circular coils, usually called the "trim" coils. These coils are placed on the upper and the lower pole faces of the electromagnet. By passing suitable current through these coils appropriate increase in magnetic field with radius may be obtained.

Particle beams from cyclotrons are usually of good intensity but of large variation in energy. However, by magnetically analysing the beam before bombardment, this energy variation may be decreased even to about 5 keV. Usually cyclotrons are best suited for intermediate energy (> 5 MeV) experiments; for low-energy work electrostatic accelerators are preferred. To decrease the output energy from cyclotrons, sometimes metallic foils are inserted in the path of the beam before the bombardment.

**Nuclear studies**

Cyclotron is a very powerful and versatile tool for nuclear research. Quite a substantial part of our presentday knowledge about the nucleus has been gained by the use of these machines. Their importance in nuclear research may be judged from the following: Cyclotrons were the first to artificially produce in 1936 a naturally occurring radionuclide radium E; to discover in 1938 an artificial element technetium; to produce in 1940 a transuranic element (with proton number, $Z$, greater than 92); to discover the mass 3 isotopes of hydrogen and helium, etc.

An interesting field which is now opening up is that of superheavy elements. For long, theoretical physicists have speculated about the possible existence of some very heavy elements (heavier than even the transuranic elements). It was thought that after a region of very great instability, $106 < Z < 112$, due



**The 88 inch spiral-ridge sector-focussed cyclotron at Berkeley. Experimental area with the necessary equipment is shown in the foreground. (*Courtesy*: Lawrence Radiation Laboratory, University of California)**

to low fission barriers, an island of stability connected with the magic numbers may be observed. Recently, some U.S. scientists, R. V. Gentry, T. A. Cahill and others, have obtained the first experimental evidence for the existence of three superheavy elements with $Z = 116$, 124 and 126. Cyclotrons, in combination with other accelerators, may be used to produce artificially these elements, and to look for some new ones.

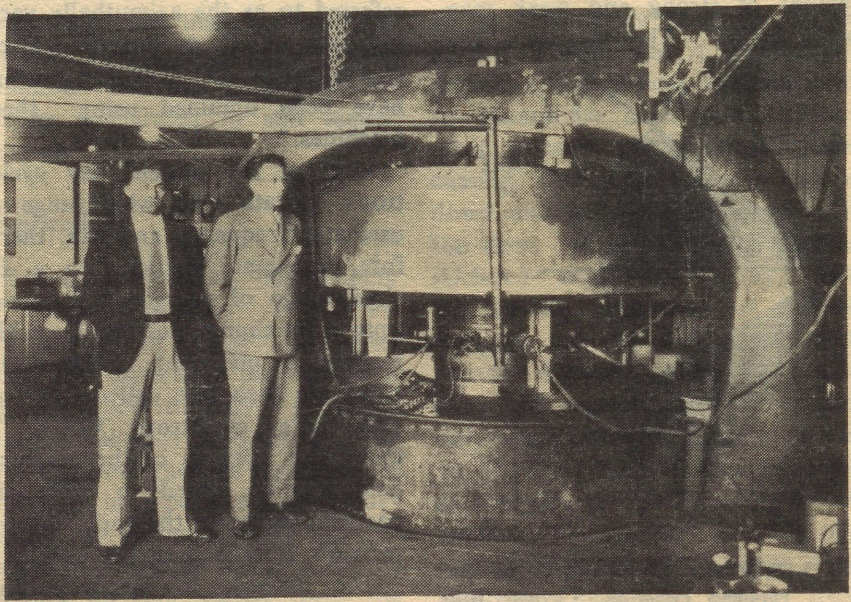
### Other applications

Apart from the use of cyclotrons in nuclear research, these machines are now also being extensively used in many different branches of physics and science. Many of their applications are in fundamental fields with tremendous potential for gaining new knowledge and in applied fields with vast uses in industry. Their use in medical science is on the rise.

One of the most important applications of cyclotrons is in the production of radio-isotopes. These isotopes have numerous uses in almost all branches of science. Their contribution in the therapy of some lethal diseases like cancer, and as "tracers" in biology and agriculture are too well-known. As isotope producers cyclotrons have always been of great value. They can even produce those isotopes which cannot be obtained using a nuclear reactor. For producing very short-lived clinically useful radio-isotopes, cyclotrons have even been installed in some medical centres in advanced countries.

Cyclotrons are used for therapeutic work also by directly exposing the patients to well-defined beams of neutrons. A recent advancement in medical science using particle accelerators is in meson therapy. In an experiment at Los Alamos (U.S.A.), pions ($\pi$-mesons) have been used to cure deadly skin tumours. The cure with pions has been found to be definitely better than with the X-rays. At present only five cyclotron meson facilities exist, the notable among them are the TRIUMF (Canada) and the SIN (Switzerland).

Neutron beams from cyclotrons may be used for non-destructive testing of heavy and complicated parts of machinery (neutron radiography). Damage caused in various structural materials by high-energetic particles (radiation damage) may also be studied. An important use of radiation damage studies is in nuclear technology. Nuclear reactor materials usually get damaged because of heavy bombardments by fast neutrons from the reactor core. Another use of cyclotrons is in determining



**The 27 inch cyclotron built at Berkeley in 1934 (*Courtesy*: Lawrence Radiation Laboratory, University of California)**

## Cyclotrons in India

A variable energy cyclotron is being installed at Calcutta at a project cost of Rs. 8 crores by the Bhabha Atomic Research Centre, Trombay. When operational, it is designed to produce 6-60 MeV protons, 12-65 deuterons and 25-130 MeV alpha particles. It is a three sectored (spiral) AVF cyclotron, whose design has been adapted from a similar machine at the Lawrence Radiation Laboratory, Berkeley, (U.S.A.). Some of its design specifications are :

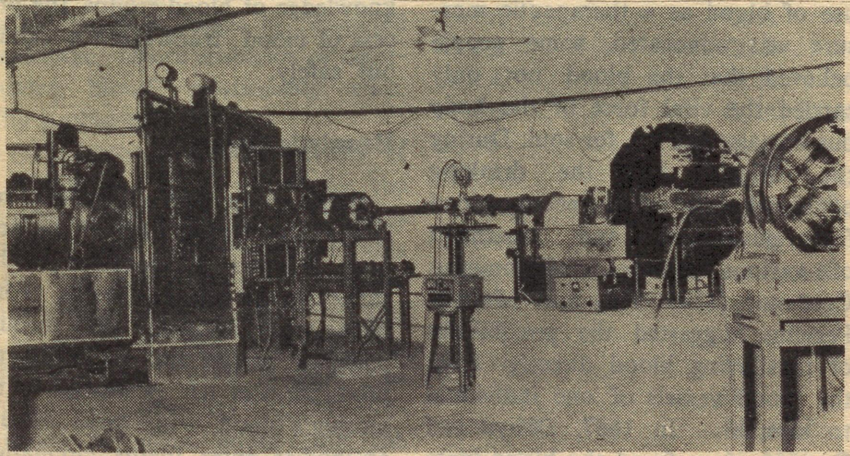
| | |
|---|---|
| Weight of the magnet | 262 tons |
| Diameter of pole faces | 224 cm |
| Average magnetic field | 17 kilo gauss |
| Pole gap between ridges | 19 cm |
| Pole gap between valleys | 30 cm |
| Trim coils | 17 pairs |
| Oscillator frequency range | 5.5-16.5 mega hertz |
| Maximum dee voltage | 70 kilo volt |
| Maximum deflector voltage | 120 kilo volt |
| External beam | 100 micro ampere |
| Main coil power | 490 kilo watt |

Various components of this machine have been fabricated in different institutions in India. Main participants in this commendable feat of collaboration are the Heavy Engineering Corporation, Ranchi, Heavy Electricals, Bhopal, Garden Reach Workshop, Calcutta, and the Bhabha Atomic Research Centre, Trombay. This machine will be a national facility for advanced research in nuclear physics and for the controlled direct irradiation of biological and agricultural products.

The other cyclotron, a small "conventional" machine, has started functioning recently at Panjab University, Chandigarh. This machine, a gift from the University of Rochester (U.S.A.), is designed to accelerate 2-8 MeV protons, 1-4 MeV deuterons, 2-8 MeV alpha particles and 3-11 MeV $^3$He nuclei. Some of its design specifications are :

| | |
|---|---|
| Weight of the magnet | 20 tons |
| Diameter of pole faces | 26 inch |
| Maximum magnetic field | 14 kilo gauss |
| Dee voltage | 30-40 kilo volt |
| Oscillator frequency | 10-20 mega hertz |

Both the Calcutta and the Chandigarh cyclotrons are single dee machines. A small cyclotron is also at Saha Institute for Nuclear Research, Calcutta.



A part of the cyclotron machine at Panjab University Chandigarh (*Courtesy*: Professor H. S. Hans)

the elemental and/or isotopic composition of material samples (materials analysis).

### Trends and prospects

There are now about 20 AVF cyclotrons in the world with proton energies greater than 45 MeV. General trend these days is in building cyclotrons with still higher energies and developing heavy-ion sources for possible use in these machines. A challenge for cyclotron experts is to design small, reliable, cheap and easily operable machines which can be installed in hospitals for medical applications. Nowadays, instead of installing a cyclotron in a hospital, one may have to think of building a "hospital near a cyclotron."

A recent improvement over the existing cyclotrons is the "superconducting cyclotron." In this cyclotron, one can reduce the amount of iron needed for the magnet by the use of superconducting magnetic coils. This is expected to reduce the conventional cost of cyclotrons to about half. The two superconducting cyclotrons under construction are at the Michigan State University (U.S.A.) and at the Chalk River Nuclear Laboratories (Canada). Design studies for such a machine are also underway at the Lawrence Radiation Laboratory, Berkeley.

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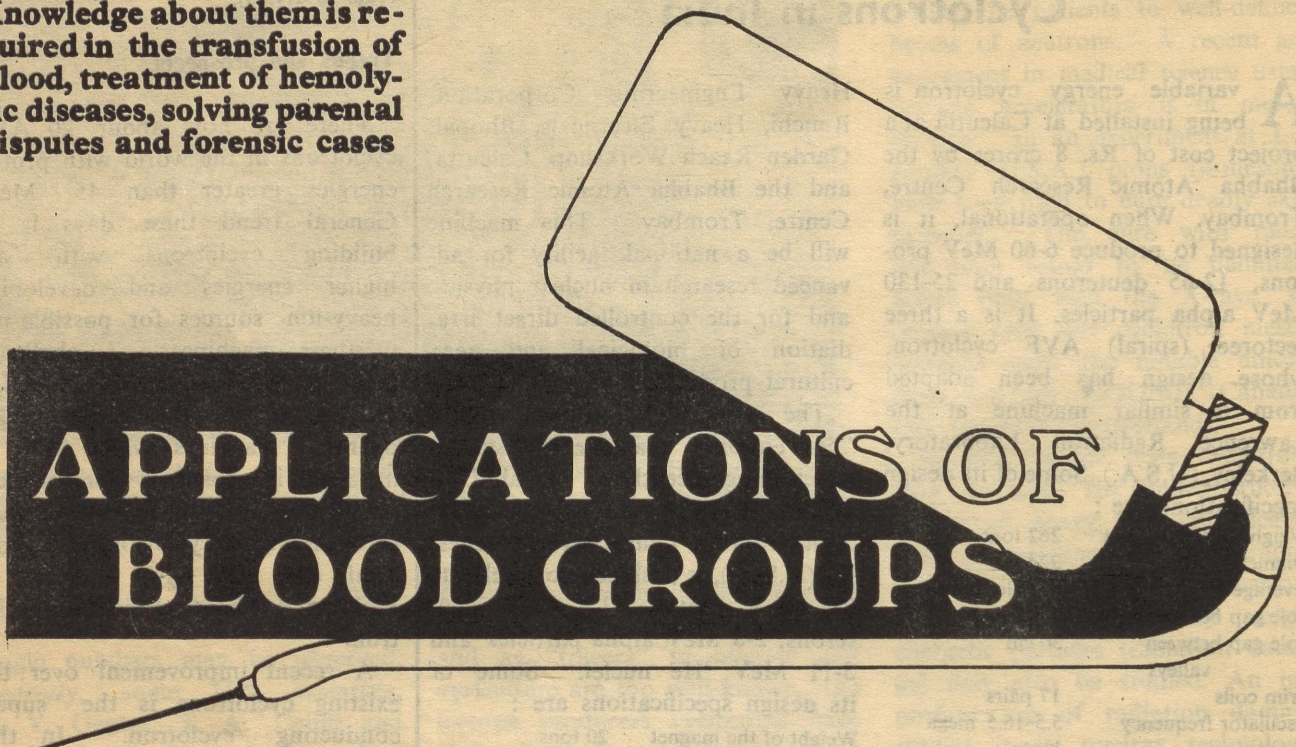
**Antigens and antibodies, the blood group factors, vary from person to person. Knowledge about them is required in the transfusion of blood, treatment of hemolytic diseases, solving parental disputes and forensic cases**

D. P. BHATNAGAR



# APPLICATIONS OF BLOOD GROUPS

BLOOD consists of plasma and cells. It is primarily a medium for the carriage of oxygen, nutrients, hormones and antiinfection agents to the tissues and for the removal of carbon dioxide and other waste products from the tissues and their elimination from the body. Antibodies belong to $\gamma$-globulins and are formed widely in the body by reticulo-endothelial system. The antigen is found on the red blood cells.

Blood group factors belong to the family of substances known as antigens and antibodies. A type of serological reaction between antigens and antibodies which results in the clumping of red cells is known as agglutination. Antigens and antibodies vary from person to person. These differences in human blood are the basis of blood groups. Table 1 shows most of the human blood group systems and some of the related antigens within each system.

The knowledge of blood groups can be applied in the following fields.

### Blood transfusion

From early historical times, the use of blood as a therapeutic measure was advocated, some people believed that the blood not only carried the vital force of the body but was also the sea for soul. During the Middle Ages the drinking of blood was much recommended for rejuvenation and treatment of various diseases. Hieronymus Cardanus (1505-1576) and Magnus Pegelius suggested the possibilities of tansferring blood directly from the blood vessels of one individual to another. In 1667, Denys and Emmerez transfused the blood from the carotid artery of a lamb into the vein of a youngman. This transfusion was successful. A patient in France died when Denys tranfused blood because the patient received fatal transfusion. The fatal results from transfusion led to the discovery of blood groups. With the knowledge of blood groups, the process of blood transfusion is carried out safely.

### Hemolytic disease

Blood groups play a significant role in the hemolytic disease of the new-born. When an Rh-negative mother carries an Rh-positive foetus, some of the foetus antigens pass through placental barrier and stimulate the production of Rh antibodies in the mother's blood. When these immune antibodies enter foetus circulation,

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Table 1

| System | Antigens |
|---|---|
| $A_1A_2BO$ | $A_1$ B, H, $A_2$, $A_3$, $A_x$ |
| Rh | D, C, c, $C^w$, $C^x$, E, e, $e^s$, $E^w$, G, ce, $ce^s$, Ce, CE, $D^u$, $C^u$, $E^u$ |
| MNSs | M, N, S, s, $M_2$, $N_2$, $M^c$, $Mi^a$, Vw, Mu, Hu, $M^g$, Vr, $M_1$, $Mt^a$, $Ri^a$, $St^a$ |
| P | $P_1$, $P_2$, $P^k$ |
| Lutheran | $Lu^a$, $Lu^b$ |
| Kell | K, k, $Kp^a$, $Kp^b$, $Js^a$, $Js^b$ |
| Lewis | $Le^a$, $Le^b$ |
| Duffy | Fya, Fyb |
| Kidd | $Jk^a$,$Jk^b$ |
| Diego | $Di^a$ |
| I | I, i |
| Aubergar | Aua |
| Xg | $Xg^a$ |
| Very infrequent antigens | Levay, Becker, Ven, $Wr^a$, $Be^a$, Rm, $Sw^a$, Good, Bi, $Tr^a$, Wb |
| Very frequent antigens | Vel, $Yt^a$, Ge, Lan, Sm |

they destroy the red cells of foetus and cause hemolytic disease of newborn or erythroblastosis foetalis. The detection of immune antibodies in the maternal circulation in early pregnancy can save the foetus by various methods like early delivery and exchange transfusion (Jolly *et al.*, 1970; Bhatnagar, 1972 and Sidhu and Bhatnagar, 1974).

**Parentage disputes**

Blood groups can be applied in medico-legal cases of disputed parentage, where problems of determining blood relationship arise. The problems may be :

(a) a husband denies paternity of a child, (b) man named by the mother as the father of a child denies paternity, (c) two newborn infants have been accidentally interchanged in a hospital shortly after birth and it is desired to identify the parents of the infants, (d) it is suspected that a wet nurse has wilfully substituted her own infant for the one placed in her custody, so that her own child may have the benefits of a better home, and (e) a woman has simulated pregnancy and child birth and now pretends that the child is her own in order to compel a man to marry her or to obtain dowry of her dead husband's estate or be heir to her husband's estate.

For this purpose ABO and MN systems of blood grouping are most commonly employed. Table 2 shows the possibilities of children's blood groups in various parental blood groups combinations.

**Forensic cases**

Blood grouping has proved to be of great value in criminal or forensic cases where it is required to determine the origin of blood stains. This application was first suggested by Landsteiner and Richter who showed that it is possible to demonstrate the presence of antibodies in dried blood stains. Blood grouping tests on blood stain were first applied in criminal cases by Latters in 1916 in an Italian criminal court. Blood grouping tests may help not only to acquit the innocent but also convict the guilty. The properties of antigens A and B can be demonstrated in the seminal fluid. This may prove helpful in the cases of rape or assault.

Table 2

| Blood groups of parents | Blood groups of children | Blood groups of children not possible |
|---|---|---|
| O×O | O | A, B, AB |
| O×A | O, A | B, AB |
| O×B | O, B | A, AB |
| A×A | O, A | B, AB |
| A×B | O, A, B, AB | — |
| B×B | O, B | A, AB |
| O×AB | A, B | O, AB |
| A×AB | A, B, AB | O |
| B×AB | A, B, AB | O |
| AB×AB | A, B, AB | O |
| M×M | M | N, MN |
| N×N | N | M, MN |
| M×N | MN | M, N |
| MN×M | M, MN | N |
| MN×N | N, MN | M |
| MN×MN | M, N, MN | — |

## Genetics

The discovery of so many human blood groups is providing a new tool for studying the Mendelian inheritance. The geneticists have long felt that the blood groups are an ideal material for the study of human genetics. They are easily determinable inherited characters unaffected by environment. So what more could a geneticist desire ? Blood groups can be used in the study of human genetics as under :

(a) to study each blood system, not only as examples of straight Mendelian inheritance but also the effect of one gene on another, position and dosage effects and closely linked genes ; (b) use of blood groups as markers of chromosomes; (c) in balanced polymorphism. It follows that natural selection is influenced by our blood groups differences. Different combinations of genotypes will have slightly different survival values; and, (d) relation of blood groups with diseases.

## Anthropology

All the known blood group systems how variations in gene frequency in different populations. The first published discovery that frequency of the blood groups varied from one population to another was made by Professor and Mrs. Hirszfeld, when they were working at Salonika during the First World War. Now, at present, the distribution of various blood groups is fairly well-known. It has been concluded that the population has reached an equilibrium—the proportion of blood groups remain constant from generation to generation, provided there is no crossing with other people. Verzar and Weszechoky studied the distribution of blood groups in gypsies, who had originally lived in India and then migrated to Hungary where they lived for several hundred years. It can be seen that the serological composition of gypsies does not differ from the natives of India, although it differs greatly from the Hungarians among whom they live. Similar results were obtained by them when they studied the distribution of blood groups among German colonies in Hungary. Aggarwal (1966) worked on Burmese immigrants. Knowledge of blood group gene frequencies in the population helps in setting up of blood banks, immunization units and ante-natal clinics accordingly.

## Archaeology

Blood groups are also applicable to the comparative study of genetic composition of the population who lived in the last few thousand years from now. It was believed that blood groups of the people of the past could not be determined, for all that ever remains of them is skeletons or bloodless mummies, but even these dry relics may be made to reveal their blood groups. The chemical substances of blood groups are not restricted to the red cells of the individuals, but exist throughout his body in practically all his cells and tissue fluids. They are rather unusally stable antigens. They resist drying, heating and exposure to a number of drastic chemical reagents which would quickly inactivate the protein antigens. The study of Egyptian mummies revealed that the frequency of antigen A and B was not as high as in their present day descendants. In American Indian mummies of Wild West United States, the antigen A was very infrequent and only one B group individual was reported from all the specimens studied. The present day Indians of that region show patchy frequency of A, and group B is perhaps entirely lacking. Blood groups offer most valuable information on the origin of races.

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# HOW SPIDERS CATCH THEIR PREY

B.L. BRADOO

**Spiders use a variety of devices to catch their preys**

SPIDERS are well-known predacious representatives of the phylum Arthropoda. They obtain their prey by several methods depending on the type of the species. The jumping spiders of the family *Salticidae* and the wolf spiders of the family *Lycosidae* do not spin any capture web. Instead, they wander in search of a suitable prey and pounce upon it. The crab spiders of the family *Thomisidae* wait and hide in flowers to capture insects that visit them in search of nectar and pollen (*S.R.*, Aug., 1973). The commensal spiders of the genus Argyrodes (Fam: *Theridiidae*) are small individuals that live on the web of some other large spiders and feed upon the smaller entrapped insects that have been neglected by the host spider. The parasitic spiders, however, steal and feed on useful preys that are entrapped in the host web (Kullmann, E., 1960, *Verh. Deut. Zool. Ges.*, 332-342).

The web-building spiders make various types of silken snares for catching their preys. Such webs (snares) differ much in shape and structure. Some spiders spin only an irregular net, but the species of Linyphia make sheet webs and the common grass spider, Agelana, makes a funnel web.

The circular webs, also called orb webs, are common in lawns and inside homes made by the species of the family *Argiopidae* and *Uloboridae*. The various stages in the construction of an orb web and the chemical nature of the spider silk are described in *Science Reporter* (Aug. 1973). The structure of an orb web is shown in (Fig. 6). It consists of a frame of supporting silk threads from which arise many radii (20-40) that converge at the central close meshed disc of silk called, hub. The hub serves as the resting platform for the spider while he keeps watch for the possible insects that may fall in the completed web. After the hub is complete, the spider makes temporary spirals over the radii for going from one radius to the next, for future spinning activity. After this, the spider spins sticky spiral threads arranged in circles, starting from the periphery of the orb till it reaches close to the hub, leaving a little gap in between the two. The spiral sticky threads are directly produced from the spinnerets as the spider moves from radius to radius

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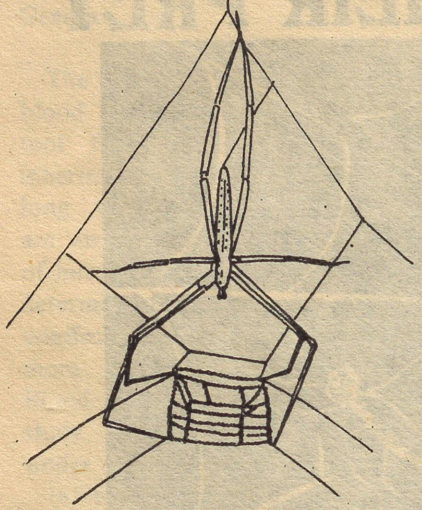


**Fig. 1**

(e.g, *in Argiopidae*). But the species of the family *Uloboridae* produce the spiral sticky thread as a secretion of the special silk glands called cribellar glands. The cribellar silk is elastic and adhesive. It is brushed out of a special porous plate called cribellum (Fig. 8) (located on the ventral side of the abdomen in front of the spinnerets) with a special brush of hairs called calamistrum located on the hind legs that are used during spinning of cribellar silk (hackled band silk).

