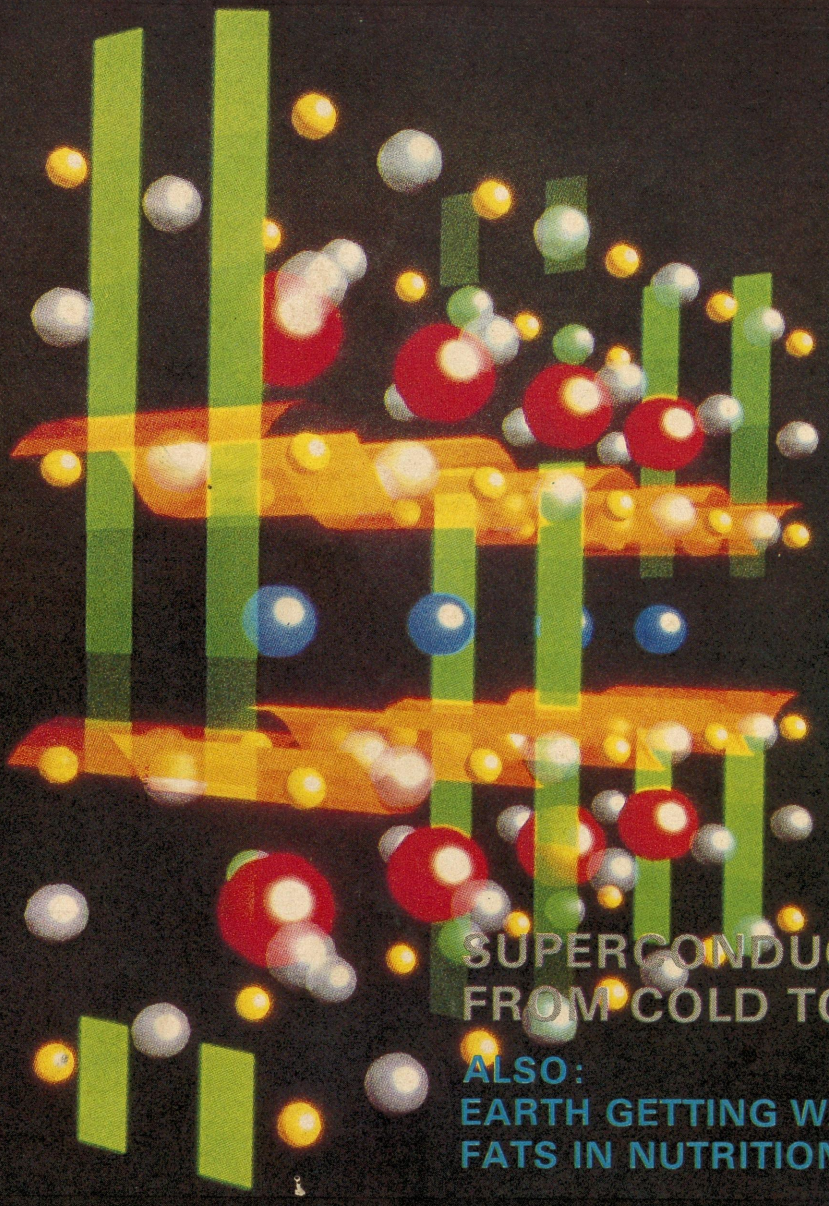
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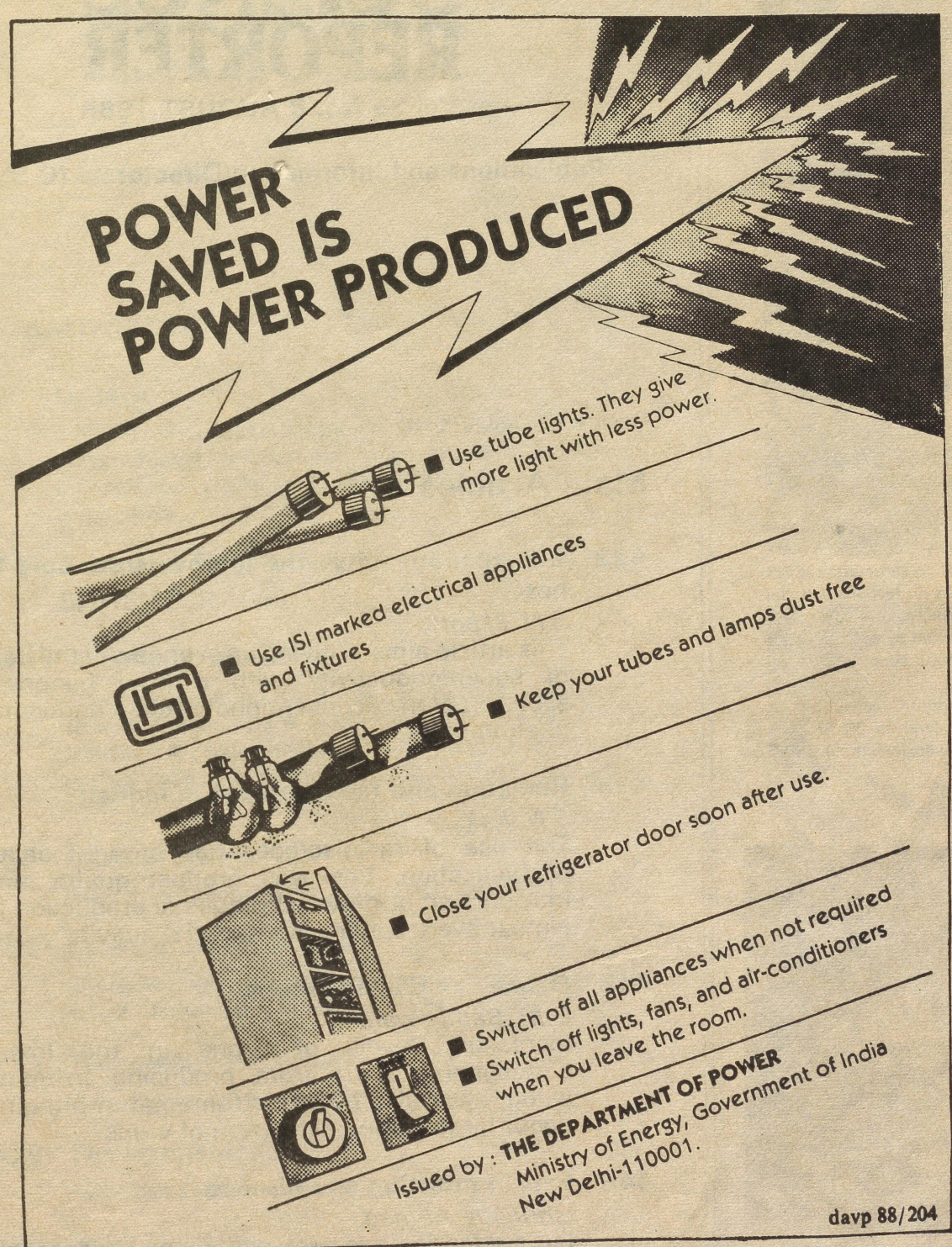
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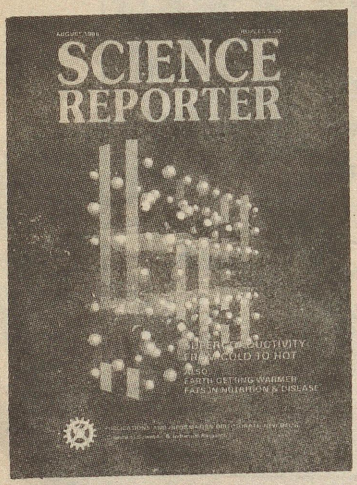
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Cover: Model of the structure of $Y_1Ba_2Cu_3O_x$.
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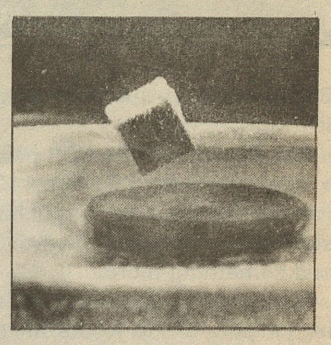
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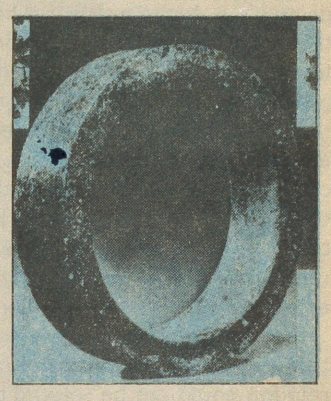
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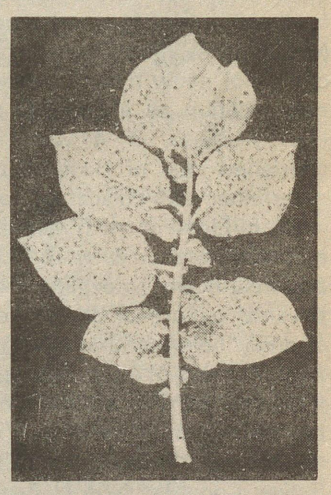