When a suitable prey falls in any of the types of the web mentioned above, the spider covers the victim in a sheet of silk produced from the spinnerets. Then digestive enzymes are poured over the prey to digest its soft parts that are eventually sucked by the spider (extracellular digestion). The remains of the prey are added to the nest structure or may be thrown down by the spider.

Many spiders have devised some unusual and unique methods of prey capture, showing many variations in feeding behaviour which help them to remain alive in extreme and unfavourable conditions. These adaptations provide them with greater chances of evolution and natural selection. They can even live without any food and water for a long time, if forced to do so.

**Unusual feeding methods**

*Hurling webs (fishing nets)*. Spiders that make various types of web wait for preys that come and strike their webs. But the species of the family *Dinopidae* which includes two important genera, Dinopis and Menneus, catch small insects by hurling their sticky webs with the help of their long thin legs. The American stick spider, *Dinopis spinosus*, from Florida, spins a small rectangular web across which are laid a number of sticky cribellar silk threads. The completed web is held with the first two pairs of legs (Fig. 1) stretched 5 to 10 times its original size and then hurled over a passing insect. The prey captured in this manner is then wrapped in silk and bitten before the feeding starts.

This unique method of prey capture has been confirmed by M.H. Robinson and Barbara Robinson (1971) in *Dinopis longipes*, a specialist in capturing ants, found in Panama.

*Spring webs*. The ray-spider, *Theridiosoma radiosa*, spins a unique orb web without a central hub. The radii converge upon a small number of lines radiating from a point near the centre. The sticky spiral turns are less than 12 in number. The spider rests in the centre of the web and pulls the orb into the shape of

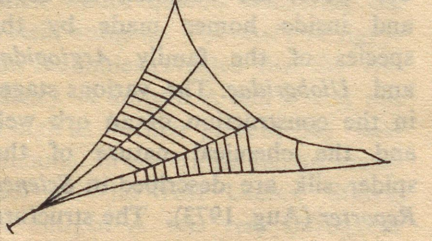
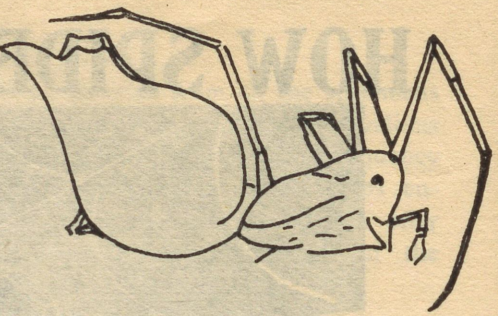
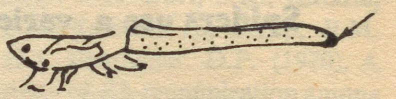


**Fig. 2**



ARGYRODES

THERIDION



MIAGRAMMOPES

**Some Indian spiders.**

a cone (funnel) (Fig. 7). When an insect gets entangled in the web, the spider releases its hold, allowing the web to spring back that ensnares the prey more firmly.

Spiders of the genus Hyptiotes (*Uloboridae*) construct a vertical triangular web (Fig. 2) that has only 4 radii of non-sticky silk. About 10 to 20 sticky silk threads are then laid on these four radii that meet into a single draw thread fixed to a nearby twig. The spider then cuts the draw thread and suspends itself between two parts of the draw thread. It holds the anterior thread taut with its legs. When an insect strikes the web, tension is released at once so that the prey is entangled and captured by the spider.

The African stick spider, *Miagrammopes*, spins a single silk thread, about one meter long, between any two adjacent twigs. The central part of the thread is covered with sticky cribellar silk and then the spider holds its one end taut like *Hyptiotes* does. When a small insect alights on the web, tension is released that entangles the prey. In 1971, Dr. B.K. Tikader described five new species of this interesting genus in India.

Professor B. J. Marples of New Zealand reported in 1955 another single line web (10 cm long) in *Ulesanis pukeiwa*. This spider rests on a twig and holds the silk thread, coated with droplets of sticky silk, in tension. The thread entangles a suitable prey when made slack by the spider.

*Gum-footed webs.* Some spiders like *Steatoda*, *Teutana*, *Theridion lunatum*, *T. saxatile*, *Lithyphantes albomaculatus* and sometimes the common house spider *Theridion tepidariorum* make special gum-footed webs. These webs consist of a number of straight vertical threads attached to the substratum which bear at the lower end (for about 3mm) a coating of 3 to 10 visced globules of silk for trapping small ground insects.

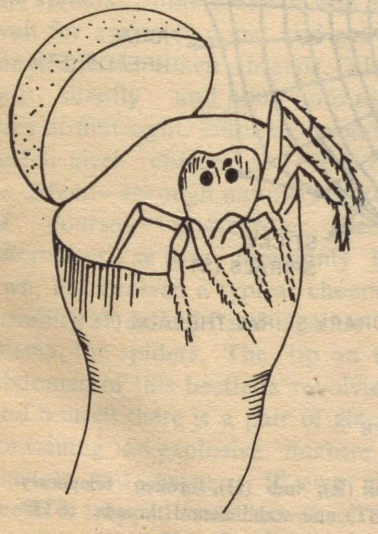


**Fig. 3**

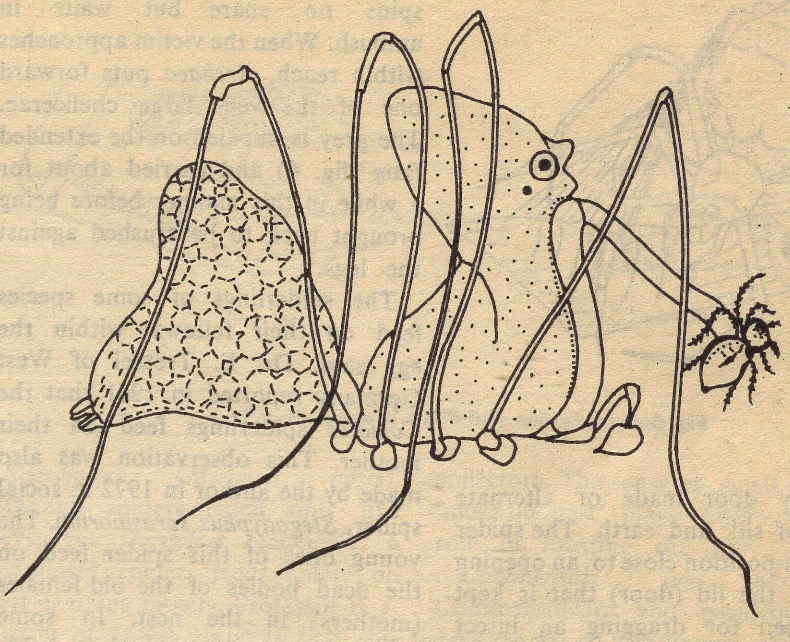


**Fig. 4**

In case of *Episinus*, the web consists of only two vertical 'gum-footed' threads, connected transversely above, so as to present an H-shaped appearance. The spider hangs from the cross thread with her hind legs and holds her front legs down along the two vertical threads to catch a suitable prey.

*Bolas-throwing spiders.* The common examples include *Mastophora* from Africa, *Dicrostichus* from Australia and *Cladomelea* from S. Africa. These interesting spiders sit on or suspend themselves from a twig and hold a silk thread. To the lower end of this silk thread is attached a sticky globule of silk which is flung at a passing insect. The insect is then hauled up by the spider. The details of bolas-throwing spiders have been published by C. E. Hutchinson in 1903 (*Scientific American*, **89**: 172) and by Dr. W. J. Gertsch (1855) (*Bull. Amer. Mus. Natur. Hist.*, **106**: 225-254).

*Gum-spitting spiders.* The spiders of the genus Scytodes catch prey by squirting a mucilaginous secretion as recorded by two workers, S. Dabelow (1958) of Germany and W. H. McAlister (1961) of U.S.A. These spiders raise their anterior legs and search for the prey during night. When a prey is near the spider, the gummy spray is thrown from a distance of about 10 to 20 mm and may be repeatedly thrown. As many as eight sprays have been recorded for one encounter.

Using high speed cinematography, Dr. Dabelow found that the duration of each spray varied from 1/8 sec to 1/6 sec and the gummy secretion was flung at a velocity of 6 to 9 m/sec. In 1930, Professor J. Millot of France studied the anatomy of the glands concerned. He reported that the gland is large with a smaller anterior lobe for venom and a larger posterior lobe that secretes the gum. When the spider bites its prey, only the venom is injected, but when it sprays gum some venom also comes out and paralyses the prey. At least four species of Scytodes have been recorded from India.

*Trap-door spiders.* The trap door spiders (*Tarantula*) of California and Arizona make simple burrows with the help of their fangs and anterior legs. The burrow (Fig. 3) is lined with silk and has

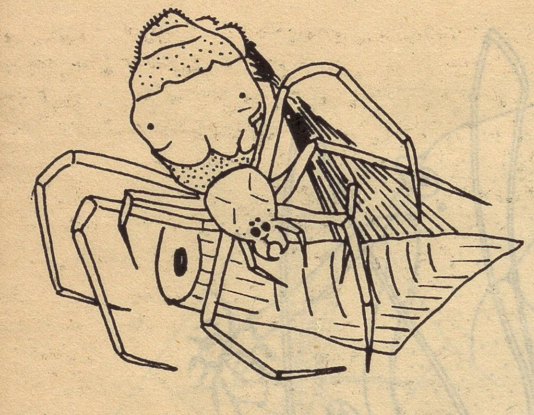


Fig. 5

a heavy door made of alternate layers of silk and earth. The spider takes its position close to an opening beneath the lid (door) that is kept half open for dragging an insect inside the burrow. When an insect is in, the door is shut and the insect is fed upon by the spider. Very often these trap-door spiders camouflage the door with bits of leaves and earth so that the spider is not easily detected by its most common enemy, a large fearless wasp (*Pepsis*) that has a wing span of 7.5 cm to 10 cm.

*Spider-eaters* (Strict cannibals). The author recorded a green stick-like spider *Ariamnes* sp. (*Theridiidae*) in Kerala (*Ent. Monthly Mag. London*, 1972, **107**:241-243). The adult female spider is about 45 mm long. It spins a straight line-web and suspends itself upside down, holds anterior thread with its front legs and posterior thread fixed with the spinnerets. During the aerial dispersal, when some spiderlings of other species come on the web line, the *Ariamnes* rushes quickly to wrap the prey in silk before actual feeding commences.

W. S. Bristow, a famous arachnologist of England, found that *Ero furcata* paid no attention to various insect preys offered, but it readily accepted other spiders as prey. In 1961, Professor Roland Legendre of Madagascar reported an interesting spider *Archaea* that spins no snare but waits in ambush. When the victim approaches within reach, *Archaea* puts forward one of the very large chelicerae. The prey is impaled on the extended fang (fig. 4) and carried about for a while in this manner before being brought back to be crushed against the legs.

The spiderlings of some species feed on their fellows within the egg sacs. Dr. E. Tretzel of West Germany reported in 1961 that the *Coelotes* spiderlings feed on their mother. This observation was also made by the author in 1972 in social spider, *Stegodyphus sarasinorum*. The young ones of this spider feed on the dead bodies of the old females (mothers) in the nest. In some spiders, the mothers catch suitable preys or regurgitate nutritive secretions for their brood.

*Cocoon and egg-eaters*. There are records of mother spiders that feed on their own cocoons and

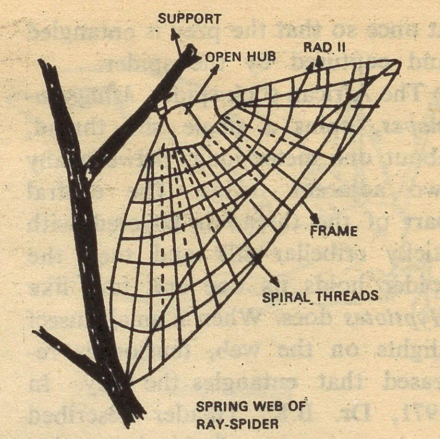



**Fig. 7. The spring web of *Theridiosome radiosa* held in the form of a cone by the spider**

eggs. Probably such cocoons are defective and eggs infertile. Sometimes, it is the extreme disturbance that forces the mother spider to take such a drastic action as reported in *Scytodes thoracica* (a gum-spitter) by S. Dabelow in 1958 (*Zool. Jahrb.* pp. 85-162).

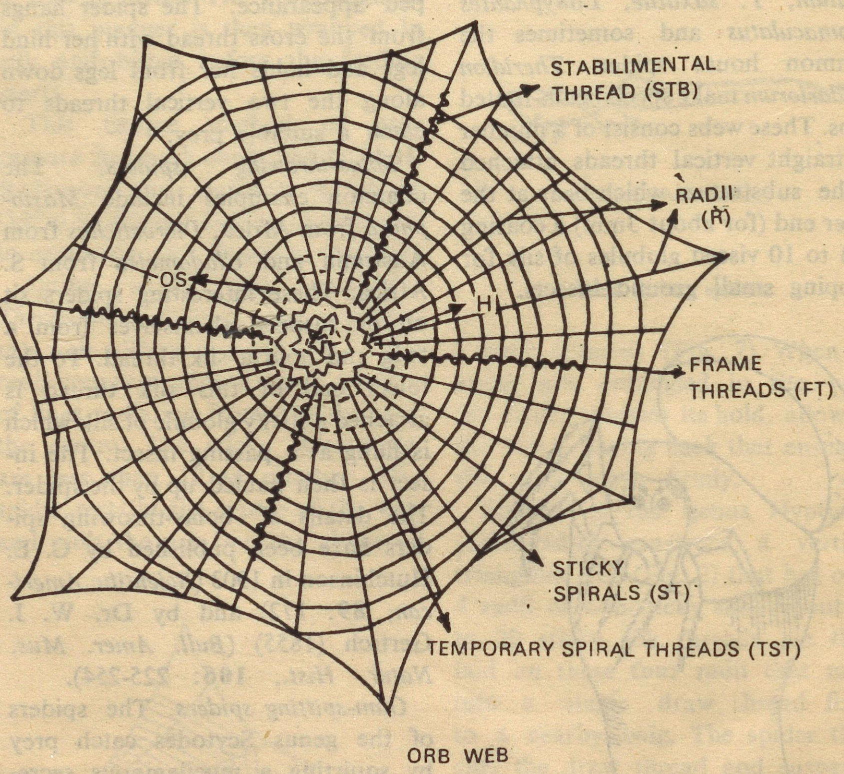



**Fig. 6. An orb web showing frame threads (FT), radii (R), hub (H), broken temporary spiral threads (TST), sticky spiral threads (ST) and stabilimental threads (STB) and open space (OS) between the hub and the spiral threads**

*Bird-eaters.* There are records of many spiders that catch bats and small birds in their large sticky webs. Some spiders are known to have killed lizards, snakes and frogs. Mygalomorph spiders of the family *Avicularidae* are true bird catchers. They run with great speed on vertical tree trunks and have very strong fangs with highly effective proteolytic enzymes to kill and digest the captured birds.

The Australian funnel-web spider, *Atrax robustus,* is a venomous and a very aggressive spider that assumes a "fighting attitude" with its front raised and fangs extended out. The venom is very toxic to the vertebrates. The spider does not flee at the approach of danger and cannot be cornered so easily.

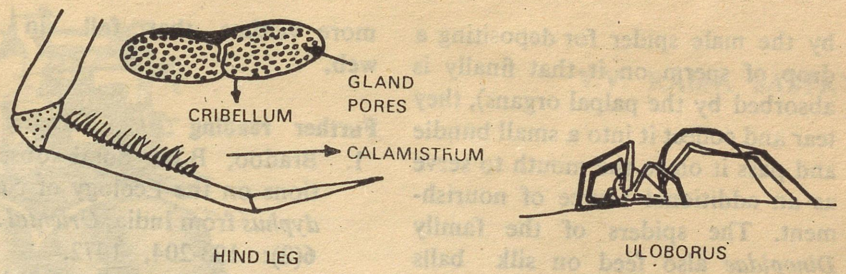



**Fig. 8. Shape of a cribellum and calamistrum**

*Scavengers* (*Museum pests*). Although spiders catch only live preys, yet *Herpyllus blackwalli,* a Gnaphosid spider, feeds solely on dead or dying insects. Professor B. J. Kaston of U.S.A. reports that this spider often eats the lepidopterans fixed on stretching boards by insect collectors. The sense of smell in this 'museum pest' plays an important role in locating the prey.

*Commensals and parasites.* Commensalistic and parasitic spiders are not so well known, although many studies have been recorded recently. Some small spiders feed on preys that fall on the webs of other spiders and live as commensals on the webs. The well-known ones are Conopisthine spiders that are found on the webs of many other spiders. Species of the genus Argyrodes also live on the webs of many other spiders. They steal preys from the host web by using certain methods or tricks. They are often termed as kleptoparasites. The small preys are actually captured by the host spider and kept in reserve in the web for future use. But these food packets are detached and stolen from the web by the kleptoparasites. *Uloborus* spiders have been recorded by the author to live as commensals on the web of social spider *Stegodyphus sarasinorum.* These commensals capture and feed on small preys that are generally overlooked and neglected by the host spiders.

*Silk-eaters.* Those spiders that wrap prey in silk (Fig. 5) feed not only on the prey but also digest the silk that covers it. However, males of some spiders feed on pure silk. As soon as they charge their palps with seminal fluid from the sperm web (a minute triangular web made

## Spiders vs beetle

IT has to eat and that has to avoid being eaten. This is perhaps what happens in nature where there is no dearth of enemies of an organism. There is a harsh life-and-death struggle. One of the most fascinating tricksters to catch their preys are the spiders : some make a web and wait for a prey to come and get entangled in the silken threads. Others wait silently and jump onto their prey at first sight. Nature is wonderful! It gives chance to every one to defend—through natural selection of course. Bombardier beetle (*Brachinus*), as it is commonly known, has evolved a typical chemical armoury to defend itself against its enemy, the spiders. The tip on the abdomen of this beetle is revolving, and housed there is a pair of glands containing an explosive mixture of phenols and oxygen. If ever the beetle is trapped into a web of the spider of the genus *Nephilia,* the spider immediately runs to feast. Feeling pressure of the jaws, the beetle directs its abdomen towards the enemy, takes aim and fires with a small but laudible bang. The spider finds itself in trouble; it gets busy in cleaning itself, and meanwhile the beetle escapes.

Being well-equipped with this sort of a chemical defence, *Brachinus* is less likely to have many enemies. If, however, there is anyone to fool this bettle, it is a spider of the genus *Argiope. Argiope* is very alert. It does not bite the beetle trapped into its web immediately. Instead, it first gently spins a silken cocoon around its prey so that the latter does not know of it. When the beetle is completely immobilized, *Argiope* bites and takes her full dinner.

Z.I.

by the male spider for depositing a drop of sperm on it that finally is absorbed by the palpal organs), they tear and collect it into a small bundle and pass it on to the mouth to serve as an additional source of nourishment. The spiders of the family *Dinopidae* also feed on silk balls made out of their torn webs that have been used for catching preys during the night.

The wrapping of the prey by many spiders is very intersting. The spider is capable of avoiding personal injury from the live prey and a lot of time is saved in subduing the prey that could be left safely in the web to tackle more victims that fall in the web.

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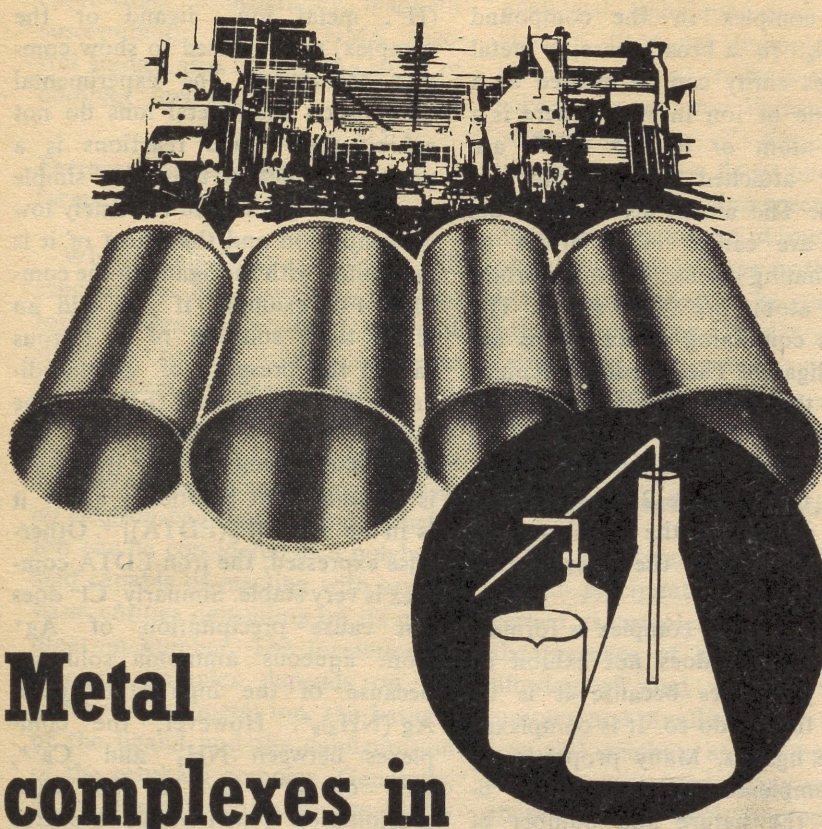
V.V. RAMA SASTRY



# Metal complexes in analytical chemistry and industry

**Metal complexes are gaining increasing importance in industry and analytical chemistry**

IMAGINE a world without metal complexes! It would be far beyond anybody's imagination. It would be a lifeless world, because the two important substances, chlorophyll and haemoglobin, vital for life processes, are metal complexes. By virtue of their nature, the metal complexes exhibit special properties. Chlorophyll, found in green leaves, is able to use solar energy to convert carbon dioxide and water into starch and oxygen. Similarly haemoglobin in blood is able to store, transfer and later release oxygen.

Metal complexes and their applications has been an attractive field of research for beginners as well as established scientists. This is clear from the fact that every year thousands of new metal complexes are added to the existing list.

**Origin and understanding of metal complexes**

Though the initial uses of the metal complexes were as dyes and pigments, the exact origin of these complexes is not clear. Alizarin dye and prussain blue are the two long known coloured complexes. Prussian blue, an artist's colour, was made accidentally when animal wastes and sodium carbonate were heated in an iron container. Alizarin dye was prepared from madder and clay. Alizarin dye, as we now know it, is a calcium-aluminium (ions present in clay) complex of hydroxy-anthraquinone(from madder), while prussian blue is a complex of ferric iron with potassium ferrocyanide.

The understanding of metal complexes goes back to 1798 when chemists started studying the reactions of metals with ammonia. Many metals interact with ammonia to give compounds which exhibit unusual valences (combining capacity) for the metal ions. For example, when spirits of ammonia are added to cupric chloride ($CuCl_2$) and the resulting contents evaporated, beautiful blue green crystals with a composition of $Cu(NH_3)_2Cl_2$

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are formed. Copper is divalent in $CuCl_2$ and it appears to be tetravalent in the new compound. What intrigued the early chemists was how ammonia molecules were held to copper when both the valences of this atom were already used up in the bonds with chlorine atoms. Similar is the case with the interaction product of ammonia with $CoCl_3$. This is a compound represented by $Co(NH_3)_6Cl_3$. Cobalt is a typical trivalent element, but in this compound it seems to exhibit nonavalence. Many other metals are found to exhibit such preposterous valences.

Later, Alfred Werner gave an explanation based on primary and secondary valences. According to him, after saturating their primary valences (e.g., chloride ions in the above two examples), metals can still display additional valence ($NH_3$ molecules). N.V. Sidgwic (1927) made an important advancement by extending the contributions of G.N. Lewis (1916) to the theories of bonding by extending them to metal complexes. The approach was extended by Linus Pauling in 1939 into the valence bond theory which could successfully explain many properties of complex compounds. Still, certain facts were not tenable by this theory. Towards the end of 1950's the electrostatic field theory (also known as crystal field theory) and the ligand field theory were revived by the early works of J.H. Van Vleck and H. Bethe. The molecular orbital theory was also being developed from 1935. Though in principle, this is the most exact theory, the other three theories are generally used for complex bonding, in view of the difficult calculations involved in it.

**Metal complexes and stability**

Compounds such as $Co(NH_3)_6Cl_3$ are called complexes. In fact, the cation $[Co(NH_3)_6]^{3+}$ is a complex. Similarly, the anion $[Pt(Cl)]_6^{2-}$ is a complex in the compound $K_2PtCl_6$. In a broad sense, a metal complex entity can be defined as a molecule or ion in which there is a metal atom or ion to which are closely attached other atoms or groups. The atoms attached to the metal are called donor atoms or coordinating atoms. Three important donor atoms are N, O and S. The groups containing donor atoms are called ligands. The coordination number of the metal defines the number of atoms or groups attached to the metal. The most common coordination numbers are 2, 4 and 6. The entity containing the metal and its ligands is called the coordination sphere.

When a metal complex is formed, the metal ion does not exhibit its usual properties because it is no longer free to do so. It is complexed by the ligands. Many properties of the complexes are due to the ligands, the nature and number of the donor atoms, and the charge on the ligand. The ligand can have one donor atom and be unidentate, or the ligand may have two donor atoms and be bidentate. When the ligand contains two or more donor atoms, the resulting metal complex is called a chelate because chelates are ring compounds. If the sum of the negative charges of the ligand is equal to the charge on the metal ion, the resulting complex is uncharged (neutral), otherwise it is either positively or negatively charged.

**How to discern complex formation**

As many ligands are either weak bases or acids, the formation of a metal complex from a metal ion $M^{n+}$ and an acidic ligand HA can be represented as

$$M^{n+} + nHA = MA^{n+} + nH^+$$

for the formation of the neutral complex. In general, any property of the system which is related to the concentration of one of the species involved in the complex formation ($H^+$, metal ion, ligand or the complex) may be used to show complex formation. The experimental observation that metal ions do not exhibit their usual reactions is a positive evidence that the simple metal ion is present in extremely low concentration and that most of it is associated with the ligand in the complex. For example, if you add an alkali to a solution of a ferrous salt in the presence of ethylenediamine tetraacetic acid (EDTA), the familiar green $Fe(OH)_2$ does not precipitate, because the free $Fe^{2+}$ is so small that practically all of it is in the form $[Fe(EDTA)]^{-2}$. Otherwise expressed, the iron-EDTA complex is very stable. Similarly, $Cl^-$ does not cause precipitation of $Ag^+$ from aqueous ammonia solutions because of the high stability of $Ag(NH_3)_2^+$. However, the complexes between $NH_3$ and $Ca^{2+}$, $2n^{2+}$ or $Al^{3+}$ give all the usual precipitation reactions of the free metal ions. This is because the complexes are not highly stable, which means that appreciable amounts of the simple metal ions are left uncomplexed by ligands in these complexes. The stability of a complex defines the extent to which the formation of the complex takes place.

Complex formation sometimes associates itself with the appearance of bright colours. When a drop of 1, 10- phenanthroline is added to ferrous iron, brilliant red colour develops because of the formation of the complex, ferroin. In some cases, coloured metal ions may lose their colour by the formation of colourless complexes. Colour may be a way of discerning complex formation. Isolation and characterisation of the complex is the best way to show complex formation. Changes in hydrogen ion concentration and conductivity measurements help identify complex formation in some cases. Other methods like optical activity, ion exchange absorption, oxidation-reduction potentials, kinetic rate expressions, polarography, magnetic susceptibility, IR and NMR spectral studies also help in the study of complex formation.

### Factors affecting complex formation

Why metals form complexes still remains to be answered satisfactorily. There are no hard and fast rules to predict when complexes would form. At least some of the factors can be considered. According to the Lewis theory, an acid is ane lectron-pair acceptor and a base, an electron-pair donor. Thus, a metal ion can be considered as a polybasic acid capable of reacting with several basic entities depending on its coordination number. The formation of a metal complex depends on the acidity of the metal ion, the basicity of the ligand and the configuration of the resultant complex. Generally, 5 or 6-membered rings are highly stable and hence the functional groups in the ligand must be so situated as to form stable rings. Complex formation is sometimes sterically hindered when bulky atoms or groups present close to the donor atom in the ligand do not allow it to approach the metal to form bond. For example, 1, 10-phenanthroline forms a chelate with $Fe^{2+}$ whereas neocuproine (the 2, 9 - dimethyl phenanthroline) does not form a complex.

### Metal complexes in analytical chemistry

Analysts are fortunate that complexing agents come to their rescue and help them finish otherwise difficult and time consuming analyses easily in a short time. Metal complexes have one or more of the following characteristics: low solubility product in aqueous medium, high stability, solubility in organic solvents, intense colour, etc. These characteristics form the basis for analytical techniques such as gravimetry, titrimetry (complexometry, photometry and redoximetry) and solvent extraction. Various instrumental methods of determination like polarography, flame photometry and atomic absorption spectrophotometry also make use of metal complexation at one stage or the other. Metal ions can be separated from solutions and can be estimated by means of electrogravimetry making use of complex formation.

### Gravimetry and complexation

The principle of gravimetry consists in precipitating the species concerned as completely as possible in the presence of a suitable reagent, filtering off and washing the precipitate and finally drying or igniting and weighing as a compound of known composition. Many complexes themselves are used as precipitating agents. For example, ferrocyanide ion $[Fe(CN)_6]^{4-}$ forms sparingly soluble salts with many metal ions including $2n^{2+}$ and $Cu^{2+}$. Similarly $[Co(NO_2)_6]^{3-}$ is useful for separating $K^+$ from $Na^+$ by precipitation. Hexachloroplatinum (IV) and $(AuCl_4)^-$ are convenient precipitants for organic amine salts. Dimethylglyoxime is an important complexing agent used for estimation of nickel. Precipitation is carried out in ammoniacal solution and the complex is weighed after drying at 110°C-120°C. The interference of iron, aluminium or bismuth is eliminated by the addition of a soluble citrate or tartrate which forms soluble complexes with these metals. This is called masking and is a very useful technique for suppressing interference. The advantage of metal complexes in gravimetry lies in the fact that the complexes usually have high molecular weights and hence increase the accuracy of the analysis.

### Titrimetry and complexation

Complexation forms the basis for several titrimetric methods of analysis, the important ones are complexometric, photometric and redox titrations.

*Complexometric titrations.* These involve the formation of a soluble, slightly dissociated complex, as in the titration of a solution of cyanide with silver nitrate ($2\ CN^- + Ag \leftrightarrows [Ag(CN)_2]^-$ or of chloride ion with mercuric nitrate solution. ($2Cl^- + Hg^{2+} \leftrightarrows [HgCl_2]$). Ethylenediamine tetraacetic acid (EDTA) is one of the most important reagents in complexometric analysis. This reagent can be used to determine most of the metal ions either alone or present in admixture by selecting suitable pH, metal ion indicator and masking agents. EDTA titrations can be classified into four groups: direct titrations, back titrations, substitution titrations and alkalimetric titrations.

*Photometric titrations.* These titrations make use of the linear dependence of colour intensity of the complex on its concentration. As the titration proceeds in a suitable assembly of apparatus, the colour of the species is measured at suitable wavelengths. The results, when plotted as optical density vs volume of titrant, give two straight lines intersecting at the end point.

*Redox titrations.* The redox potential $E$ of a system

$$\underset{\text{oxident}}{Ox} + \underset{\text{electrons}}{ne} \leftrightarrows \underset{\text{reductant}}{Re}$$

is given by $E = Eo + 0.0591/n \times \log [Ox]/[Re]$ at 30°C. $E$ is a measure of the oxidizing capacity of the system in question. The redox potential of a mixture of ferric and ferrous ions:

$$Fe^{3}+\ e^{+} \leftrightarrows Fe^{2+}$$

is given by $E = Eo + 0.0591 \log [Fe^{3+}]/[Fe^{2+}]$ at 30°C.
It is evident that the redox potential depends on the ratio of the ferric ions to ferrous ions. The value of $E$ can be increased or decreased by

changing this ratio. We know that ferric ions form complexes with fluoride and phosphoric acid. Addition of fluoride to a ferric salt decreases its oxidation potential and consequently its oxidizing capacity. In the presence of fluoride, ferric ion can no longer oxidise iodide to iodine and, in fact, this normal reaction is reversed and ferrous ions reduce iodine to iodide in presence of fluoride. Such a reversal of normal reactions is an important application of complex formation in redox titrations. Another important use of complex formation is the acceleration of an otherwise slow reaction. For example, the addition of phosphoric acid accelerates the reduction of molybdenum (VI) to molybdenum blue by a number of reducing agents. A third application of complex formation in redoximetry consists in the stabilization of unstable valence states, as exemplified by the stabilization of unstable Mn (III) with pyrophosphate during the oxidation of Mn (II) with potassium chlorate or bromate.

**Solvent extraction and complexation**

Solvent extraction is a versatile technique employed in analytical chemistry for the separation and determination of various species. The technique involves removal of a metal ion from an aqueous solution into an immiscible organic solvent as its metal complex. The water solubility of metal salt is because of the water molecules associated with the metal ions. When complex formation takes place, these water molecules are either wholly or partly replaced by the reagent molecules reducing the water solubility of the metal salt. The uncharged complexes so formed can be separated by organic solvents. Since the metal complexes are sufficiently coloured, determination of the metal ion s can be made by measuring the colour. A typical example is the determination of nickel as dimethylglyoxymate in chloroform by measuring the colour of the complex at a wavelength of 366 nm.

However, the colorimetric determination of a metal ion in a mixture of metals often suffers interference because the reagent may form coloured complexes with all the metals and carry them into the organic solvent. Such difficulties are eliminated by suitable choice of pH and masking agents. For example, in the determination of uranium as 8-hydroxyquinolinate many interfering agents like iron and aluminium are masked by EDTA as their water-soluble complexes.

**Miscellaneous applications**

A relatively recent application makes use of the rates of formation or decomposition of metal complexes for quantitative determinations. An example is the determination of $Ni^{2+}$ in the presence of $Cu^{2+}$. Both the ions form complexes with $\alpha$-amineoxime. On addition of EDTA to these complexes, the metal-EDTA complex forms rapidly in the case of $Cu^{2+}$, but slowly with $Ni^{2+}$. The absorption spectra of copper and nickel $\alpha$-amineoxime complexes overlap (as well as the two of EDTA) at most frequencies, but Cu-EDTA and Ni-$\alpha$-amineoxime do not overlap which enables determination of both Cu and Ni in a mixture.

The organic chemist uses complex compounds in many preparative reactions like Friedel-Crafts reaction, Grignard reaction and Sandmeyer reaction. In physical chemistry, complex compounds formed the basis for understanding the theories of bonding and kinetic behaviour, electrolytic behaviour, magnetic behaviour, etc. In biochemistry too, complexes are a subject of intensive study. Hemin and chlorophyll-a contain coordinated $Fe^{2+}$ and $Mg^{2+}$ respectively, while vitamin $B_{12}$ contains cobalt. The activity of many enzymes is traced to the metal ions present.

EDTA

THE ability of chelating agents to reduce the chemical activity of certain metal cations has found extensive application in many areas of science. The hexadentate (having six coordinating groups) chelating agent, ethylenediamine tetraacetic acid (EDTA), has found a wide commercial market. EDTA may be used in :

* Water softening, because of its ability to form stable chelates with Ca, Mg and Fe ions.
* Separation of rare earth ions.
* Leather tanning for clearing, stripping and removal of stains by forming complex with Ca, Cr and Fe ions.
* Medicinal preparations, as blood anticoagulent due to its property of complex formation with Ca.
* Prevention of colour distortion in metal dyes due to impurities (Fe, Cu, Ni, hardwater metal ions).
* Control of rancidity in soaps by reducing oxidative effect of transition metals.
* Improvement of flavour retention in carbonated beverages.
* Prevention of surface discolouration, stabilization of ascorbic acid (Vit. C) and removal of spray residues in fruits and vegetables.

**Complexes in chemical industry**

*As dyes and pigments.* An age old application of coordination compounds is as dyes and pigments as is evident from the accidental discovery of prussian blue and alizarin dye.

*As catalysts.* Coordination compounds are known to influence the course of polymerization so as to produce plastics with desirable properties including higher softening temperatures and greater strength.

*Ion control.* Often, it becomes necessary to control concentrations of the metal ions which cause undesired reactions. This can be achieved either by physical removal or by sequestration. In sequestration, the reactivity of the metal ions is suppressed without physically removing them. This is achieved by complexation. The Raschig synthesis of hydrazine involves interaction of hypochlorite with ammonia. The yield of hydrazine is however greatly reduced if copper ions are present because of metal-catalysed side reactions. EDTA suppresses the harmful effect of these metal ions through chelate formation. Another interesting example where the undesirable effect of large quantities of metal ions (particularly $Ca^{2+}$ ions) is suppressed is the conditioning of water by agents like EDTA. The chelated calcium ions do not precipitate with soap, EDTA is added to liquid soap for haze prevention; to hydrogen peroxide for prevention of catalytic decomposition, and to wines for prevention of turbidity. Calcium-EDTA complexes are also used in the treatment of lead poisoning.

Rigorous control of ion activity is also necessary in metal plating for obtaining smooth coherent plates. This is achieved by the addition of complexing agents; for example, cyanide ion is added in silver plating.

**Separation and purification of metals**

Many industrial processes of separation and purification of metals are based on complex formation. The alkylphosphoric acids are useful in the process of recovery of uranium from low grade materials. Certain metals like $Ce^{4+}$ and $Au^{3+}$ are easily extracted into ether from strong nitric acid solutions. Tributylphosphate is a useful complexing agent in the separation of zirconium and hafnium.

**Conclusion**

The importance of coordination complexes in laboratory as well as industry can be seen from the large consumption of the single versatile complexing agent, EDTA. Every year, millions of kilograms of this compound are utilised throughout the world. Metal complexes can be made to suit any purpose, provided the right type of complexing agent is selected. The utility of the metal complexes is limited only by the synthetist's ability to make a suitable organic reagent that is specific in respect of its particular use in the laboratory or industry.

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# SCIENCE SPECTRUM

## Communication via meteor trails

FREAK receptions of television signals from transmission stations at long distances are not uncommon. In fact, not long ago such receptions of transmissions from Philippines were reported by Madras TV viewers. This effect arises from what is known as ionospheric scattering.

Apart from reflection, the ionosphere can cause scattering of radiowaves because of minute inhomogeneities in refractive index. Also, the distribution of electrons even within a narrow altitude range is not uniform and quite frequently small regions, in which the electron density is larger than that in the surrounding atmosphere, exist. Such regions can scatter electromagnetic waves of very high frequency, as particles of dust, moisture, etc., do. If the dimensions of these regions with higher than average electron density are greater than the wavelength of the radio waves, there will be a tendency for preferred scattering in the forward dirction, i.e., in the direction in which the waves are travelling resulting in increasing the range of reception of the transmitted signal. Besides the inhomogeneities in the ionospheric electron density, meteors impinging on the terrestrial atmosphere produce 'meteor trails' of very high electron density that can cause scattering of radiowaves. It should be noted that ionospheric and meteor trail scattering occurs only in waves which are not normally reflected by the ionospheric layers (i.e., wavelengths less than 10 m).

Although the freak reception of television signals from long distances is of little value, the meteoric signals (scattered waves from meteor trails) received at distances of several hundred kilometer are found to be sufficiently numerous to support almost continuous communication. In fact, practical communication systems of VHF radio waves over distances of 1000 to 2000 kilometres have been developed at various places. Let us now know some details about these meteor trails and communication by meteor trail scattering.

Meteors as we know are celestial phenomena associated with a streak of light of very short duration. They are commonly known as shooting stars. The bright light associated with the meteor results from the heat generated when a particle of matter travelling at a high speed in space enters earth's atmosphere. Earlier it was thought that the heating of the atmosphere and the consequent production of visible light and ionization is caused due to compression of air in front of the fast moving meteor. However, the small dimensions of the meteoroid particles and the low density of air at meteoric heights (above 80 km) make this explanation unsatisfactory. The most commonly held view is that the individual molecules and atoms of the atmosphere bombard the surface of the meteoroid and their kinetic energy is converted into heat. The temperature of the solid is thereby raised to the point where its surface begins to vaporize. The vaporized meteoroid atoms move into surrounding atmosphere at about the same high velocity as the solid particles from which they originate, and collide with atoms and molecules of the air. In these collisions the directed kinetic energy is converted into random kinetic energy, i. e., into heat, and this heat produces both light and ionization. The resulting ionized region is capable of reflecting radio waves. The ionized gases form a trail behind the meteor. Every day millions of meteors hit the earth's atmosphere, producing ionized trails at 80-120 km altitude. It is observed that clearly discernible meteor trails are produced by particles weighing more than $10^{-5}$ gm and with a radius more than 0.008 cm each. The ionization in meteor trails is initially in the form of long, thin columns with electron density about $10^{10}$ electrons per cubic centimetre, having a diameter of about 10 cm. But these trails rapidly expand with the passage of time owing to molecular diffusion and forms large patches or clouds of dense ionization. Turbulent diffusion leads to a still further expansion and the convection cur-

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# C

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rents and wind twist the originally straight trail into curves. The aggregate effect of these ion clouds is confined within a narrow region (80-120 km) just below and partly overlapping the E layer of the ionosphere.

A radio-wave incident on these ionized columns gets reflected from the trail during the period in which there is sufficient ionization. The scattered intensity depends on the diameter of the ionized column—whether it is large or small compared with the wavelength of the incident wave, if we assume the trail as having a shape of a long cylinder of intense ionization. If the radius of the trail is small, the scattered wave has the same phase as that of the incident wave. The duration of the reception of the scattered signal depends on the life of the meteor trail. For a given meteor shower of homogeneous velocity the duration is found to vary between 0.1 sec. to 100 sec.

An important thing to be noted in this type of propagation is that the reflection of signals from 'nearly formed' trails is highly directional and looks more like 'specular reflection' than scattering. That is why more often people prefer to call it reflection rather than scattering. The waves incident on meteor trails are mainly reflected in the direction for which the angle of reflection equals the angle of incidence. Therefore, out of many meteor trails formed, only those suitably oriented may be used for communication.

As meteor trails generally live for only 0.1 to 100 sec. and the trails capable of reflecting signals in the desired direction do not occur continuously, special techniques were devised—first to determine when suitable trails are available and, second, to transmit intelligence. For this, unmodulated carrier wave is transmitted continuously from a place. The reception of this carrier at a wanted distant place indicates that a suitable path has been established. The output of the receiver at this situation triggers a transmitter and the information to be transmitted travels to the first point via the same trail. In the same way, signals from the first station can be transmitted to the second, thus completing the communication link between the two stations. Transmission of intelligence only while a path exists is accomplished by storing the information in memory devices, say a magnetic tape. When the link is established, the tape is run at a high speed making the signal strength above a predetermined level.

As already mentioned, everyday millions of meteors come into the earth's atmosphere producing ionized trails and it is possible to have a fairly continuous communication link. The meteor-scatter links are very useful for point-to-point communication of messages, mainly for defence communications. Because the transmission is highly directional, with proper design and orientation of the aerial system it is possible to establish communication link between two points and the signals cannot be received at any other place. Moreover, the meteor-scatter links operate on VHF (very high frequency—above 30 MHz) band well above the maximum usable frequency for ordinary high frequency propagation via the ionosphere and are much less vulnerable to sudden ionospheric disturbances (SIDs). Another important advantage is that these systems work well with low power transmitters, usually less than 500 watts and simpler aerial systems.

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# Random numbers

We had several interesting articles in the earlier issues of *S.R.* on Positional Number System (*S.R.*, Aug. 1975), Friendly Numbers (*S.R.*, Nov. 1975), The Waring Conjecture (*S.R.*, Jan. 1975), etc., and in this article we will see another type of numbers called Random Numbers. Number arithmetic has always been a fascinating field of study and Indian mathematicians like Ramanujam, Leelavathy and others are famous names in this field. Playing with numbers is a fruitful game indeed!

**What is randomness?**

We associate randomness with a madman's walk or drunkard's walk and so it appears that randomness has no use for sane persons. But, surprisingly, we find that many events in everyday life are random processes, say, the throwing of dice, the tossing of coins, the shuffling of cards, the arrival of cars at a junction, the Q length in a service counter, the molecular motion, etc. So a scientific study of the random phenomena becomes important for finding the method in the so-called madness or randomness and predicting the probability of the future course of events. It is found that random events can be simulated by the use of random numbers and hence the random number generation has become a highly sophisticated mathematical game. Not only the random numbers are useful in the simulation problems, but also in solving certain types of mathematical equations using what are known as Monte Carlo methods.

**What are random numbers?**

Strictly speaking, random numbers are best generated by picking numbers from a hat: But this method has the disadvantage of not being reproducible, though the numbers so generated have all the virtues of randomness. Philosophical models are rarely practical. Practical models use well defined reproducible methods for generating random numbers. In fact, the numbers are not really random, since the sequence is completely determined in advance and so they are called pseudo random numbers; but they work well in simulation and other applications —that is, after all, what matters to us in real life. The pseudo random numbers satisfy certain statistical properties and these characteristics are taken as the standard for finding out whether a particular formula gives a generous supply of random numbers for practical applications.