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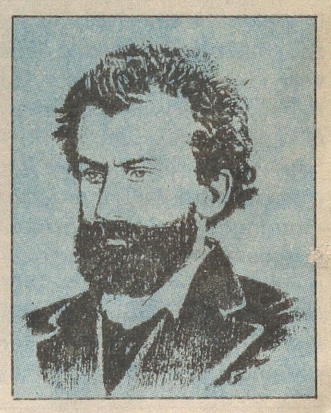
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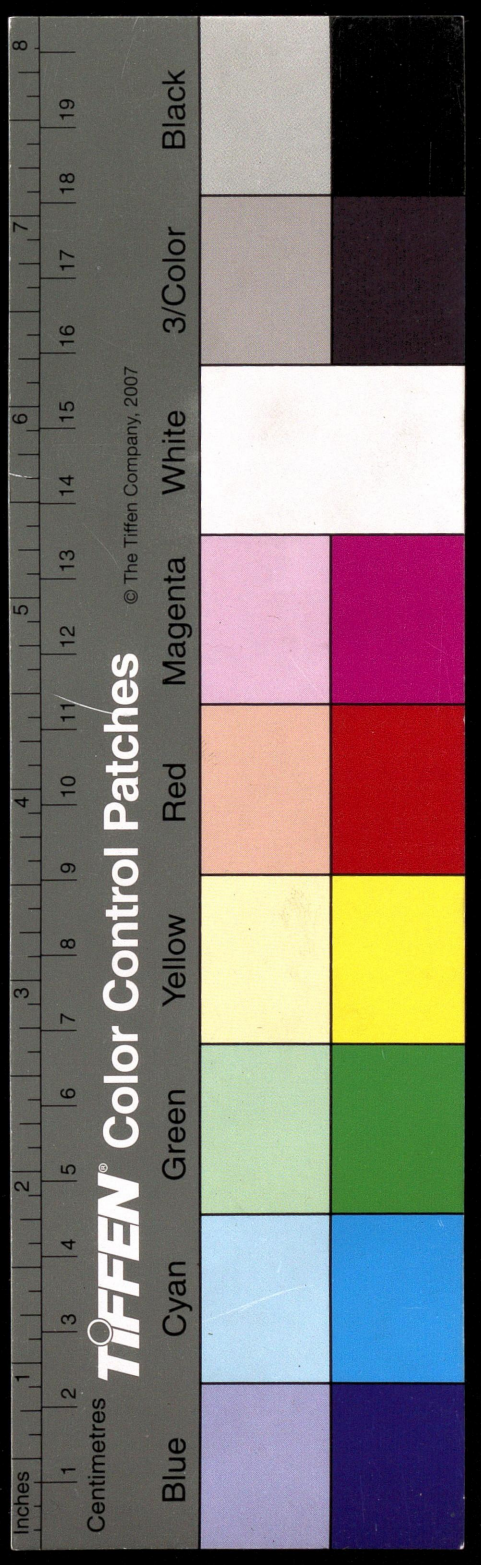
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LETTERS