The following are some of the methods employed for generating random numbers :

*Seed-multiplier method.* In this method any two numbers are selected at random. One is called the seed and the other is called the multiplier. The procedure for generating four digit random numbers is given below :

Let the seed be 2786 and the multiplier be 6345

Product : $2786 \times 6345 = 17\ 6775\ 70$

Then the random number is 6775, the seed is 1767 and the multiplier is 7570

Product : $1767 \times 7570 = 13\ \ 3761\ 90$

The random number is 3761, the seed is 1337 and the multiplier is 6190.

The above procedure can be continued until the required number of random numbers is generated.

*Mid square method.* In this method a number is taken and squared. The middle portion is taken as the next random number. This number is again squared and the middle portion is taken as the next random number, and this procedure is repeated until the required number of random numbers is obtained.

Let the first random number be 5765

Square : $5765 \times 5765 = 33\ 2352\ 25$

The next random number is 2352

Square : $2352 \times 2352 = 05\ 5319\ 04$

The next random number is 5319 and so on.

*Power residue method.* The most widely used method for generating psuedo random numbers is the power residue method or the modular multiplication method. This method has the virtue of generating numbers with long periods and good statistical properties. Generally, the number of random numbers which can be generated by any method is limited by periodicity and degeneracy. Periodicity can be defined as the length of random numbers beyond which the same sequence of numbers repeats. Degeneracy is the process whereby the generation of random numbers will stop abruptly or the same number will repeat over and over again.

For example, consider the mid square method when the first number $X_1$ is taken as 1000.

Then $1000 \times 1000 = 01\ \ 0000\ \ 00$

The next number is 0000 and so the process terminates abruptly.

Suppose the first number is taken as 0100

Then $0100 \times 0100 = 00\ 0100\ 00$

The next random number is also 0100; that is, the same number repeats itself endlessly. The above drawback can be controlled to some extent in the power residue method. The plan of this method is given by the formula

$$X_n = Cx_{n-1} \pmod N \quad .. \quad (1)$$

where C and N are two constant integers. The notation $y = 20 \pmod 7$ means that y is the remainder or the residue when the number 20 is divided by 7. In this example the value of y is 6. Suppose in the number generator formula (1) we put $C = 5$, $N = 32$ and $X_0 = 1$. By repeated application of the formula we get the sequence as

$X_1 = 5 \times 1 \pmod{32} = 5$

$X_2 = 5 \times 5 \pmod{32} = 25$

$X_3 = 5 \times 5 \times 5 \pmod{32} = 29$

.........................

.........................

The first 12 numbers of the sequence are

5, 25, 29, 17, 21, 9, 13, 1, 5, 25, 29, 17.

We observe that the sequence repeats itself after eight numbers, which is obviously too small a period for the sequence to be of much practical use. We will now see how we can generate random numbers of longer periods.

Usually, the length of the period depends on the initial values of N, C and $X_0$. The length of the period is found to increase with N and so we would like to choose as large a value for N as possible. It must be mentioned at this juncture that it is extremely difficult to generate a large supply of random numbers by manual calculations and so one has to resort to computer methods for a copious supply of pseudo random numbers. It can be shown that the longest period attainable by this method is N/4, where N is a power of 2. So the choice of N is decided by the capacity of the human or the computer that we use for the generation.

Let us now see how the period is affected by the initial value of $X_0$. In the above example, if we use $X_0 = 2$, we get the sequence as

2, 10, 18, 26, 2, 10, 18, 26, 2....

which has a period of only 4 numbers. It is seen that for a given value of C and N, any other choice of $X_0$ yields the same period if $X_0$ is odd and half this period if $X_0$ is even. This means that the initial value of $X_0$ should be odd.

It can be shown that the longest period is obtained when C has the form $C = 8n \pm 3$, when n is any +ve integer and so, in summary, we can state the conditions for obtaining pseudo random numbers possessing the longest period as follows :

1. N should be as large as possible; the limitation being the capacity of the human or the computer usedfor generation.
2. $C = 8n \pm 3$, where n is any +ve integer.
3. $X_0$ is any odd integer.
4. In order that the sequence may have good statistical properties it is recommended that the value of c be chosen close to $\sqrt{N}$ although theperiod is not thereby lengthened.

**Test of randomness**

Having obtained a supply of ran dom numbers we would like to test how random they are. We produce random numbers with the obvious intention of being impartial to any particular number or any particular region or range of numbers. (In fact, it is our social objective also to provide equality of opportunity to all, unbiased by considerations of caste, creed, region or religion, etc.). If we plot the number on a scale, they must show a rather uniform distribution without any obvious preference to any part of the scale. In other words, the number of random numbers or the frequency of random numbers in the region say, 1000 to 2000, must not be much different from the frequency in another range, say, 7000 to 8000. This is scientifically found out by calculating the standard deviation of the frequency and finding out whether that lies within the prescribed confidence limits. Of course, this is not the only test, for we can see that if the same numbers had been generated in a monotonically increasing or decreasing sequence, we would still get the same standard deviation for the frequency and so the standard deviation test alone would be misleading. So we have to make what is called a 'frequency run test'. A run of length 'k' consists of a string of k consecutive numbers, which is either monotonically increasing or monotonically decreasing. The test involves counting the occurrence of runs of different lengths appearing in a given sequence and comparing with the expected results by what is called the chi squared test. Modern computers intended for simulation applications are already provided with random number generation subroutines and so one has only to call SUBROUTINE RAND to get a supply of random numbers of desired characteristics.

**Use of random numbers**

Customers arrive in a random fashion at a service point, say a hair cutting saloon and if a previous customer is being served, they form a waiting line or queue. One may be interested to find how best the service point can be kept busy for maximum time and whether the rate of customer arrivals warrants another service point to be opened and so on. It is possible to stimulate the random arrivals of customers by using random numbers and in fact any random process which takes place in time can be simulated by using random numbers. Suppose 20 customers arrive on an average per hour for a service which takes 10 minutes to complete. The probability of customer arrival per minute is 1/3. To simulate the customer arrivals we consider a random number table of 5 digits in the interval 0 to 1 as shown below:

| | | |
|---|---|---|
| .03474 | .37386 | .97742 |
| .63564 | .16227 | .79439 |
| .57608 | .60244 | .18180 |
| .46762 | .16766 | .25766 |
| .84427 | .75331 | .63016 |
| .79246 | .26623 | .89775 |
| .12568 | .59926 | .55595 |
| .43785 | .33211 | .23429 |
| .23424 | .06474 | .52362 |

We choose a small interval, say 1 minute to correspond to every random number. We find that the first random number is .03474. Since it is less than the probability of the customer arrival which is 1/3, we assume that a customer has arrived in the first minute. The second number is .37386. Since it is greater than 1/3, we assume that a customer has not arrived in the second minute. Thus the process of customer arrivals can be simulated for any length of time, 3 or 4 hours. During this interval, the number of customers served, and the number of people in the waiting line can be found. If the queue length is continuously increasing, we can simulate the process by adding one more service counter and see how the queue length changes. It is easier to alter the different parameters like customer arrrival rate, service time, number of service points, etc., in a simulation model, than to make a change in the actual physical process itself. In summary, we can say that random numbers serve very useful purpose in the simulation of all random processes.

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# Halogen lamps

ELECTRIC lighting has assumed a significant importance in our everyday life. Good and efficient lighting creates a warm and cheerful atmosphere. It has added a new dimension to the outlook, style and comfort of human life. We can no longer do without it. Every room of a building, laboratory, industry, auditorium, studio or sports ground requires illumination to avoid unnecessary strain on our eyes. Streets and roads also need proper illumination.

In India, energy used for lighting is approximately 2% of the total consumption of electric energy. However, in cities like Delhi, Bombay, Calcutta, the percentage consumption of electrical energy for domestic lights and fans is about 75% of the total domestic consumption and out of this, 60% is used for lighting only At present we have light sources which are almost 20 times more efficient than the initially discovered incandescent lamps. However, a fairly recent development in this field has been the halogen lamps which came into production in the sixties.

We know how an ordinary incandescent lamp works (*S.R.*, June 1976). An electric lamp is based on the principle of heating effect of current. When electric current is passed through a filament of an electric lamp it gets heated and emits light. The first electric lamp, invented by Edison in 1878 consisted of carbon filament enclosed in an evacuated glass bulb. But the luminous flux (light output) from this lamp was very small, nearly 3 lumen/watt only. Lumen is the unit of luminous flux or light emitted per second within a unit solid angle by the light source having a uniform intensity of 1 C.P. (candle power) so that 1 C.P. $= 4\pi$ lumens.

The efficient design of an incandescent lamp of reliable quality centres on obtaining a high temperature at the filament without sufficient loss of heat or disintegration of filament. In 1909, Coolidge introduced tungsten metal filament in a vacuum glass bulb. The light output of about 8 lumen/watt could be obtained from this lamp. Due to very high melting point, nearly 3400°C, the tungsten filament can withstand sufficiently high temperature of about 3000°C without melting. In an evacuated lamp, however, the tungsten filament gradually and slowly begins to vaporise or disintegrate at about 2000°C resulting in blackening on inside of the bulb. The filament becomes thin. Also, it is not uniformly vaporized over its entire surface and so some weak spots are formed through which it may finally burn off. This reduces the life of the bulb.

Later in 1913, Langmuir introduced the coiled-coil filament type inert gas-filled lamp (initially with a single coil but later a double coil tungsten wire) by filling the evacuated glass bulb with a gaseous mixture, generally of nitrogen and argon at a very low pressure. The vaporized tungsten molecules strike the molecules of the filled rare gas and return back partially to the filament. In this way, the rate of vaporisation could be retarded and reduced considerably. Also, the filament temperature could be further increased thereby increasing light output with its life still retained. But some of the tungsten molecules still get deposited on inside the bulb, blacken it and reduce the luminous flux.

The modern coiled, gas filled lamps at the running colour temperature of about 2700K have the light source efficacy (formerly, called light-source efficiency) of about 22 lumen/watt with an average life of about 1000 hours for general service. Although at its melting point, tungsten can emit luminous flux of 52 lumen/watt but due to physical and practical limitations efficacy of 22-27 lumen/watt only can be obtained. In India, however, such lamps of light efficacy ranging from 10-18 lumen/watt at colour temperature of 2700 K and average life of 1000 hours have been designed. It may be noted that the higher the filament temperature and colour temperature, the greater is the light produced. Hence higher the light efficacy (lumen/watt), brighter (whiter) the light.

In halogen lamps, the vaporisation of the tungsten filament as well as the blackening of the bulb wall are reduced considerably by adding a minute quantity of halogen such as bromine or iodine to the gaseous mixture in the bulb. Here the free tungsten molecules which would otherwise be deposited on inside the bulb wall readily combine with the halogen by forming a volatile compound at the wall temperature lower than filament temperature. The volatile compound so formed gets decomposed again in the space around the filament so that the vaporised tungsten molecules get deposited on filament itself. The free halogen molecules recombine with tungsten molecules at the bulb wall and so a regenerative cycle is created inside the lamp. Halogen helps in bringing the vaporised tungsten molecules back to the filament without allowing them to be deposited on the bulb wall. The bulb becomes clear. Additionally, the bulb can be made quite tough and strong by reducing its size so that high pressure gas can be easily filled to reduce rate of vaporisation of the filament. Since the filament and bulb wall are quite close enough, the bulb is made of quartz glass which has a very high melting point. Therefore, the luminous flux and so the light efficacy of the lamp can be increased considerably with practically no light loss and the life of filament still retained. Tungsten filament halogen lamps made in India have light efficacy of about 22 lumen/watt at colour temperature of 3200K with an average life of 2000 hours.

### Applications and special uses

The prospects of possible applications of halogen lamps in various fields are interesting. These areas include lighting applications such as indoor lighting (commercial, industrial and home-lighting) and outdoor lighting (street lighting and flood lighting), reprographics and heating engineering, etc. The halogen lamps may be used in general service lighting for light signalling, railways, sports grounds, swimming pools, parks, halls, auditoria, head-lights of automobiles and locomotives, light-houses, operating theatres, air fields and factories. They can also be used for efficient flood lighting of buildings, monuments and fountains where accurate beam control is required. For such applications, halogen lamps having very high luminous flux of approximately 10,000 lumens for a 500 W lamp upto about 250,000 lumens for 10 KW lamp have been developed in India.

Infra-red quartz halogen lamps may be used for drying paints, manufacturing safety glass, producing sanitary-ware or plastic mattings. They have also helped in designing heating ovens which are quite compact in size, light in weight and simple to operate. Special tubular halogen lamps also make rapid copying possible due to high luminous flux at a sufficiently high colour temperature. Miniature quartz halogen lamps for the purpose of slides and picture projection can be used in smaller and portable projectors. Special halogen studio flashlight lamps at colour temperature nearly 3200K are quite suitable for shooting colour film and TV pictures. Special types of halogen lamps have also been developed for rough service applications as showcase lamps, sign lamps, spotlights, insect control lamps and for severe vibration applications.

These days halogen lamps are also being used as photographic lamps, in medical (surgical and dental) instruments and as a heat source for soldering. They can also be used for the interior lighting of aircraft and for the illumination of scoreboards. In fact, the development and use of the halogen lamps has opened up a wide variety of possible applications in various disciplines. More valuable and interesting applications may be explored in near future.

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## Chemicals in war

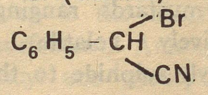
CHEMICALS can be used against any enemy to reduce his military effectiveness. Such chemicals can be incendiary, anti-crop weapons or toxic. Most weapons used to-day are chemicals. The explosion of T.N.T. (Trinitrotoluene) is a chemical reaction and so is the combustion of napalm. By chemical weapons, we mean those chemical agents which are based on the toxic properties of chemicals rather than on the energetics of their interaction.

The chemical agents used for chemical warfare can be broadly classified under the following heads depending upon the effect caused by them : (a) vomiting gases and lachrymators, (b) chocking gases, (c) nettle gases, (d) vesicants, (e) nerve gases or G-agents, and (f) incapacitating agents.

In the training manuals, vomiting gases and lachrymators are classified as riot control or harassing agents. They are irritant and are lethal only in very high concentrations. A famous example is CS (ortho-chloro-benzal malononitrile). Its effects are extreme burning sensation of the eyes and copious flow of tears, coughing, difficult breathing and chest tightness, nausea and vomiting. CS is more effective than the older agent CN (chloro-acetophenone) in that it supplements the latter's lachrymatory action with a more severe skin irritation and is more stable to store.

The agent known as CNS is a pre-war formulation of CN. It contains chloroacetophenone and vomiting agent chloropicrin dissolved in chloroform. A lengthy exposure to these agents is exceedingly unpleasant and painful. Soldiers are driven mad by the pain. Other important chemicals of this class are (i) CA (camite) and (ii) DM (adamsite).

CA(Camite)



DM (Adamsite)

Camite is a pinkish to brown oily liquid. It produces burning sensation in mucous membranes, headache, severe eye irritation and lachrymatory effect. Adamsite is in the form of canary yellow to brownish green crystals and produces headache, sneezing, coughing, chest pains and vomiting.

### Lethal agents

Choking gases or lethal agents are those which act by irritating the lower reaches of the breathing apparatus. Far from being merely harassing, their irritancy is sufficient to destroy the more delicate membranes of the lungs or respiratory passages. Lethal agents are classical agents of chemical warfare. They include chlorine, phosgene (CG), prussic acid (AC), sesquimustard (Q), and disulphur decafluoride. They are unlikely to be used in modern chemical wars because their initial irritancy or smell immediately warns of their presence.

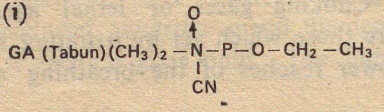
The nettle gases are primary skin irritants but more painful than those discussed above. A typical nettle gas is dichloro formoxime. At higher concentrations it blisters skin and penetrates into the blood circulation. There is probably no tactical need at present for nettle gases. Lethal agents must nowadays be imperceptible and therefore non-irritating, while riot control agents must be non-lethal.

Vesicants injure body tissues which they come in contact with. Their principal targets are skin and eyes which burn and blister. There are two classes of vesicants; first, arsenicals and second, mustards. The arsenicals, like various dichloroarsines, have sharp, irritating odours and cause immediate eye pains. Mustards have no smell and cause no initial pain. There are several different mustards ranging from comparatively volatile bis (β-chloroethyl) sulphide to the highly persistent α, bis (β-chloroethyl thio) alkanes.

Nerve gases or G-agents were developed by Germans shortly before and during World War II. They are quick killers with tremendous potency. Some, like Tabun persist in the field whereas others like Sarin do not. Of the better known G-agents, Tabun is about half as toxic as Sarin and Soman about twice as toxic.

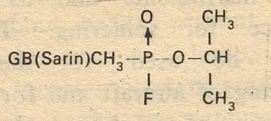
Some common nerve gases are:

(i)



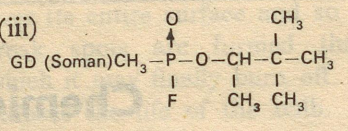
The colour of the liquid ranges from colourless to dark brown. Either it has no smell or smells fruity. It affects eye's pupil and shortens eyeball.

(ii)



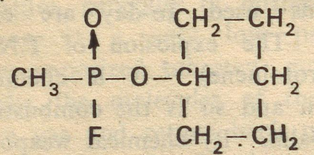
It is a colourless liquid and produces chest tightness and difficulty in breathing.

(iii)



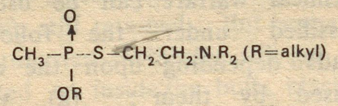
This liquid has smell slightly fruity to camphor-like. The symptoms of intoxication are nausea, vomiting, jerking, confusion, coma and convulsion.

(iv) GF (CMPF)



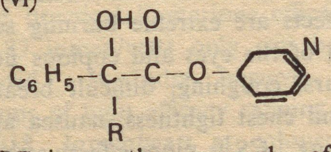
It is a liquid. Its effects are drooling, sweating, nausea, vomiting, staggering, headache, confusion and coma.

(v)



In the physical state this compound is liquid. Incapacitating agents put the enemy out of action for several hours without permanently harming him, preferably in such a way that he needs no medical treatment. These agents are paralysants (denying movement), hypotensives (causing fainting), laxatives, and so on.

(vi)



BZ is another example of this class. It is a solid that slows physical and mental activity and produces giddiness, hallucination and disorientation.

## Napalm

Napalm is gelled petrol. The name is derived from the first syllables of naphthenate and palmitate, the two fatty acids. Recently the term has been applied to a gel consisting of petrol, benzene and polystyrene which is also called Napalm B.

When mixed with a thickener, petrol changes from a thin volatile liquid into a tough, stable and sticky gel. Raw petrol is useless as an incendiary weapon. Napalm is ideally suited for this purpose.

Its adhesiveness, prolonged burning time and high burning temperature cause burns. Kidney failure may be another serious complication. In contrast to many modern weapons, napalm is produced from cheap, common ingredients and can be delivered through simple devices.

## Defence

For defence against chemical agents, the toxic agent is chemically decomposed before it can enter the body. Ointments containing reactive chemicals should be smeared over the skin before an attack. There are powders for dusting on the contaminated skin after an attack. Clothings are impregnated with reactive chemicals. For collective protection, anti-gas squads with chemicals and spraying apparatus are used to destroy toxic agents deposited on the terrain.

Medical defence or prophylaxis involves the destruction of the toxic agent within the body before it can exert its toxic effect, or the reversal of its biochemical effect, or the biochemical protection of susceptible sites within the body.

While it is true that impermeable clothes have been developed and indeed supplied to soldiers as a standard equipment, the best gas alarms available can give no more than a few seconds warning.

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# Surfactants the cleansing agents

THE problem of making things clean is of diverse nature. It ranges from washing hands with a toilet soap to removing heavy grease from roads and buildings, removing milk stains and egg residues from glass bottles and crockery, and washing off blood stains from surgeon's overalls. That is why a variety of cleansing formulations are available in the market to meet specific requirements. For example, milk stains on glassware can be easily removed by strongly alkaline solutions like sodium hydroxide or sodium silicate. Special chemicals, called tensides, become the agents of choice for dealing with oils, greases and finely divided particulate matter.

## Use in industry

In many industries cleansing operations are a necessary part of the manufacture. In textile manufacturing, conversion of raw fibre into finished fabric involves much wetting and cleaning. Similarly, in metal finishing industries, thorough cleaning is of utmost importance. Metal articles that are to be plated or painted must be freed of all surface dirt for uniform and durable coatings. The food processing industry is yet another example where cleanliness plays an essential role. Fruits, vegetables, eggs and other foods have to be cleaned before packing.

## Surfactants

The role of a surfactant is to promote emulsification and dissolution of oily and greasy matter from the surface. The surfactant wets particulate matter so that, upon application of mechanical energy as in a washing machine or by hand-scrubbing, the dirt is removed easily. The dirt removing capacity is substantially enhanced by the presence of builders. Builders are materials in synthetic detergents which chelate polyvalent metal ions present in cleansing solution. The most commonly used builders are the condensed polyphosphates, particularly pentasodium tripolyphosphate (STP), and to a lesser extent tetrasodium pyrophosphate.

A surfactant may be broadly defined as a substance that can reduce the surface tension in water solutions or which can reduce the interfacial tension between two liquids, or between a liquid and a solid. It is not easy to count the number of surfactants in current use. However, all surfactants have the same structure (Fig.1). They are composed of a long hydrocarbon chain which is oil-soluble but water-insoluble (hydrophobic), and a terminal water-soluble but oil-insoluble (hydrophilic) part.

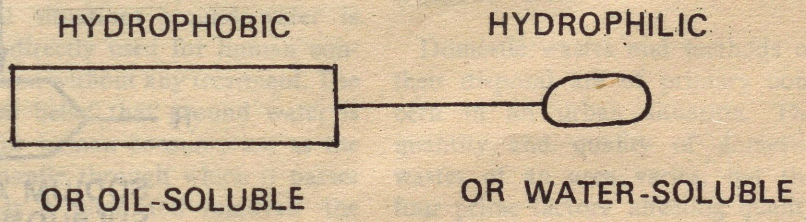



Fig. 1

By nature, surfactants concentrate at the interface of the soil-water system with the hydrophobic part oriented towards the soil (Fig. 2). As a result, a marked reduction in surface tension occurs which promotes improved penetration, wettability or oil emulsification. Surfactants work at very low concentration and, in fact, fabric washing is carried out with an aqueous solution containing about 0.03 per cent by weight of surfactant.

## Classification

Surfactants are classified into four groups based on the electrical charge present on surfactant molecules in solution. Anionic surfactants have a negative ion as their polar part while cationics have a positive ion. Non-ionics have no charge while ampholytics have either a negative or a positive charge depending on the pH of the solution.

*Anionic surfactants.* They are the least expensive ones and form the largest group of surfactants (70%). Soap is the oldest known anionic surfactant. Amongst anionics, dodecyl and tridecyl benzene sulphonates, allyl sulphates of $C_{12}$-$C_{14}$ chain length (coconut oil origin) alkyl sulphates of $C_{16}$-$C_{18}$ chain length (tallow source), and the alkyl ether sulphates are most popular.

The hydrophilic part of anionics is either sulphonate, sulphate, phosphate or carboxylate. Sulphates and

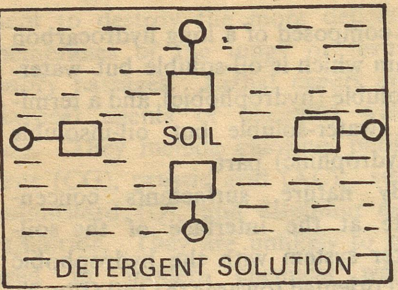
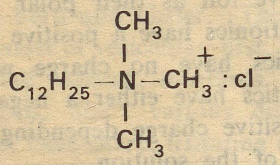



Fig. 2.

sulphonates are produced by reaction between the base hydrocarbon and sulphuric acid, 10%—30% oleum, $SO_3$ in a stabilized liquid form or chlorosulphonic acid under controlled conditions. The reactions taking place may be exemplified by the following sulphonation reaction (Fig. 3).

### Cationic surfactants

They constitute only about 4% of the total surfactant production, Salts of long chain amines and

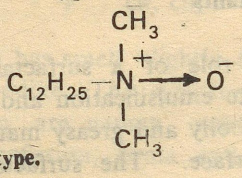


quarternary ammonium compounds are the common cationics. Trimethyl dodecyl ammonium chloride above carries a positive charge on hydrophobic part and hence is attracted to negative surfaces such as human hair and cellulose.

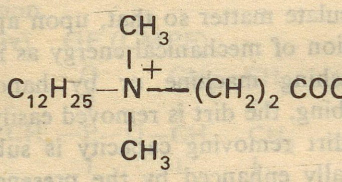
### Non-ionic surfactants

The next most important class of surface-active agents is non-ionics. Non-ionics do not ionize in solution; Their activity depends on their structure. Hydroxyl, amide, ether and ester groups provide them a hydrophilic character. Non-ionics have an advantage over anionics in that they do not easily precipitate in the presence of calcium and magnesium ions.

*Ampholytics.* Ampholytics contain both anionic and cationic groups. They can be semipolar or Zwitter-ionic type.



Semipolar type.



Zwitter-ionic type.

### Applications of surfactants

*Soaps and detergents.* Soaps and detergents industry is the bulk consumer of surfactants. The development of synthetic surfactants is the most remarkable innovation that has occurred in soap and detergents industry. Synthetic surfactants have outperformed traditional soaps which were in vogue with reasonable effectiveness upto the late 1920's. However, the latter suffered from decided disadvantages like their poor performance in hard water. From 1930's onward chemists came out with thousands of new surface active agents with improved performance. As a result, the industry today buys most of its raw materials from the chemical and petrochemical industries rather than exclusively from agriculturally-based industries as it did in the past.

Soaps are fatty acid salts that can exhibit surface-active properties. They are made up of natural oils and fats (agricultural origin). Synthetic detergents, or syndets in short, are now made from synthetic organic compounds. Soap forms a curdy insoluble precipitate with hard water and hence its inability as a cleansing agent. Synthetic surfactants could replace soap particularly in case of heavy duty cleansing because the former do not form curd. However, soaps continue to be popular for mild cleansing and particularly for personal care.

Synthetic surfactants for cleansing applications are usually marketed as a mixture with builders such as sodium tripolyphospate, and diluents such as sodium sulphate. Household detergents may also contain various additives such as sodium carboxymethyl cellulose to prevent soil redeposition, optical

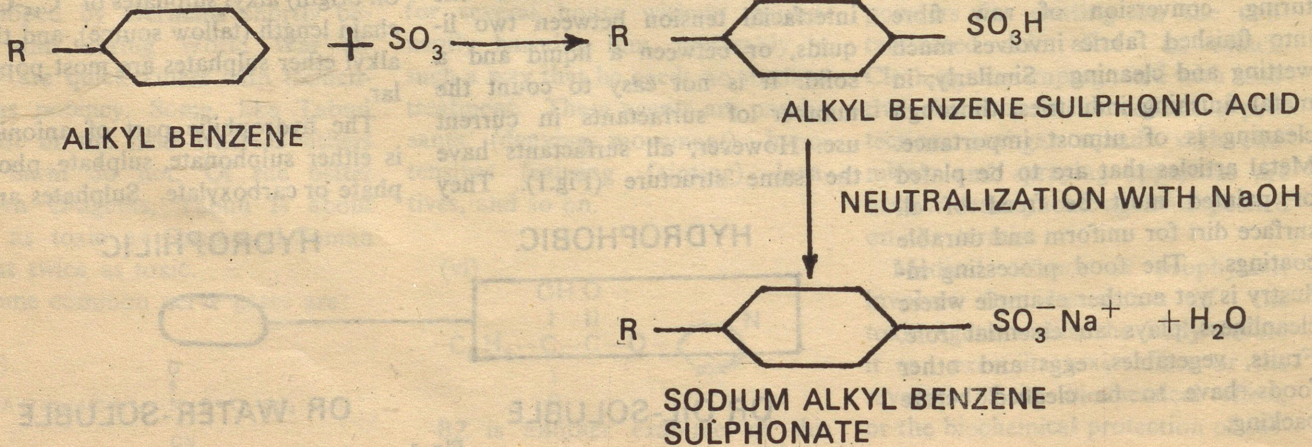



Fig. 3

brighteners and enzymes to reduce stains. As a result of successful formulation of synthetic surfactants into cleansing products, inedible fats, which were bought mainly by soap manufacturers earlier, are now used in animal feeds, special chemicals and lubricants.

Alkaline hypochlorites and soap-phenol or soap-pine oil mixtures were the only materials used in sanitation and disinfection before the development of synthetic surfactants. In 1935, chemists found that quarternary ammonium surfactants were highly effective against many of the common infectious bacteria and their use as germicides has since grown steadily.

**Non-cleansing uses**

In general, surfactants are useful wherever interfaces between different phases are to be modified. They find many non-cleansing uses of which wetting and emulsifying are important. When finely divided solids are stirred into a liquid medium, they tend to agglomerate into clumps and settle out. Inks, paints, ointments and cosmetic preparations are all dispersions of solids in liquids and for their proper functioning they should be stable. Manufacturers, since antiquity, have used a number of organic substances like gums, resins and tannins for obtaining proper dispersions. Modern surfactants find extensive use in emulsifying insecticides, fungicides and herbicides for easy application in dusts, wettable powders and sprays. Shortenings, cake mixes, salad dressings and various other emulsion preparations benefit from the presence of surfactants in their processing. Surfactants find place in petroleum industry for adjusting the viscosity of the drilling muds and in mining industry as conditioners and collectors for ore floatation.

*Water conservation.* In hot countries, loss of water from lakes because of evaporation is of serious social and economic concern. Cetyl alcohol was commercially exploited in Australia to prevent water loss in lakes as a result of a unimolecular surface-layer formed by the surfactant.

**Environmental pollution control**

There is a lot of concern in recent years about environmental pollution. Steps have been taken to produce materials that bacteria can biodegrade into innocuous end-products. Soaps and many synthetic surfactants (those having linear hydrocarbon nonpolar groups) are biodegradable. Unfortunately, the first alkyl benzene sulphonate household surfactants were non-biodegradable and the problem became serious by the late 1950's. As a result, the industry had to change to the biodegradable varieties of surfactants.

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# Ground water contamination

THE accelerated pace of development has increased demand on our water resources. In areas where ground water is available, the increased demand is essentially met from this resource, particularly, for municipal supplies. Yet, the very uses for which water is utilized, viz., human needs, industry and agriculture, are adding contaminants to ground water reservoirs at an alarming rate. Implications of ground water contamination are not fully realised. It is generally accepted that ground water contamination is "irreversible", i.e., once it is contaminated, it is difficult to restore the original water quality of the aquifer over a short time span. It is therefore desirable to prevent ground water contamination. The matter assumes significant importance when it is realised that in several situations ground water is being directly used for human consumption without any treatment. The general belief that ground water is safe for human consumption as the soil mantle through which it passes acts as a filter and removes the harmful substances is not always true.

**Contamination possibilities**

Ground water contamination can occur from several sources. They are industrial wastes, solid waste disposal sites, waste water treatment lagoons, agricultural areas, mine spills, septic tank tile fields, etc. The type of contaminants added will depend upon each particular situation that is considered. Currently, there are no generally accepted limits to contaminants in ground water. The purpose for which the ground water is used dictates the allowable limits of contaminants.

Fig. 1, depicts potential sources of ground water contamination.

**Domestic wastes**

Domestic wastes and methods of their disposal are of primary concern in an urban situation. The quantity and quality of domestic wastes of an area varies, but the four prime factors affecting quality

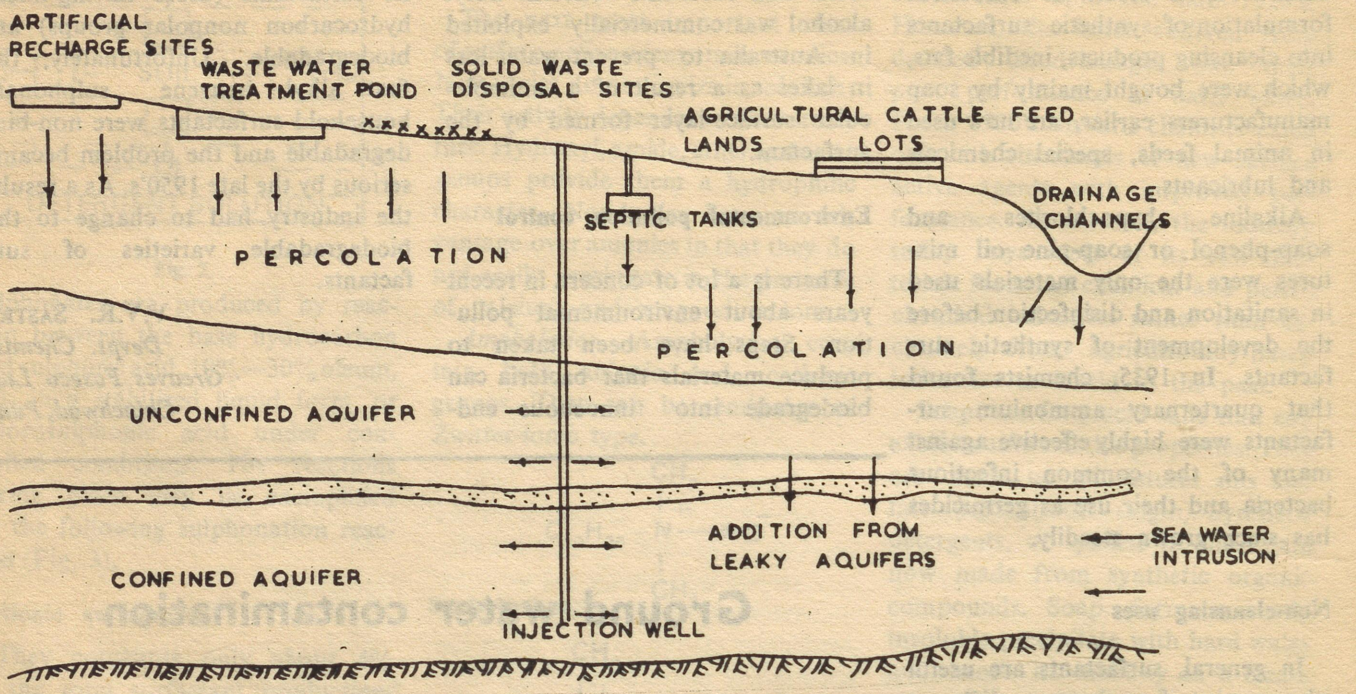


**Fig. 1. Potential sources of groundwater contamination**

are pathogenic organisms, oxygen demand, nutrients and solids. Nutrients, particularly nitrogen and phosphorus are of major importance.

Parts of the domestic wastes are taken to disposal sites as solid wastes. They are partly burned and partly incorporated in the soil. They are a potential source of ground water contamination and the leachates of the areas join the aquifers below. If the same aquifers are used for drinking water supplies, care should be taken regarding the movement of contaminants in these aquifers as there is a danger of contaminated water being drawn up.

### Runoff from urban areas

The runoff from rainfall in the urban area is another potential source of contamination of ground water. It may contain relatively large concentrations of oil and grease, nutrients, pesticides and heavy metals. The runoff, where there are no proper outlets, could accumulate into small ponds and depending upon the subsoil strata may join the aquifers below. The rainfall in the city could also pick up substantial contamination from dust and air pollution before it reaches the ground. Its pollution potential is considerable and cannot be neglected.

### Agricultural wastes

Wastes of agriculture can be significant in some areas. Agricultural wastes may be animal wastes, processing wastes and agricultural chemicals. A major problem in agricultural areas is the runoff from farm lands using large quantities of fertilizers. The contribution of agricultural wastes to ground water contamination appears to be marginal, but specific situations should be investigated.

### Industrial wastes

Industry has become a part of several urban areas. Most industries, produce some wastes. Industrial wastes consist mainly of inorganic chemicals and heavy metals.

Industries also draw heavy supplies from ground water and also produce contaminants on a large scale. Wherever industrial complexes form a part of the urban environment, a thorough analysis of the ground water should be undertaken to assess its contamination.

### Cases of ground water contamination

Cases of ground water contamination have been reported from several parts of the country. Aboo (1968) surveyed the quality of well waters in the city area of Bhopal

(M.P.). The survey showed that 24% of the wells had one or more of the chemical constituents in quantities higher than the permissible limits. Only 4% of the well waters studied showed less than 20 MP/100 ml of coliform bacteria, a bacterial count used as an indicator of water pollution associated primarily with excreta of warm blooded animals including humans.

In a study of ground water contamination in Anakapalle (A.P.),P.S. Rao and M.V.V Rao (1973) observed that the municipal water supply was contaminated as a direct consequence of indiscriminate discharge of industrial wastes into river waters. The organic waste effluents from the sugar-cum-distillery factory created anaerobic conditions in the river bed due to the bacterial decomposition of the organic matter which in turn reduced the insoluble ferric iron content of the river sand to soluble ferrous state. The soluble ferrous iron subsequently infiltrated into ground water.

In a recent study, the Industrial Toxicology Research Centre, Lucknow reported manganese contamination of well waters in nearby areas.

Though the studies reported are sporadic in nature, there is no doubt that ground water contamination is occurring at an alarming rate.

**Protecting ground water**

The following general steps are suggested for protection of ground water:

1. The contaminant sources as indicated earlier should be surveyed;
2. Location of a disposal site (either of industrial or municipal wastes) should be decided keeping in view the ground water levels and flow patterns in the area;
3. In case of likely presence of harmful constituents, particularly of industrial effluents, steps should be taken for pre-disposal treatment by the industry itself; and
4. Location of wells for drinking water supplies should be decided with utmost caution. Surrounding contaminant sources and flow directions should be taken into account. It is also not advisible to tap the uppermost aquifer in case of drinking water wells.

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# Deterioration of ascorbic acid in diseased fruits

ASCORBIC acid (vit. C) an be synthesised by a variety of plants for their nutrition. The best source of this vitamin are guava, citrus, tomatoes, strawberries, raspberries, grapes, lemons, oranges and many green vegetables. Severe ascorbic acid deficiency produces scurvy and some other diseases. Fruits and vegetables are used to supplement this vitamin.

During pathogenesis a number of fungi such as *Botryodiplodia theobromae*, *Rhizopus nigricans*, *Aspergillus niger*, *Alternaria tenuis*, *Gloeosporium psidii*, *Phytopthora parasitica*, *Macrophoma allahabadensis*, *Drechslera australiense*, *Clathridium corticola*, *Cylindocladium scoparium* and *Geotrichum candidum* have been reported to cause considerable loss of the vitamin C contents of the host fruits and vegetables.

Deterioration in the ascorbic acid contents in guava fruits due to infection by *Aspergillus niger*, *Phomopsis destructum* and *Phoma psidii* was observed to be 87.5, 75.4 and 58.6 per cent respectively. Loss in the quantity of this vitamin has also been observed in healthy tissues adjacent to the infected regions.

Deterioration of vitamin C in pathogensis may be due to production of some ascorbic acid degenerating enzymes either by the fungus alone or by the host-pathogen complex. The loss may be due to increased respiration in the diseased tissue and this may induce increased oxidation.

Vitamin C is easily destroyed by cooking, for it is readily oxidised. High temperature causes loss in vitamin C of storage fruits and vegetables. Storage of fruits and vegetables stores at low temperature reduces the destruction of ascorbic acid.

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## Advantages of eucalyptus growing

AFFORESTATION is the need of the hour. Senseless felling of trees has caused all round misery to man. Soil has been exposed to erosion, moisture is lost from the soils quickly, climate is getting warmer and rains scanter. There are reasons to believe that desert area in the world is on increase as trees are disappearing.

There are no two opinions about the necessity of growing more trees in India. But what are the good trees that should be grown? Eucalyptus offers many advantages to man and his environment.

Recent researches done at Forest Research Institute, Dehra Dun show that there are three advantages of growing Eucalyptus in India.

1. Eucalyptus consumes less water and gives more dry matter. Scientists at F.R.I. have found that in the juvenile stage, *Eucalyptus citriodora, Dalbergia latifolia, Pinus roxburghii* and *Populus casale* seedlings consume 16,579/5,526; 4,570/1,143; 1,872/936 and 8,112/2,704 mm of water respectively. Though the consumption of water by Eucalyptus was higher, water consumed per unit gram of dry matter was least by Eucalyptus, i.e., 1.41 mm per gram of dry matter as against 2.59 mm for *Dalbergia latifolia*, 3.04 mm for *Populus casale* and 8.87 mm for *Pinus roxburghii*.

This is very important from production point of view as Eucalyptus consumes least water with maximum production.

2. Eucalyptus causes less loss of rainfall due to interception than many other trees. Investigations carried out on interception of rainfall by an 8 year old plantation of Eucalyptus hybrid have indicated that the rainfall lost by interception was only 11.56 per cent even with high stand density of growth.

The interception loss is lower as compared to indigenous species like *Shorea robusta* (25.3%). *Alstonia scholaris* (26.0%) and *Pinus roxburghii* (22.1%) with comparable densities. Rainfall availability to the soil through the canopy of Eucalyptus plantation is much higher than by any native species.

3. Eucalyptus induces physical changes in the soil to make it more fertile than other trees. Studies on the soils under Eucalyptus in Sal area have revealed that humification (breakdown of organic matter) is faster and easier in these soils. Consequently, the mode of change of physical characteristics of these soils is effective for nutrient recycling.

## Heterosis

WE do not know whether our ancestors were scientists in the modern sense of the term, but when they forbade marriage between too close relatives and kins they were scientific in outlook. The ill effects of too close inbreeding have been known for a long time. Charles Darwin (1868) believed that natural selection had produced in humans an instinct against incest, because of the higher survival chances of the more vigorous offspring of exogamous matings.

The disadvantages of inbreeding and advantages of cross-breeding in animals, humans and plants, became known in 1716 when the first plant hybrid was described. But the systematic and scientific investigations of plant hybridization (process of hybrid formation) were published by Josef Gottlieb Koelreuter, a German botanist, in 1766 in which he noted among other things 'hybrid vigour' in interspecific crosses of *Nicotiana, Dianthus, Mirabilis, Datura* and other genera. Charles Darwin (1876) studied the effects of self-and cross-pollination in the vegetable kingdom and concluded that in plants cross-fertilization is generally beneficial and self-fertilization injurious.

Though hybrid vigour in plant hybrids was first studied by J.G. Koelreuter, the basic principles of inheritance were known only in 1900 when Mendel's Laws were rediscovered. Then it became known that genetic variance is the expression of genetic variability. It was also realised that crossing (cross-breeding) produces heterozygosis (Aa Bb) in all characters by which the parents differ and inbreeding tends to produce homozygosis (aa bb or AA BB).

The term heterosis (derived from heterozygosis) was coined by George Harrison Shull of Station of Experimental Evolution at Oldspring Harber (U.S.A.) in 1914. He used the term to avoid the implication that hybrid vigour was entirely Mendelian in nature (heterozygosis is entirely Mendelian). The term heterosis is generally used as a synonym of hybrid vigour but heterosis and hybrid vigour have a relationship that exists between the mechanism and its product. Heterosis is the phenomenon which gives its phenotypic expression through hybrid vigour.

**What is heterosis ?**

A hybrid (also called $F_1$ hybrid to denote its first filial generation) gets half of the genes from male parent and half from female parent. On theoretical basis, the hybrid should exhibit medium performance between the two parents. When the vigour of the hybrid is more than mid-parent value $(P_1+P_2/2)$, or superior (dominant or better) to parent, the existence of hybrid vigour (and hence heterosis) is obvious. It is customary to express hybrid vigour in percentage. The heterosis can be expressed by any of the following formulae:

1. $\text{Heterosis} = \dfrac{F_1}{(P_1+P_2)/2} \times 100$

2. $\text{Heterosis} = \dfrac{F_1-(P_1+P_2)/2}{(P_1+P_2)/2} \times 100$

3. Heterosis $= \dfrac{F_1\text{—Better parent}}{\text{Better parent}} \times 100$

**Theories of heterosis**

Though the occurrence of heterosis is a common feature and has been known for a long time, there is no agreed reason why heterosis occurs. Several theories have been put forward from time to time to explain the mechanism of heterosis.

*Cytoplasmic interaction theory*: The American botanist A.F. Shull in 1912 attributed hybrid vigour to a stimulus from the interaction of a changed nucleus and a relatively unaltered cytoplasm. (In the process of hybridization the cytoplasm inherits through female parent and remains unchanged, while the nucleus changes by taking half of the genes from the male parent). The effects of cytoplasm on several plant characters have been known and the heritable changes due to the so-called 'plasma genes' (cytoplasmic genes, i.e., DNA which is present in the cytoplasm of the cell and cytoplasmic organelles which are responsible for cytoplasmic inheritance) are also known.

*Dominance theory:* A.B. Bruce of U.S.A. in 1910 proposed the dominance theory. This theory states that hybrid vigour results from the interaction of favourable dominant or partially dominant genes which are assembled in the hybrid from the two parents.

$$\begin{array}{ccc} \text{Parent I} & \times & \text{Parent II} \\ \text{(aa bb CC} & & \text{(AA BB cc} \\ \text{dd EE)} & \downarrow & \text{DD ee)} \\ & \text{hybrid} & \\ & \text{(Aa Bb Cc Dd Ee)} & \end{array}$$

D.F. Jones of Connecticut Agricultural Experiment Station, U.S.A. in 1917 favoured Bruce's theory and added the linkage concept. Linked favourable dominant or partially dominant genes are responsible for vigour of the hybrid.

*Overdominance theory*: The concept of stimulating effect of hybridization was developed independently by G. H. Shull (1908, 1911) and Edward M. East (1908) of Connecticut Agricultural Experiment Station, U.S.A. According to this concept, a heterozygote (Aa) would be better than homozygote (aa or AA). One of the explanations of this theory is that the hybrids exhibit overdominance due to cumulative action of divergent allelic genes.

*Physiological stimulus theory*. E. M. East (1908) and G. H. Shull (1908-1914) emphasized that heterozygosity was the basic cause of heterosis. They believed that the two allelic (divergent) genes present in the hybrid provided some sort of physiological stimulus to the hybrid which resulted in the enlarged size of the vegetative characters and higher yield.

*Initial capital theory*. The work of E. Ashby and his co-workers (1930-1936) in U.S.A. emphasized that hybrids have increased rate of growth during early stages of development and their embryos attain larger size. This theory believes that the initial capital of the hybrid embryo ultimately results in the expression of heterosis.

*Complimentary gene action theory*. Several characters such as height, growth, yield, etc. are not governed by a single gene but by the combined (complimentary) action of several intermediate characters (genes). Lack of or poor potential of even one intermediate character can influence the final product. Let us assume that the yield character of a plant is influenced by six intermediate characters A, B, C, D, E and F. If the C character is represented by less efficient C′ in one parent (A) and E by E′ in other parent (B), then both the parents would have poor yield, but a hybrid between these two parents would show vigour over the two parents. This concept has gained support from the recent analysis of heterosis by S. K. Sinha and Renu Khanna (1975) of the Indian Agricultural Research Institute, New Delhi.

*Balanced metabolism theory*. William J. Robins (1952) of the Columbia University (U.S.A.) analysed the parents and hybrids for various growth factors such as vitamins and growth regulators and found that usually the parents were poor in one or two factors but the hybrids were normal in composition. This theory believes that vitamins and enzymes neither in shortage nor in excess are beneficial to plant. Only in balanced form they are effective.

**Utilization of heterosis**

With the development of heteros is it conceptwas postulated that the $F_1$ crosses probably would beof commercial value in some crops where crossing was easy, such as eggplants, tomatoes, pumpkins and sugarbeets. Today, the use of heterosis in practical plant and animal improvement has surpassed earlier predictions.

Table 1 lists some plants and animals where heterosis has been exploited on commercial basis.

**Table 1**

| | |
|---|---|
| Farm crops : | Maize, sugarbeets, sorghum, pearl millet, wheat, barley, paddy. |
| Forage crops : | Forage sorghum, alfaalfa, and grasses. |
| Vegetable and horticultural crops : | Tomatoes, onions, spinach, carrot, cauliflower, cabbage, eggplant, sunflower and annual ornamentals. |
| Fruit crops : | Squashes, watermelons, muskmelons, coconuts. |
| Livestock : | Swine, poultry, beef, and milk cattle. |

**Methods of breeding for heterosis**

*Choice of the parent.* It should be emphasized that sometimes the hybrids show negative heterosis (they are inferior to parents). It is actually the complementation between the parents which is important for expressing hybrid vigour. For the production of good hybrids, the choice of parents should be based on genetic diversity related to productivity and adaptability. The components of heterosis and their relation to the diversity between parents are of great importance. Therefore, the selection of the specific plant type for increasing yield (or other agronomic characters) should be carried out by measuring the relative performance of plants through diallel crossing system, a system in which all possible crosses are made and studied.

*Hybridization*: All methods of hybridization in plants are based on the principle of transference of pollen from one parent to the stigma of the other parent. Depending upon the nature of flower (self-pollinated or cross-pollinated), the methods of hybridization are different in different crops. In self-pollinated crops the plants are first emasculated (male organs are removed) and then pollinated with the desired parent. In cross-pollinated plants the desired parental plants are sown near each other and emasculated only to eliminate the chances of self-pollination. Cytoplasmic male sterility (the specialized condition of the bisexual flower which contains non-functional male parts, hence functions as female) has opened up a new era in the history of plant breeding. It is being extensively used for hybrid seed production now a days.

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# Lysosome—digestive body in the cell

WITH the help of electron microscope and the cyto-/biochemical techniques, the various cellular components have been recognised and their functions studied in detail. The structures known as lysosomes were first called pericanalicular dense bodies, a name that suggests their location but not their function. Their function, until recently, was quite unknown. In 1955, Christian de Duve and his colleagues at the Catholic University of Louvain renamed these bodies as lysosomes because they contain digestive enzymes capable of lysis, that is, digestion. The exact cytoplasmic origin of lysosome is not yet clear. However, it has been suggested that they are formed in association with the Golgi apparatus or endoplasmic reticulum.

**Structure**

Lysosomes usually appear as dense bodies surrounded by a membrane. Their shape and density vary broadly, but most of them are between 0.25 micron to 0.50 micron in size. Lysosomes contain more than a dozen enzymes including ribonuclease which act on ribonucleic acid, deoxyribonuclease for hydrolysing deoxyribonucleic acid, phosphatase to break phosphate esters, cathepsins to digest proteins, glycosidase for polysaccharide and glycosides and sulfatase to split sulfate esters. All these lysosomal enzymes are enclosed within a membrane.

Depending upon their digestive activity, the lysosomes can be characterized as follows ; (i) the storage granule (primary lysosome) with a relatively homogeneous content and a peripheral localization of enzyme, (ii) the digestive vacuole with a heterogeneous or frothy content and a random distribution of enzymes (secondary lysosome), (iii) the autophagic vacuole with mitochondria or endoplasmic reticulum in the process of degeneration and a randomly distributed enzyme, and (iv) the residual body containing myelin-like bodies and a peripheral distribution of enzymes.

### Function

The simplest and most obvious role of a packet of digestive enzymes within a cell is in necrosis and autolysis, the death and self-dissolution of tissues respectively. The membrane of the primary lysosome simply dissolves liberating the enzymes which dissolve the cell. This can follow wounding or other damage to tissue or it can take place naturally in the course of development, i.e., in the ovary after degeneration of corpus luteum and in a tadpole when it loses its tail. In a tissue, or an organ isolated from body the lysosomal enzymes are released in the cell which break down rapidly the large molecules such as proteins, lipids, nucleic acids and carbohydrates. It has been established that the concentration of lysosomal enzymes in the tail of an amphibian increases before metamorphosis. The concentration of these enzymes, which act as catalysts and are not consumed in the process of tissue digestion, increases as the tail is resorbed. Lysosomal enzymes play their role in these processes in three different modes: (i) White cells and other scavenger cells invariably invade the areas where cell destruction occurs by the action of lysosomal enzymes inside them. (ii) Autophagy: portions of a cell somehow find their way into the cell's own lysosomes and are broken down. How the self-engulfment of the cell fragments takes place is now known. During starvation, this process apparently enables the cells to use part of their own substances as fuel and for the renewal of essential constituents without doing themselves irrepairable damage. As in normal endocytosis, autophagy remains localized by the limiting membrane. (iii) By rupture of the lysosome membrane inside the cell and the digestion of the latter by the released enzymes. It can be described as a perforation of the cellular digestive tract. Such ruptures take place fairly quickly in dead cells in a manner that recalls the rapid postmortem purification of the digestive mucosa of higher animals. It is obvious that once repair mechanisms are interrupted the areas most dissoluted will be those immediately adjacent to destructive enzymes. In the normal life processes of multicellular organisms lysosome rupture, following the death of a cell, may have some value as a built-in mechanism for the self removal of dead cells.

However, can a cell discharge lysosomal enzymes to destroy surrounding structure? Apparently by reverse phagocytosis a packet of enzymes from a lysosome is released outside the cell where it digests contiguous structures. This is how a sperm penetrates the protective coating of the ovum. It also explains how osteoblasts, the cells that destroy bone, act and the ability of white blood cells to pass quickly out of the blood vessels into the tissue spaces at the site of an infection.

In multicellular animals there are generally three stages involved in the series of reactions by which complex foodstuffs are utilized. Firstly, digestion takes place in the digestive tract. Digestion may be defined as the process of converting complex food into simple products which the individual cells can use for their metabolic needs. In this way, the complex molecules of carbohydrate, fat and protein are split into glucose, fatty acids and amino acids respectively. The basic reaction involves the addition of water and, therefore, is called hydrolysis. Enzymes which participate in these reactions are called hydrolases. There are specicfi hydrolases for each substrate. Secondly, further degradation of the end products of hydrolysis occurs exclusively within the cell and involves glycolysis, fatty acid oxidation and deamination (for details see *Text Book of Physiology and Biochemistry* by G. H. Bell, J. N. Davidson and H. Scarborough E.L.B.S. edition, 1970). By these processes the end products of digestion are converted into acetyle coenzyme A, alpha-ketoglutaric acid and oxaloacetic acid. These, in turn, enter the third and final stage referred to as the citric acid cycle or the Krebs' cycle. This stage takes place within the mitochondria and involves reactions by which energy is made available or stored in the form of adenosine triphosphate (ATP).

In lower forms, which do not have digestive tract, much depends upon intracellular digestion of the large molecules; there is a mechanism for intracellular digestion of the large molecules which are taken into the cell by the process called phagocytosis. Recently, a new term endocytosis has won favour. As the cell engulfs the particle and forms invagination, the latter is pinched off from the cell membrane to become an internal sac or body. It is referred to as a phagosome. The phagosome moves towards the primary lysosome. The two bodies come into contact and their membranes fuse, to form one body, the secondary lysosome. The enzymes from the lysosome come into contact with the molecules brought into the cell in the phagosome, and thus the digestion occurs. Once the molecules are degraded sufficiently, the smaller products can diffuse out of the secondary lysosome, also called digestive vacuole. Within the cell the steps described are carried out, and ultimately ATP is formed in the mitochondria. In the digestive tract there remain residues that must be eliminated by defecation. The residues left in the digestive vacuole are also eliminated. The vacuole now moves on to the cell membrane where reverse phagocytosis occurs.

For this primitive intracellular digestive tract to continue to function there must be lysosome production at a rate equal to that of the endocytosis. Practically little is known concerning the formation of lysosome, or the factors that control the rate of formation. The digestion of bacteria by leukocytes is an important form of defense against diseases. Not surprisingly, bacteria have developed adaptations that enable them to survive lysosomal attack. Several bacteria elaborate poisons that kill leukocytes before the bacteria are themselves destroyed; others, including those causing tuberculosis have thick waxy coats that resist attack by enzymes. There are some rare inherited diseases in which the lysosomal system is ineffective. In the Chediak-Higashi syndrome, one of the inheritable diseases in man caused by chromosomal abnormalities (the children develop malignant disease of the spleen and lymph gland), the lysosomal granules are abnormally large. The ingested bacteria are not killed. In another disease, the enzyme leukocyte oxidase is inactive; bacteria or viruses are phagocytized but are not digested in the usual manner. In much the same way, the inactivity of individual lysosomal enzymes may be responsible for certain 'storage' diseases in which a metabolic product is not broken down. It accumulates in a pathological quantity.

### Lysosome and disease

Most of the lysosomal disease processes investigated so far involve situations in which the untimely rupture of the lysosomal membrane leads to some form of cell damage. A. Allison and his associates (1967) at the National Institute for Medical Research, London have studied the effects of small particles of silica, asbestos and other substances on cells. The effects were not only diseases such as silicosis and asbestosis but also gout and inflammation in general. The fact that exposure to asbestos particles is associated with the development of some kinds of cancer also provides links between lysosomes and carcinogenesis.

Most foreign particles such as carbon taken into the lungs by inhalation of smoke-polluted air remain for years within phagocytic cells and are innocuous. However, certain inhaled particles, including several crystalline forms of silica (silicon dioxide), stimulate a severe reaction in the lungs. The deposition of fibrous tissue can lead to marked impairment of lung function.

Prolonged exposure to asbestos dust leads to asbestosis, a disease like silicosis, which is associated with the deposition of fibrous tissue in the lungs. In 1960, C. J. Wagner and his associates of South Africa found the development of malignant tumors in asbestos workers. Similar tumors are found in animals that have been injected with asbestos particles in the chest cavity. Electron microscope and other studies show that asbestos particles are taken up into lysosomes, from where some of them escape later. Wagner also found that injections of silica particles into the thoracic cavity of rats lead to malignant tumors of the thymus gland.

### Effects of drugs on lysosome

The precise effects of some drugs on the lysosomal membrane are known. Cortisone and related corticosteroids, for example, stabilize the membrane making it less liable to rupture. A number of steroids and other compounds weaken the membrane making it more permeable. One such compound is carbon tetrachloride which is used against certain worms that parasitize on the intestines of mammals. The digestive tract of these worms is a tube of amoeboid cells, each of which ingests food and breaks it down within lysosome. Small doses of carbon tetrachloride damage the worm-cell lysosomes and the massive release of hydrolytic enzymes kills the worms. High doses of vitamin A also bring about the release of large amounts of lysosomal enzymes.

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## Why mosquitoes prefer attacking women

THERE is an unambiguous scientific proof that women are preferentially bitten by mosquitoes; and that men are comparatively immune to them. It will always be a bitter experience for a woman sitting with a man in a room, to find that she is bitten either exclusively or at first, and the insect may or may not touch the man.

Researches in Canada and Germany in the last decade have established categorically a close relationship between mosquitoes, malaria, and women. Speaking at the annual meeting of the New Jersey Mosquito Extermination Association in 1963, Prof. P. Roesslar of the Western Ontario University (Canada) said that estrogens—the female steroidal sex hormones—act as strong attractants for mosquitoes. Besides being present in their reproductive system, estrogens are also found in the perspiration of females. Two types of estrogens have been found on the skin surface of women: 17-hydroxy steroids and 17-keto steroids. Of the former type, "oestriol" (estriol) hormone was described to be the most effective attractant for mosquitoes. As little as $10^{-9}$ $\mu$g (1/1000,000,000 microgram) quantity of oestriol, when evaporated from the skin surface of a woman, can attract a mosquito. The 17-keto steroids (for example, "oestrone" hormone) also act more or less in the same way.

Prof. K. Bosse and his associates at Munich University, in 1964, prepared skin surface extracts from 175 women and estimated the concentration of 17-keto steroids present in them. The highest concentration of the hormones was found on 1st-4th, 9th-12th, 17th-20th, and 21st-24th day of the menstrual cycle. During these periods the women undergoing tests were frequently attacked by mosquitoes.

Whereas the concentration of 17-ketosteroids in the perspiration of men was found to be more than 74 microgram per cent, that found in women was more than 423 microgram per cent. The all time maximum hormone quantity on the skin surface of women was observed between 17th-20th day of menstruation.

Prof. Bosse further observed that certain amino acids such as tyrosine, glutamic acid, aspartic acid, serine, threonine, proline, and histidine also possess attraction for mosquitoes. The perspiration of men and women also carries these and other amino acids. The results of estimation of amino acid content of perspiration in different persons have revealed that their quantity varies from person to person, indicating the severity of mosquito attack. If an individual (man or woman) has a higher content of these amino acids as compared to another person, the former will become more susceptible to attack by mosquitoes.

In view of the above observations it becomes desirable on the part of the women to adopt anti-mosquito measures, especially on the specified dates of menstrual cycle, in order to save themselves from malaria.

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## Carbon granules produced

CRUSH the anthracite coal to a suitable size and seive through suitable size mesh to get particles of 225 $\mu$. Baking at a temperature above 1000°C in inert atmosphere, oxidation treatment for a suitable period of time and at a suitable temperature in the presence of air or $CO_2$, and other steps follow afterwards. The material is finally seived and bottled. This is briefly what P. T. John and K. K. Datta of the Materials Division of National Physical Laboratory, New Delhi, describe as the process developed by them for manufacturing carbon granules for use in telephone transmitters. In our country, presently the requirements of carbon granules for the above mentioned purpose are completely met through imports. With an annual present consumption of about 4000 kg, demand for carbon granules is likely to increase with the expected increased demand and supply of telephones in the near future.

Telephone transmitters or microphones are a class of transducers which act as the interface between a listener and the transmission system and are "among the most essential components of the telecommunication system." As John and Datta put it "there are many types of microphone with different principles. But the type that employs the use of fine carbon granules is more common due to its robustness, high sensitivity and low cost". Exactly, of what use these carbon granules are in a telephone transmitter? A carbon microphone consists of two carbon electrodes fitted in a chamber whose walls are well insulated by a paint. In between the electrodes are filled up the carbon granules. Out of these two electrodes, one is fixed while the other one can move—the latter being attached to the diaphragm. While speaking into the microphone, sound waves falling upon the diaphragm make it to vibrate causing carbon granules to move in resonance with the diaphragm. The compressions and rarefaction in granules cause variations in the current passing through them from one electrode to the other; the variation in current finally passes through the telephone wire.

The carbon granules produced at National Physical Laboratory have been tested by Indian Telephone Industries, Bangalore, and found satisfactory and comparable to the imported ones.

Zaka Imam

# NEWS & NOTES

## Indian Science Congress—1977

DR. H. N. Sethna, President of the Indian Science Congress Association introduced the focal theme in his presidential address. He appealed to developing countries to join hands for protecting their raw materials which he said are being exploited by developed nations and their transnational corporations. He called for regional economies, more "investment in man" and advocated the use of remote sensing and satellite technology for better and rational utilization of India's natural resources.

It was perhaps one of the dullest Science Congress sessions. The Calcutta cricket test match was on the minds of many participants and many paper reading sessions were thinly attended. The medical and veterinary sections wound up on the third day and the popular lectures, except two, were neither popular nor interesting. Dr. A. G. Jhingran, Director of the Central Inland Fisheries Institute (CIFRI) in Cuttack gave an excellent popular lecture on fish resources in India, the great potential for fishing in the continental shelf, the glass jar hatchery and the induced breeding with pituitary extract methods developed at CIFRI. Cyril Ponnemperuma of the University of Maryland gave a popular lecture on the oft-repeated subject of Mars and the Viking mission and concluded by saying that the Vikings found no evidence of life on Mars.

One of the report read was the distressing finding by scientists of the Anthropological Survey of India that Indians are adapting to malnutrition by becoming smaller in size. Some 60 population groups have been studied for two generations and 43 of them have become shorter in varying degrees. Another project of ASI has confirmed that Indians are losing weight. Dr. Ganguly said that diminution in height and weight of Indians could be the result of the process of adaptation to malnutrition.

In his presidential address to the section on "Zoology, Entomology and Fisheries," Prof. P. N. Srivastava, Dean of the School of Life Sciences at the Jawaharlal Nehru University exposed some of the side effects of administering radioisotopes to pregnant women. The use of Iodine-131 and P-32 has been widespread but according to Dr. Srivastava very little is known about their adverse effects.

In a symposium on the "Mechanism of sleep" in the physiology section, Dr. H. S. Narayanan revealed the first recorded case of "hypersomnia." in India. He said the 21-year old male patient had the habit of sleeping for four days in a stretch. If disturbed in sleep he would become restless and demand a lot of food like the mythical Kumbakarna of the epic Ramayana who slept for six months and ate voraciously when woken up. According to Dr. Narayanan, hypersomnia is an extremely rare phenomenon and only 11 cases are recorded so far in the world. Dr. Narayanan is working at the National Institute of Mental Health and Neurological Sciences in Bangalore.

Some of the developments on research in Indian Medicine were conveyed through an exhibition organized by the Central Council for Research in Indian Medicine (CCRIM). One significant finding was that L-dopa, the only known drug for Parkinson syndrome, could be produced from the plant *Mucuna pruvrita*.

A new nematode parasite that causes havoc to bananas was reported in a paper by Dr. R. S. Tandon and Dr. Parveen Kumar from Lucknow. They said roots of the plant *Musa paridisiaea* were heavily infested with the nematode "pratylenchus."

The beneficial effect of orange juice in reducing the severity of rubella virus infection (german measles) was highlighted by an Indian doctor from the University of Florida. (USA). She said that a controlled study was done on 55 volunteers who were challenged by the virus through the nasal route. The severity of the infection was found to be reduced in those who were given 250 ml of orange juice four times a day. The antibodies against the infection also appeared much sooner in the orange juice group compared to the group that did not receive orange juice. She said that several substances in orange juice, and not vitamin C alone, were probably responsible for altering the course of German measles.

Prof. W. H. McCrea, the British astronomer, gave an account of the possible effect of the galactic structure on the solar system. According to him the ice ages occur probably because the solar system is accreting interstellar dust as it moves across the dust-laden inner limb of the spiral arms of our galaxy. It takes the sun about 250 million years to go round the centre of the galaxy during which it crosses twice the dust limbs of the two spiral arms. During its lifetime the sun has made about 50 orbits around the centre of the galaxy and has accreted billion billion tonnes of dust. Prof. McCrea said that accretion of dust would cause a slight increase in the solar emission enough to advance ice age. He said that right now the sun had crossed the dust limb and entered the spiral arm. It would take some ten million years for the sun to cross the width of the spiral and this period may be critical for the earth and the solar system. An ice age may come as the solar system is moving within the arm and it is likely that the sun and its planets would come close enough (30 light years) to a supernova that will remove the ozone cover on earth and destroy life. The chances of sun's encounter with a supernova are high in the next ten million years because the sun is right now in the midst of the spiral arm—the region where most supernova explosions are known to occur.

In the Botany Section, Prof. K. K. Nanda of the Punjab University reported success in propagating many forest trees from stem cuttings. Out of 155 tree species examined, more than 100 species were found incapable of vegetative reproduction. But Prof. Nanda said that with the use of regulatory substances such as gibberelins and phenolic compounds, it was possible to induce root formation from stems of these "reluctant" species. Since trees grown vegetatively are of "pure types", and can be multiplied rapidly, the research has considerable potential in breeding and tree plantation programmes. One immediate application of this work is in growing teak (*Tectona grandis*) from stem cuttings. Many horticultural plants hitherto grown from seeds can be grown from stems using nutrients and growth regulators. Trees that do not grow uniformly in all seasons (poplar trees, salix and shoe flower) can now be induced to grow in and out of season using regulatory substances, Dr. Nanda said. He said work is now in progress for vegetative reproduction of trees like *Pinus longifolia* (chil) and *Cedrus deodara* (deodar) used in house construction and furniture making.

On the final day of the Science Congress, ISCA President Dr. Sethna announced several recommendations on the focal theme. Among the general recommendations were : (1) application of statistics in various resource areas; (2) longterm planning for continuous updating of information on survey of natural resources; and (3) utilisation of aerial and satellite methodology for the assessment of resources.

K. S. JAYARAMAN
*Sceince Correspondent*
*Samachar, New Delhi*

## Science paper reading contest

THERE is much talk about scientific temper in the country. But, the other day, on December 6,1976, when I attended the All India Science Paper Reading Contest organised by the Physics Society, St. Stephen's College, I was at a loss to find the temper lacking even among our science community, the students and teachers. Only a few local colleges took part in this competition and the size of audience was below expectation. Only a few participants, mostly those who were expecting prizes, remained glued to their seats till the end, while others, after taking the lunch, left the scene. Teachers, it was sad to see, were mostly those of the college, as if for the rest the contest was an alien, non-academic phenomenon. So much scientific temper, one can imagine, is in our temples of learning, what to say of the entire country!

The Science Paper Contest which, as claimed by the organisers is only one of its kind in the country, was on the whole well organised. In all 15 minutes were given to each participant, five for reading the paper, five for drawing figures, etc., and five for question-answers and discussion. The subjects on which papers were read were varied, but as expected certainly not on the most talked about. For instance, except Genetic code, Space science, students read papers on Anti-worlds, colour in plants, scientific progress, superconductivity, resistivity in solids.

Utpal Banerjee of Chemistry Honours, St. Stephen's College, was unanimously selected the best contestant and was awarded the first prize. His was not 'paper reading' affair but a talk on genetic code. Utpal has in him the making of a popular science lecturer, with such a remarkable ease and clarity he dealt the subject. The second best was Shishir Priyadarshi, also of St. Stephen's College, who talked about the anti-worlds. Though he presented the subject nicely, he was on occasions uncomfortable. M. Chandrasekhar, who won the team trophy for Kirori Mal College, talked about the 'Colour in plants' and his presentation was also fairly good. One peculiar instance was of Miss Vatsala Chana of Miranda House College who though read nicely, had selected the subject' 'The limitation of scientific progress' which was difficult. She went on talking about pollution and pesticidal problems, which have not scientific advancement (the srindered latter has a bit but she couldn't strike the nail on the head) but have led us to look for alternative means of tackling them.

Some issues I wish to comment on: The judges shouldn't show what they think of a contestant publicly. There is no need of asking too many questions when one or two 'insight' questions could serve the purpose in judging whether the contestant knows the subject or not.

A bit of so-called 'leg pulling' can dissuade many a young people from entering such contests again. It is better to call the contest 'Popular lecture', changing its purpose and making it more meaningful, as I found many participants reading out papers in a monotonous manner. The topics selected for such a contest should have a popular bias, should be topical so that more students would like to sit through—classrooms are enough for details and technical stuff given in textbooks. Scientific temper needs much purposeful financing of the scientific activities. The need is to start from schools and colleges only, where the receptors for scientific wonders are maximum: In short, it is a matter of popularising science in form of popular lectures, extra-curricular activities, films, etc, on a large scale.

DILIP M. SALWI

## Efficacy of chemical pesticides is declining

AFTER three years of studies, a Committee of the U.S. National Academy of Sciences headed by Dr. Donald Kennedy of Stanford University and composed of about 60 specialists in various aspects of pesticide use and hazard recently concluded that the efficacy of chemical insect control is declining alarmingly and hence the U.S.A. might have difficulty in achieving increased food production. Because many insect species have apparently developed some genetic resistance to insecticides, the Committee recommended the making of a new generation of insecticides that would be designed more efficiently to harm their targets. The Committee also recommended that alternative method should be developed to supplant chemical insecticides and suggested that biological weapons such as viruses and microorganisms should be used against insects. The Committee listed many factors that contributed to the loss of chemical control of important insect pests. Some of these are the appearance of genetic resistance to the chemicals in many pest species, breakdown of natural control mechanisms, sometimes chemicals also killing the insects' natural enemies, and strict regulation or ban of use of insecticides from public concern over hazards to environment and human health. The young American adults probably consume about 40 milligrams of chemical insecticides a year in food and carry about 100 milligrams permanently in their body tissues. As a measure to reduce this hazard, the Committee recommended compulsory reporting to the government of production and use data of insecticides. The contemporary pest control based primarily on chemicals had been one of the main factors in the high yields of the U.S. agriculture. On the other hand, the great reliance on chemicals often led to increases in crop-destroying pests or causing health hazards by producing pesticide-resistant insects that harbour diseases, the Committee pointed out.

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## Nobel Laureate Lars Onsager passes away

IN the death of Lars Onsager, who won the 1968 Nobel Prize for chemistry, on the night of October 5/6 due to heart attack, the world has lost perhaps the greatest theoretical chemist of the century.

Born in Oslo, Norway on Nov. 27, 1903 Onsager did not really have very good schooling but he showed the markings of a genius quite early. Thus at school, he had jumped a grade and in the tradition of other great geniuses of this century (Einstein, Bohr, Heisenberg and others), he had done his Nobel-winning work in his twenties and had presented the same at a Scandinavian scientific meeting in Copenhagen at the age of 26. Two years later (1931), and four years before obtaining his Ph.D., he published his work in final form in two papers in *Physical Review*. So elegant was the presentation of the papers that they extended only to 22 and 15 pages, one of the briefest to win a Nobel Prize. Onsager's work was so far ahead of his time that it literally went unnoticed for a quarter of a century.

While the three laws of thermodynamics are based on a very sound footing, they are not adequate in dealing with many of the natural processes, which are irreversible e.g. dissolution of a lump of sugar and its diffusion throughout a cup of tea. Onsager's reciprocal relations represent the fourth law of thermodynamics which deals specifically with irreversible processes and describes them adequately. In the words of Professor S. Claessen, who delivered the presentation speech at the Nobel Award ceremony in 1968, "The proof of the reciprocal relations was brilliant."

Onsager was a truly multifaceted genius who made very significant contributions in diverse fields as colloids, dielectrics, order-disorder transitions, metals and superfluids, hydrodynamics and fractionation theory. He is also famous for his work on the theory of strong electrolytes, the solution of the Ising problem and quantization of vortices in liquid helium.

No wonder, he was honoured very widely. A host of universities including Harvard, Brown, University of Chicago, etc. conferred honrary doctrates on him. He was awarded many medals including the Rumford Medal of the American Academy of Arts & Sciences, the Lorentz Medal from the Royal Netherlands Academy of Sciences, the Peter Debye Award of the American Chemical Society, etc. Professor Onsager was a member of many learned societies.

After obtaining his Ph.D. from Yale University in 1935 on the mathematical treatment of deviations from Ohm's law in weak electrolytes, he taught at his *alma mater* upto 1972, having been elevated to the post of J. W. Willard Professor of Theoretical Chemistry in 1945. At the time of his death, Professor Onsager was working at the Centre for Theoretical Studies of the University of Miami in the United States.

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## Symposium on plasma physics and MHD

A symposium on Plasma Physics and Magnetohydrodynamics is being organised at the Plasma Physics Section, Bhabha Atomic Research Centre, Trombay, Bombay-400085 from February 21 to February 23, 1977.

For more information, write to Dr. V. K. Rohatgi, Convener, Symposium Committee, Plasma Physics Section, Bhabha Atomic Research Centre, Trombay, Bombay-400085.

## MEDICAL NOTES

# Fingerprints may expose heart trouble

FINGERPRINTS may provide a clue to a common heart condition that can cause chest pain and irregular heart beats, according to Dr. Mark. H. Swartz of Mount Sinai Hospital. He said the finding may help doctors spot persons with the problem, called mitral valve prolapse, in which a heart valve fails to close properly, so allowing the blood to flow in the wrong direction. Swartz told an American Heart Association meeting that he found some persons with the valve defect had abnormally high numbers of arching patterns in their fingerprints. An arch is made up of gently curving ridges from one side of the finger to the other without the much more common looping or whorling patterns.

Swartz and his associates thought of looking at fingerprints to see if there was an association with the valve problem because there has been speculation that the defect is inherited. The heart is formed during the third and eighth weeks of pregnancy and fingerprint patterns are initiated during the sixth week. Other heart irregularities and other diseases also have been linked to fingerprints. He speculated some genetic or environmental factor may be responsible for the problem. It interferes with the orderly fetal development of the mitral valve and at the same time interferes with the fingerprints patterns. He says that mitral valve prolapse may exist in as high as 6% to 10% of the general population and the condition is more common in women including many in their twenties. Its symptoms include chest pain, irregular heart rhythms, light headedness and fainting. The condition was first detected in 1887, but was not looked at in any depth by doctors until about 10 years ago. Doctors often missed the condition. The condition is difficult to treat although, drugs do relieve the symptoms to some extent.

R. RAGHUNATHAN
*Nashville, Tennessee (USA)*

# Propranolol curbs hazards of cocaine overdose

A valuable heart drug is finding a new life saving use in treating people overdosed with cocaine. The drug 'propranolol' quickly brings galloping blood pressure and pulse down to normal range averting the threat of lethal brain strokes or heart failure. It protects against the physical hazards without taking away the euphoria or "high" from cocaine, says Dr. George R. Gay of Mendocine, California, who is a co-author of a report on propranolol in clinical toxicology.

Propranolol is used to control cardiac arrhythmias or erratic heart beats, and in some cases of angina pectoris or heart pain on exertion. Dr. Gay and his associates have now treated more than 50 persons, who in the language of drug users, had sniffed too much cocaine and were "overramped" or "juiced". The drug is a specific antagonist for the overdose reaction, they said.

Citing one instance, they said they were called backstage during a rock music concert and see a young male musician who was "too wired to play". Friends said he had a lot of coke, had been up all night, and had his last sniff of cocaine a few minutes earlier. The man was pale, nervous, shaking and intermittently retching. His pulse was 140 (normal 70) but thready and weak. His blood pressure was extremely high, at 220 over 160 and was breathing 40 times a minute. Sixty seconds after he was given one milligram of propranolol by vein, his pulse dropped to 120, blood pressure to 200 over 120, and respiration to 32 a minute. Within another 15 minutes, after more doses of propranolol, his pulse was 78, blood pressure a normal 120/70, and respiration 14 a minute.

Propranolol has specific blocking effects to offset the nervous system stimulus of cocaine. It appears absolutely to protect the cocaine abuser from the risks of cardiovascular accident, acute congestive heart failure and cardiac arrythmia. The report is preliminary and more studies are needed under controlled conditions to measure the beneficial effects of the drug.

Cocaine is so popular now that it can be called the "sniffing seventies". He cited Haight Ashbury clinic's figures to show that now about 15% of all drug users had used cocaine within the last 30 days compared with only 2% coming to clinic in 1967. As such, if the validity of the preliminary studies is proved, propranolol will become a potential life saving drug.

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# Of stress and tumours

THE influence of physical stress upon various physiological and pathological processes of the body has been the subject of extensive research for past few years. Recently, an interesting addition to the influence of stress in the process of tumour development has been made by a group of American Scientists. Dr. Eli Seifter and his co-workers of Yeshiva University, New York have demonstrated (*Experientia*, vol. 29, 1379, 1973) that physical stress increases the incidence and severity of tumour development in experimental animals. In their study with the mice inoculated with a murine sarcoma virus, muSV-M (a virus that causes connective tissue tumour) they have noticed that excessive and unusual physical stress causes a rapid development of tumour in experimental animals in comparison to the control specimens inoculated with the same virus, but were kept in a peaceful condition away from any sort of unusual physical stress.

It is, however, still a riddle how stress influences the process of tumour growth. It has been hypothesized by Dr. Seifter and others that stress reduces the immunocompetence of an organism through increased adrenocorticosterone secretion and makes an easy growth of tumours. Vermon Riley of Pacific North-West Research Foundation, Washington has added further information regarding the mechanism of immunosuppression and tumour growth in overstressed animals. According to his idea expressed in *Science* (vol. 189, pp. 465, 1975), any sort of unusual stress causes an increase of plasma corticosterone values in blood two to ten times higher than the normal. This abrupt increase of plasma corticosterone value is always accompanied by the involution of the thymus gland and lymphocytopenia. These two latter phenomenon in turn reduce the immunocompetence of an individual and thereby facilitate tumour growth. The idea of Dr. Riley has recently been verified in Dr. Seifter's laboratory by the administration of metyrapone, a chemical that inhibits corticosterone production in blood. In his recent communication (*Science*, vol. 193, 74, 1976), Dr. Seifter has suggested that upon entering the blood stream of tumour bearing animals metyrapone removes typical stress reactions for adrenal hypertrophy and thymus involution and thus makes the individuals resistant to muSV-M infection.

Another agent which is also reported to be effective in preventing virus induced tumour development, is vitamin A. According to Dr. M. Zisblatt and his research team of Yeshiva University, USA repeated administration of vitamin A in tumour bearing mice immediately blocks most of the host responses to stress and prevents thymus involution and immunosuppression within a very short time (*J. Nutr*, vol. 103, 30, 1976). It is, however, quite surprising that vitamin A reacts not only with the muSV-M induced tumours but also with a variety of animal tumours of both virus and non-virus origin. Extensive research is now in progress in different parts of the world to explore various unrevealed aspects of the action of vitamins on cancer and to find out whether vitamins could produce similar fruitful effect on the process of tumour development in human beings.

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# SCIENCE FOR THE YOUNG

## Tricks of the desert snails

THE molluscs or soft-bodied animals constitute the second largest and most variable group of spineless creatures after arthropoda—the jointed-limbed animals. Rapid spreading capacity and wide range of structural diversity have enabled these slow moving, sluggish creatures to exploit all conceivable habitat on the earth. Though snails in general are inhabitants of moist and cool places such as damp forests, ponds, rivers, lakes, etc., it is not surprising that certain species survive well in arid regions where the conditions are exactly opposite. The most adverse conditions for life in desert consist of a combination of aridity and high temperature. The combination presents a great thermoregulatory challenge to all desert creatures. For the snails, survival at this high temperature poses additional problems; due to extreme water-loving nature they are in constant threat of thermal death, dehydration and shortage of food during long, dry season.

The estimated lethal temperature of snails varies between 50°C to 55°C depending on the species and the time of exposure to heat. But quite often, the temperature of the desert exceeds 55°C even in the shade, particularly during summer. How then does a desert snail keep its body below the surrounding lethal temperature during summer?

A group of scientists led by K. Schmidt-Nielson of the Duke University, U.S.A. studied the thermoregulatory mechanism of a desert snail, *Sphincterochila boissieri*, a species commonly found in the deserts of the near East. In their recent report presented at a symposium on Comparative Physiology of Desert Animals sponsored by the Zoological Society of London in 1971, the scientists have suggested that the snails face the problems in various ways.

Many desert snails, particularly *S. boissieri*, bear an empty space within the shell which forms a sort of air cushion around their soft and moist body. When the snail comes in contact with a hot surface such as a stone or a flint or sunbathed sand, the air cushion insulates the animal against the high surface temperature. Moreover, like many higher animals, the snail remains in a dormant state during extremely hot season. This seasonal dormancy lowers its metabolic activity, reduces oxygen consumption and thereby cuts down the heat production. It is, however, of further interest that unlike other desert forms the snails are restricted in their activity except during the short rainy season when suitable food and drink are easily available. Because of their summer dormancy, the food taken during rainy season is sufficient for long periods. While in dormant state snails can withstand high temperatures, their water loss is reduced so much that their reserve of water is sufficient for survival for several years.

These investigations of Dr. Schmidt-Nielson and other scientists on the physiology of desert animals have revealed that, like many higher forms of life, the desert snails are equipped physiologically to withstand long droughts which may extend even beyond a year.

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## Humour in science

WHEN British mathematician Charles Babbage, the man who first thought of computer, read Lord Tennyson's poem "The Vision of Sin", he wrote to the poet: "In your otherwise beautiful poem there is a verse which reads, 'Every moment dies a man, Every moment one is born.' It must be clear that, were this true, the population of the world would be at stand still. In truth, the rate of birth is slightly in excess of that of death. I would suggest that in your next edition of the poem you have it read, 'Every moment dies a man, Every moment one and one-sixteenth is born'.

Strictly speaking this is not correct. The actual figure is a decimal so long that I cannot get it in line, but I believe one and one-sixteenth will be sufficienlty accurate for poetry".

Albert Einstein had once attended the wedding of a young friend. A few years later, the couple brought their eighteen months old son to him. The child looked once at him, and burst into a screaming fit. The embarrassed parents were speechless, but Einstein's eyes lighted up. He patted the boy on the head and crooned, "You are the first person in years who has told me what you really think of me".

Shortly after Enrico Fermi, the Nobel Prize winning atomic scientist, joined the University of Chicago staff, he was told by university executives, "Now that you are undertaking work for the government you undoubtedly will need a stenographer. We will see to it that one reports to you tomorrow". "But", protested Fermi, "I am a physicist not a businessman. What would I do with a stenographer?"

"You must have one" the executives explained, "All important people in this country have stenographers"

"All right", said the scientist, "but in that case I shall need two stenographers—so that they can keep each other busy".

The Mathematician Marc Kac, a Professor at Rockefeller University, had worked closely with many physicists. When he was delivering a lecture at California Institute of Technology some years ago, he was interrupted by Nobel Prize winning physicist Richard P. Feynman who said, "As some of us have been saying, if mathematics had never been invented, the progress of physics would have been delayed by about a week"

Kac fielded the good natured insult with the grace of a sportsman. "Absolutely true," he replied instantly, "By exactly that week in which the Lord God created the universe".

Electrical inventor Nicola Tesla was a brilliant mathematician who constantly looked for problems to solve. In a restaurant, he would not touch his soup until he had first calculated the amount of liquid in the bowl. He enjoyed eating a chunk of steak, but determining its cubic content was even more fun. One night when he was dining out, a waiter brought him a bowl of fruit salad. Each piece of fruit was of a different size and shape. Tesla's eyes lit up. Here were problems galore —a mathematician's delight. Fifteen minutes later, his pencil was still flying over his pad, covering it with mathematical symbols. The waiter approached and asked, "Is there something wrong with the fruit salad? You have not touched it"

"Wrong? Of course not," replied Tesla, without looking up, "It could not be better".

In the old League of Nations, Julio Casares, a scientist from Spain, had the privilege of sitting on a committee with H.A. Lorentz, the famed physicist, and with his even more famous disciple, Albert Einstein.

The day came when a shrinking budget forced a readjustment in salaries. Since they agreed that the cuts should be proportional to the reduction in funds, it was a simple problem in arithmetic.

Einstein and Lorentz began separately to work out the new figures. Perhaps one used trigonometry and the other differential calculus. But the two scientists came up with results that were not only completely different but totally absurd.

Lorentz, his brows furrowed, stared fixedly at Einstein, who registered complete amazement. Finally both broke into loud, helpless laughter. The conflict was solved by bringing in an accountant, for whom problem of ratio and proportion were a child's play.

G. V. JOSHI
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# How an electric bell works

THE drum beating and ding-dong of the primitive age have now been replaced by the 'ring' of the electric bells and telephones. This sound has today become the sophisticated way of calling on anyone, whether the place is a house or office or factory. Nevertheless how this pleasing but shrill sound is produced is a mystery to many.

Consider the electric bell shown in Fig. 1. It has a two pole electromagnet ; facing it is a hammer that could strike the gong, producing the metallic sound, 'ring'. There is a contact interrupter attached to the hammer, which also moves in accordance with it, breaking or making the circuit. The circuit, it is clear from the figure, say, begins at push button, through the electromagnet, then through the hammer and contact interrupter , through the source of electricity, and ends with the push button.

When the button is pressed, the electric circuit is complete. Current goes through the electromagnet, to the contact interrupter, and back. As

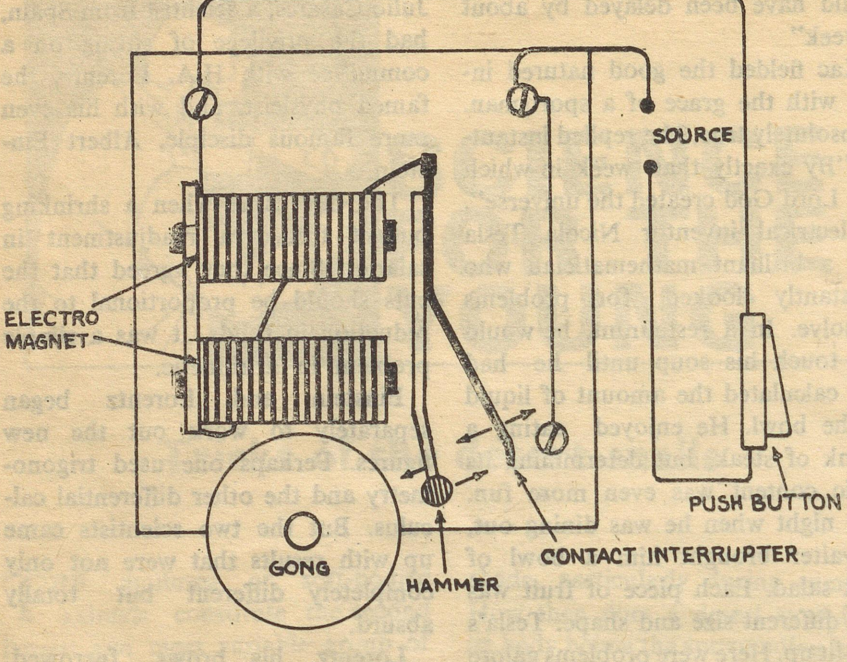


Fig. 1

soon as this happens, the electromagnet acquires the magnetic property and so attracts the hammer. The hammer when pulled stretches the contact interrupter. The circuit, as a result, gets broken. The electromagnet loses its property resulting in the release of hammer. When the hammer jumps back, the contact interrupter also jumps back, and the circuit becomes complete. The electromagnet therefore again attracts the hammer and the process repeats. While the shaft of the hammer hops from electromagnet to the contact interrupter, the other end

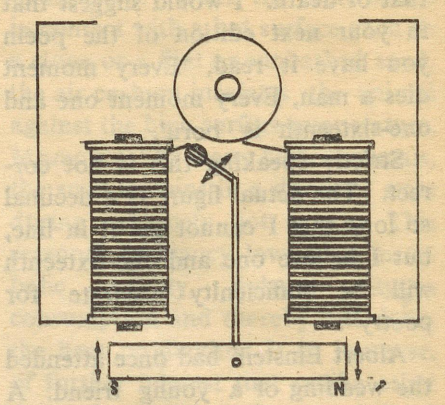


Fig. 2

strikes the gong, producing that metallic shrill sound we call a 'ring'. As long as the button is pressed the bell continues to ring.

In the telephone, there is a different type of bell which produces the less shrilly sound. Shown in Fig. 2, there are two electromagnets and the hammer is itself a magnet. This bell works on alternating current. Depending upon the polarity of the electromagnets, the hammer is attracted by either of them, producing the buzzing sound.

Dilip M Salwi

## Books Received

**CYTOGENETICS, PLANT BREEDING AND EVOLUTION** by U. Sinha and Sunita Sinha *Vikas Publishing House Pvt. Ltd.* 5 Ansari Rood, New Delhi, Pp 319, Rs. 45

**FLORA OF HASSAN DISTRICT KARNATAKA, INDIA** *by* Cecil J. Saldanha and Dan H. Nicolson, *Amerind Publishing Co. Pvt. Ltd.*, 66, Janpath, New Delhi-110001, Pp. 915, Rs. 75

**OPTIMIZATION TECHNIQUES** *by* Asghar Husain and Kota Gangiah, *Macmillan Co. of India Ltd.*, 2/10, Ansari Road, New Delhi-110001, Rs. 18, Pp. 317

**SCIENCE IN ACTION (Books I-IV)** *by* Meera A. Parasnis, *Macmillan Co. of India Ltd.* 2/10 Ansari Road, New Delhi-110001

**HUMAN POPULATIONS** *by* David Hay, *Penguin Books Ltd.*, Harmondsworth, England, Indian Agents, *Penguin Overseas Ltd.*, 706-Eros Apt, Nehru Place, New Delhi-110024, Pp. 96, £2,75 Net

**LADY LUCK : THE THEORY OF PROBABILITY** *by* Warren Weaver, *Penguin Books Ltd.*, Harmondsworth, England, Indian Agents : *Penguin Overseas Ltd.*, 706-Eros Apt., Nehru Place, New Delhi 110024, Pp.291, £1.

# Science oddities

A PLANT that bursts into flame spontaneously, if the weather gets too hot, seems a figment of an overactive imagination. But *Dictamnus albus*, commonly called fraxinella or gas plant, does just that. On its inflorescence and flower stalks are numerous tiny oil glands which give out a volatile inflammable vapour. When a lighted match is held near, or when the temperature rises very high, this gas ignites and burns with a brilliant blue flame. Some people believe that this is the 'Burning bush of Moses' mentioned in the Bible.

✦✦ ✦✦ ✦✦

TEN meters long, with two rows of enormous bony plates on its back, and a grotesquely small head, the ten - ton Stegosaurus was indeed the oddest looking of the Dinosaurs. However, the most peculiar thing about this animal was not its appearance, but the fact that it had two brains—one in the head, and the other in its hip! The brain in the head was tiny, weighing no more than 70 gms. and functioned merely to work the jaws, while the one in the back controlled movements of the legs and tail. Experts are of the opinion that inspite of having two brains, this enormous creature was not even as intelligent as a three-week old kitten!

✦✦ ✦✦ ✦✦

THE idea of a steel ball bouncing higher than a rubber ball may sound quite incredible. Yet it is true. This is because the bounce of a substance depends on its elasticity, i.e., its ability to recover its original form or size when stretched or compressed. Though it is hard to believe, steel is one of the most elastic substances, while rubber has rather poor elasticity—though it is easy to stretch or compress, it does not return to its original shape or size accurately.

✦✦ ✦✦ ✦✦

THE only birds in the world that are not guaranteed colour-fast are the African Touracos. They are beautiful birds found in the tree tops in tropical jungles, running nimbly along the branches. Most of the species are crested, and brilliantly coloured in golden green, peacock blue and violet in various combinations, the lovely plumage being set off by crimson wings. This crimson colour is due to a special pigment found in no other bird in the world. When there is a heavy shower, this exclusive pigment is said to dissolve and get washed out by the rain.

✦✦ ✦✦ ✦✦

TO a person on earth the sun appears to be the largest and brightest object in the sky. But actually, the Sun is really a rather small star and only looks so big and bright because it is very near to us. There are stars like *Epsilon Aurigae B* which are estimated to be so vast that the entire solar system upto Saturn could be placed inside them. In fact, we would have to put 27,000 million suns together to make a star of that size. Relatively smaller, but still enormous, is the red giant star, *Antares*, which is 640 million kilometres across, and 290 times as large as the sun.

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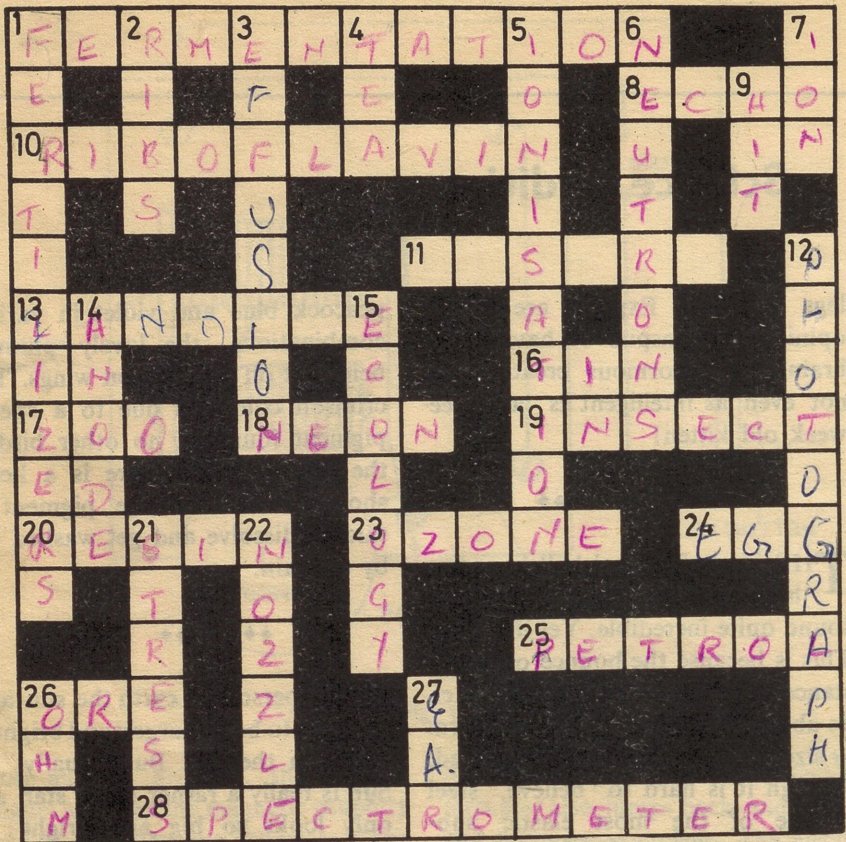
# Science Crossword Puzzle



## CLUES

**Across**

1. No bread without it.
8. You hear it, when you speak into a well.
10. A water-soluble vitamin.
11. What active charcoal does in refining of sugar.
13. Regular array of atoms or ions in space.
16. A metal that coats household utensils.
17. A home for wild animals.
18. A gas used in advertising.
19. What a mosquito is :
20. Exuded by some plants.
23. A gas which is a powerful oxidising agent.
24. A protein-rich diet.
25. A fraction obtained from petroleum.
26. A source of metals.
28. An instrument to measure wavelength.

**Down**

1. Chemicals to boost agricultural production.
2. Bones that protect lungs and heart.
3. Flow of gases from higher to lower pressure.
4. A drink prepared from processed leaves.
5. Its degree is higher in the case of strong electrolytes.
6. Fundamental particles, which hydrogen atoms lack.
7. An electrically charged species.
9. What a missile does to a target.
12. It uses silver halides which are sensitive to light.
14. An electrode where chlorine is liberated during electrolysis of NaCl.
15. Science that deals with organism in relation to the surroundings.
21. Hooke's law relates it with the strain applied to the body.
22. A converging tube connected to a hose or a pressure chamber.
26. A unit of resistance.
27. Spike of corn-containing seeds.

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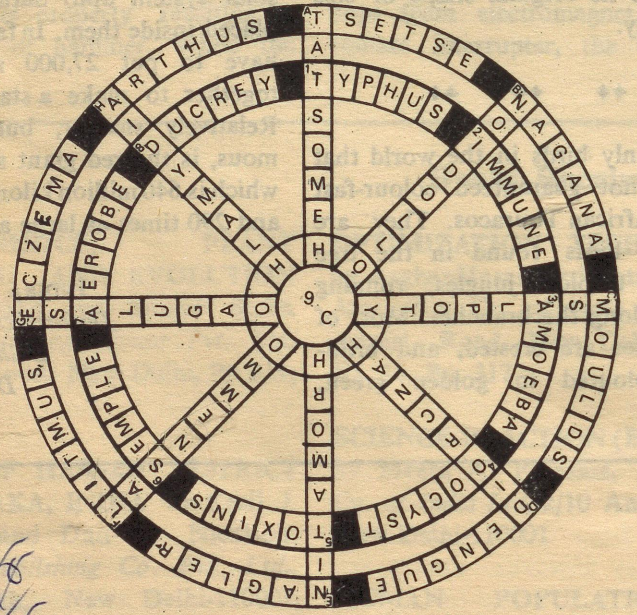
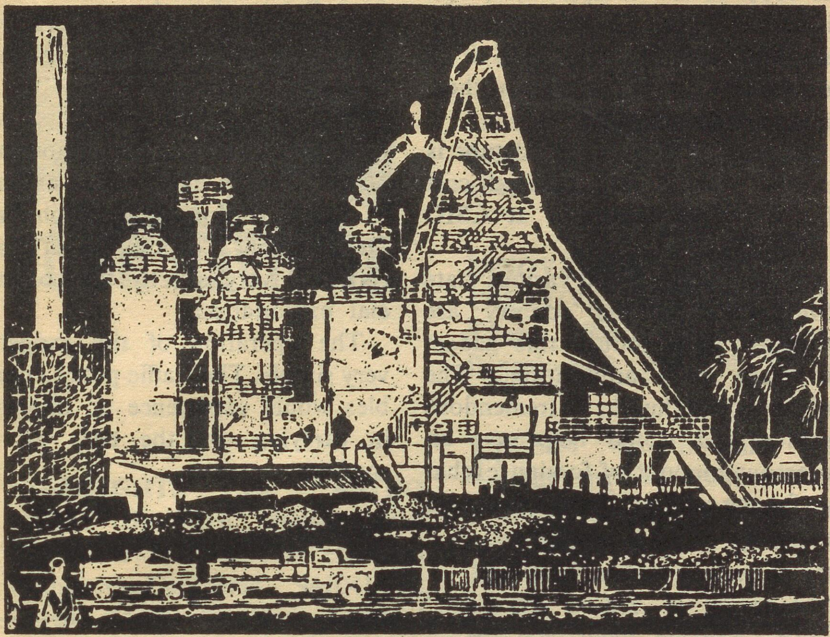



**Solution to wheelword Puzzle Published in SR Jan. 1977**



# SCIENCE IN INDUSTRY

## CSIO develops breath alcohol analyser

CENTRAL Scientific Instruments Organisation, Chandigarh has developed a Breath Analyser for estimating the level of alcohol in the blood in order to determine the level of drunkenness in the human subjects. The device has been developed at the special request from the Directorate General of Technical Development, Government of India, New Delhi.

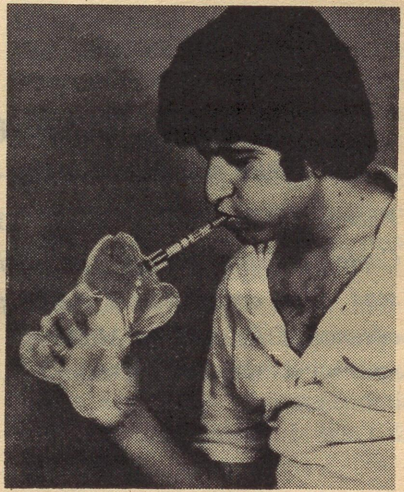
The device is in the form of a small disposable glass tube which would enable police and traffic control authorities to detect cases of drunkenness which might lead to traffic offences/ The need for developing this gadget arose because of the high incidence of road accidents which take place due to drunkenness of the drivers of motorised vehicles.

It is known that the consumption of alcohol impairs the judgement and reduces the efficiency of the drivers. The blood alcohol concentration is almost universally accepted as a reliable indicator of intoxication but it is not always possible to conduct blood tests due to certain inconveniences caused to the officials, hospital authorities and the driving public. Fortunately, the relationship between the breath and blood alcohol levels have been found to be reasonably constant for practical purposes. Therefore, in many countries of the world, breath alcohol analysis tubes have been adopted for the determination of the blood alcohol concentration for several years.

In United States, people can be convicted on the basis of the breath analysis alone. In many countries of the world, a blood alcohol level of 80 mg per 100 ml has been accepted as the legal level for convicting purposes.

The device developed at CSIO detects alcohol in the breath and provides immediate information whether or not the driver suspected of having consumed alcohol should be sent for blood examination. The gadget can be used for simple roadside screening tests. If the test is positive, the person could be taken to the police station and asked to provide a specimen of blood or urine. If the alcohol level in the blood exceeds 80 mg per 100 ml of blood the person may be convicted.

The gadget comprises of an indication tube containing a yellow coloured substance and is accompanied with a breathing bag and a mouth-piece. The person to be tested for drunkenness is asked to blow through the mouth-piece till the bag is fully inflated. It takes about 10 to 20 secs. to completely inflate the bag. The blood alcohol concentration is indicated by the green colouration of the yellow colour substance.



In case the blood level exceeds .08% or more, the discoloration reaches the red band marked on the tube. The extent of change of colour of the tube is proportional to the concentration of alcohol in the blood.

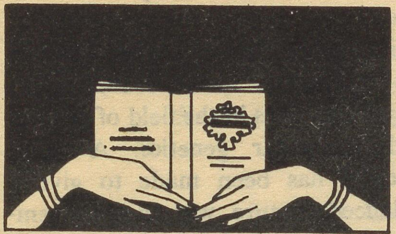
Extensive tests on this device have been carried out at the Post-graduate Institute of Medical Education & Research Chandigarh, by actually analysing the blood alcohol level in the human subjects after administering measured quantity of alcohol to them. The experimental results excellently correlated with the level indicated by the tube. A few samples were also given to the Chandigarh Police for carrying out field trials and it is proposed to give them more of these for the same purpose.

The cost of the imported tube is Rs. 15/- whereas the material cost of the gadget developed at CSIO is Rs. 2/-.

It is understood that various state governments in the country are interested to introduce this gadget for mass scale applications. The gadget would thus have tremendous demand and would help save an enormous amount of foreign exchange for the country. There might also be a great export potential for the item as it can be produced very cheaply due to low labour costs in our country.

The design of the gadget has been fully perfected and the know-how of the same is likely to be assigned to the National Research and Development Corporation of India (NRDC) very shortly for commercial exploitation.

The operation of the gadget is very simple. The traffic police constables would experience no difficutlty in carrying out the tests on the roadside.



# BOOK REVIEWS

**HIGHLIGHTS OF ASTRONOMY** By Fred Hoyle, *W.H. Freeman and Co.*, 660 Market St. San Francisco, California 9410411/58, Kings Road, Reading, England, R413AA, pp. 179, Cloth $ 10.00, paper $ 5.00.

FRED Hoyle is no stranger to scientists and science interested citizens. The Kalinga Science Prize Winner has been communicating astronomy to lay readers in the simplest language possible. He is indeed one of those few scientists who are as good in their subjects of specialisation as in the art of communication to laymen.

Fred Hoyle has been a Professor of Astronomy for a number of years. Sometimes he has also shaken the world of astronomy with his fresh and unconventional theories. However, his talent for making science understandable to laymen cannot be questioned.

The book under review is exceptionally beautiful, both for its excellent production and for the presentation of the matter. All aspects of cosmology have been explained simply, interestingly and chronologically. Illustrated pictures have added greatly to the value of this book. There is also a discussion of the perennial question whether there is life in the universe outside the earth. How life originated on this earth has also been discussed lucidly. This book will be a valuable addition to the personal collection of those who want to know how the universe originated and what has been discovered in the past 50 years about it.

**INNOVATION SUCCESS AND CREATIVE THINKING** by Anand Khare, *Bablu Books Company*, Bangalore-59, Pp. 239, Rs. 45.

EVERY man in this modern age requires creative thinking, whether he wants to invent/discover something or to earn his livelihood. The book under review, as claimed by the author, is meant to serve this all round purpose. But how much it will be a success in this respect I am doubtful. On the whole, however, the book takes one for a costly ride (mind it, the price is Rs. 45) through the various aspects of creative thinking and innovative processes fairly well.

The first part of the book, which is about the "unfreezing the personality" has indeed been well written; but in the second part the author fails to maintain the tempo and one suddenly finds himself to have finished the book, so much abrupt is the ending! The author should have taken pains to comment and brief the reader as to how he should then develop in his life creative and innovative thinking. A slight repetition could have been tolerated to the dissatisfaction one gets after reading it.

Interposed with interesting stories, particularly from Indian folk tales, of Indian kings, poets, scientists, quotations from great and creative people, plus a dash of humour here and there, the "unfreezing of personality", which contains how a peak experience in one's life can change one's way of thinking, how to think creatively by changing the reference frame, how to take idea from an experience and add it to that of another, bringing vague ideas into mind and make them solid, the psychological factors involved, makes a gripping reading. For instance, in the discussion of how to "unfreeze" yourself, arouse confidence in oneself, the author aptly puts in the story of a lion cub, who having been due to circumstances remained in the company of sheep, thinks himself as a sheep and bleats. The author, by including General Patton's words in the World War II to his soldiers that "No bastard ever wins a war by dying for his country, but he wins because some other bastard dies for his country", makes appropriate impression on one's mind as to how man can imbibe in himself spirit by changing reference frame of his thinking.

The second part is serious in content. In it the author discusses the various tools, processes and methods to do an innovation (a term with broad implications). Though he has tried his best to explain everything, every scientific and technical aspect of the problem clearly, giving stories and examples from different walks of life, in the end a reader may wonder where he has been led to? Possibly, this is a result of lack of coordination among the chapters. This part may be of more interest to the management science students and industrialists, who want to acquaint themselves with, for instance, queuing problems, logical dummies, etc.

The book is well produced but priced high to keep it within the reach of managers and industrialists only, in contradiction to the purpose of the book. The style of writing is lucid and impressive. Illustrations are not clear at some places; index is lacking; and there are many "recommendations" on the dust jacket I don't know what for.

DILIP M. SALWI

**TEXT BOOK OF PHYSIOLOGY VOL. I.** by B.K. Anand and S.K. Manchanda, *Tata McGraw Hill Publishing Company Ltd.*, Asaf Ali Road, New Delhi-110001, Pp. 343, Rs. 42.75

It has been felt in recent years that reorientation of teaching in science and technology in the country is necessary to expose students to the endogenous problems requiring scientific and technological solutions. And when it comes to the medical education in the country, there needs to be laid special emphasis on clinical and community health services. While the basic or core of any curriculum in medical education remains the same throughout the world, the concept of knowledge through the text books written mostly in Western countries and based on Western experiences is a vexed one, mainly for two reasons: first, the levels of knowledge and skill on the commencement of medical education may be quite variable across countries; second, the learning pattern of students are considerably influenced by the local educational conditions to which students are exposed during studies preparatory to the medical education. Besides, the Western text books presently available for the undergraduate medical student are also very expensive.

The book under review, written by some Indian medical educationists, is however one positive development in this direction; this book is the first volume of a three volume *Text Book of Physiology* for medical students. It is divided into four sections and runs into 334 pages plus a nine page index. The first section includes a brief introduction to physiology and describes physiology of cell and cell membrane, nerve and muscle. The second section deals with various aspects of the physiology of nervous system, and third and fourth sections deal, respectively, with control and regulation and physiology of special sense organs. As mentioned by B.K. Anand and S.K. Manchanda in the preface, the book is written in simple English and would prove easy-to-understand for medical students. Based on the lectures which its contributors have been delivering to medical students over a number of years in the past, the book's style of presentation of the subject is appealing. Another quality of the book is an "organ system approach" which would definitely help students in understanding the basic physiological facts. However, at many places details have been sacrificed and the bibliography is missing—all this done deliberately to make the book brief. Moreover, an inquisitive student could always consult more advanced text books and review articles. The book does justify its merit, but is not the price of Rs. 42.75 for this single volume of a three volume Test Book of Physiology just high in the present context?

DR. ZAKA IMAM

**TOWARDS AN UNDERSTANDING OF THE MECHANISM OF HEREDITY** by H.L.K. Whitehouse, *ELBS* 1973 (3rd Edition), Pp. XVI + 528, 43s. 0d.

Dr. Whitehouse is a Reader in Genetic Recombination at the University of Cambridge. He is a product of the wave of the molecular genetics which originated only after the stimulating discovery of the structure of the DNA molecule. He has devoted himself to the problem of genetic recombination at the molecular level. As a result, he proposed the molecular mechanism of crossing over and this hypothesis is known as "Hybrid DNA Model". The book under review aims at giving the reader an overall view of the subject. It includes the recent major advances in the field of general and molecular genetics. A good attempt has been made to give a balanced picture with a great emphasis on principles and concepts alongwith the most recent research in the field of genetics.

There are in all eighteen chapters and each chapter deals with a particular theory. In each chapter the major discoveries are given in the order of their occurrence. The important contributions are illustrated with appropriate experimental observations. Each chapter ends with a very well written 'Conclusions' for clear understanding.

Dr. Pontecorvo of the University College, London, has rightly pointed out, in his Foreward to the Whitehouse's book, that "It traces the basic ideas of Genetics through their development and describes concisely, yet without omitting any essential detail, the critical experiments which led to the establishment of each of those ideas. This historical approach........is not at the expense of keeping abreast with the advancing frontiers". The sequence of chapters is also more or less linked to the sequence of development of understanding of genetic mechanisms.

A well written 10 page glossary of genetical terms is included for the benefit of the students. However, no pains have been taken to explain the process of protein synthesis diagrammatically in Chapter 14. Also, it does not deal adequetely the important fields of population genetics, human genetics and evolution.

In short Dr. Whitehouse must be complimented for producing a work that really reflects the growth of a science. However, this book cannot be recommended for the undergraduate courses of Indian Universities. But it can be a very good text book for the Post-graduate students.

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**A FIRST COURSE IN APPLIED ELECTRONICS**, by W. Gosling, *Macmillan Press Ltd.*, London, 1975, p. 162, £ 2.95. Representive in India: 2/10 Ansari Road, New Delhi-2

LIKE discrete component circuits, integrated or micro-electronic circuits are systems of interconnected transistors, diodes, resistors and capacitors. The difference in discrete and integrated circuits is that the monolithic integrated circuit is made exclusively within a single crystal of semiconductor silicon—all the components being formed and interconnected in a single series of processing operation. Microelectronic circuits are quite small in area. Seven or eight transitors used in complicated amplifier can be accommodated on only a millimeter square of semiconductor slice surface; the slice being a fraction of millimetre thick. Usually, an integrated circuit contains tens or hundreds of components formed within a single silicon crystal. As regard the cost, technical specification, re liability and size, integrated circuits are indeed superior.

The amplifier is the most important of all electronic circuits. The book under review is based upon microelectronic amplifiers. The one, who hopes to design integrated circuits, will have to refer the subject back to its physical origins. For the majority of the professional engineers interested in the application of integrated circuits in complicated electronic systems, however, the physical processes occurring within microcircuits have less importance. The author, who is a Professor of Electrical Engineering at the University of Bath has thus rightly designed the book regarding the properties of the microcircuit as the basic point and developing a complete theory of applied electronics at an elementary level.

The book begins with an introduction to electronics where the author has discussed the need of the integrated cirtuits, their fabrication technology and amplifiers in general. The fundamental principles of amplification have been described in Chapter 2. In this chapter five kinds of the most important amplifiers have been described and of these only two, the variable dissipation amplifiers and the switching amplifiers, are likely to find use in integrated circuits. In Chapter 3, the amplifiers have been discussed in detail. Noise can arise in amplifiers from a variety of different process, swhich are included in Chapter 4.

As the name suggests, the feedback is a technique of taking out some of the output power from the amplifier and feeding it to the input circuit again. By the use of feedback the characteristics of the amplifiers can be modified. A considerable portion of the book has been devoted to the theory of feedback, its use in practice and feedback problems. Both wanted and unwanted effects of feedback on amplifiers have been described.

The architecture of the book is good. An important feature of the book is that each chapter ends with a number of problems, the worked-out answers of which have been given in the end. A list of appropriate references has also been included wherever necessary, which enables the reader to find sources of further study. The book provides a pleasant reading with short and useful proofs. It has been lucidly written with remarkable coherency. There are only a few mistakes (for example 'E' represents both efficiency and voltage in a single equation on p. 10, i.e., $E=\frac{E-V}{E}\cdot 100$)

The book is useful for self-study, students of technological courses, and professional engineers engaged in integrated circuits.

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