Einstein versus quantum mechanics

Sir, The article **The EPR paradox in a new context** (*S.R.*, May 1988) by Partha Ghose was interesting and educative. I would, however, like to add something more.

According to quantum mechanics it is not possible to locate an electron precisely at a given point in space at a given time. It can predict at best only the probability of an electron being found at a given small volume at a given time. Einstein did not agree with the other minds of Europe in regarding electron as 'smeared out' into a cloud of negative electricity having different densities at different points. His firm belief in 'Local reality' inspired him to refute the famous 'uncertainty relation' as presented by W. Heisenberg.

Einstein, however, knew very well that the derivation of the uncertainty relation could not be refuted because of its proof which was based on the fundamentals of quantum mechanics. Nevertheless, his philosophy of nature could not allow him to consider this new relation as a genuine physical law. Because, if it were so, his cherished idea of classical absolute determinacy was discarded for ever.

So, to Einstein the fundamentals of quantum mechanics were incomplete and insufficient to explain the proper physical picture of our universe. He strongly believed that they (i.e., the fundamentals of quantum mechanics) lacked something extremely important but he did not know what it was. He announced his objections at the Fifth Solvay Congress held at Brussels by inventing intricate paradoxical cases in which the uncertainties reduced to zero and thereby tried to establish the very idea of classical absolute determinacy. But it was an irony of fate that God played dice with him!

To quote W. Heisenberg, "..The discussions usually started in the early morning when at breakfast Einstein suggested a new imaginary experiment.

"Naturally, we immediately started analyzing it..... As a rule the same evening at supper Neils Bohr successfully demonstrated to Einstein that even this newest conjecture of his could not shake the uncertainty relation. Einstein started to fret, but the next morning at breakfast he had ready one more imaginary experiment, more intricate than the previous one, which he believed would at least irrefutably demonstrate the invalidity of the principle of uncertainty. But by the evening of the same day this attempt was no more successful than the previous ones".

Quantum mechanics won even against its strongest opponent! But it is quite possible that Home, Datta and Raychaudhuri's ideas will lead us to a major "breakthrough".

Partha Pratim Biswas
Department of Physics
Durgapur Govt. College
Durgapur

Value of π

Sir, The value of π (*S.R.*, May 1988), i.e., 22/7, was given not only by L. Vanceulers in 1596, but also by Bhaskaracharya in 1150 A.D. In his treatise written in Sanskrit, he writes "when we divide 22 by 7 we get the value of π, which will be only useful for easy calculation but the value 3927/1250 is the most accurate."

G.S.Srikanth
144, Ist 'N' block
5th Cross
Rajaji Nagar
Bangalore-560010

Nice presentation

Sir, I liked **Love on the run** by O.P. Bhagat of New Delhi (*S.R.* May 1988). Though it is a well known fact, its presentation was nice.

I am also thankful to you for publishing "Book Reviews" as the section helps us to know about new books.

V. Anbalugan
Muthalpet
Pondicherry-605003

Mini-batteries from leaves

Sir, Thanks for the interesting item **Mini-batteries from leaves** in 'Science Spectrum' (*S.R.*, May 1988). The author's idea is innovative. The real problem however lies in its use.

Sandeep Rajwanshi
Sunmica Factory
Nagda (Dhar) MP

AIDS

Sir, I am an avid reader of *SR* from my late school days. Most of the articles are interesting and informative. I would like to thank you for publishing **Gene therapy** (*SR*, April 1988). The article gives information on the possibility of the development of AIDS vaccine. This information will certainly be of use to me because we study AIDS epidemiology in the M.B.B.S. course.

Partha Singha
Sreenagar
P.O. Ichapore-Nawalganj
24 Parganas (North)—743144
(West Bengal)

A boon for science students

Sir, I have been reading your magazine with interest for the last ten years. It is a boon for science students.

I heartily congratulate Dilip M. Salwi and Biman Basu for their articles **Gerald Durrell—the zoo owner extraordinary** and **IRS in orbit** respectively in April 1988 issue. The articles were informative, educative and instructive. Also, the Cartoons by Pradeep K. Srivastava were meaningful.

I would suggest the inclusion of science crossword puzzles in *SR* to sharpen our ability to solve science problems.

Manas Jyoti Sarma
Morigaon
Assam-782105
(Continued on page 436)



Planetary positions for September 1988

Date	*1st*		*10th*		*20th*	
Planets	*R.A.*	*Decln.*	*R.A.*	*Decln.*	*R.A.*	Decln.
Mercury	12h 05m	1.2S	12h 46m	7.0S	13h 22m	11.3S
Venus	7h 39m	19.2N	8h 18m	18.0N	9h 03m	16.0N
Mars	0h 50m	0.4S	0h 45m	0.9S	0h 36m	1.65S
Jupiter	4h 14m	20.2N	4h 16m	20.3N	4h 18m	20.3N
Saturn	17h 42m	22.4S	17h 43m	22.4S	17h 44m	22.5S

Adopted from figures supplied by Positional Astronomy Centre, Calcutta

The moon

NEW moon occurs on 11th at 10.19 a.m. and full moon occurs on 26th at 00.37 a.m. I.S.T. The moon passes about six and a half degrees north of Jupiter on 3rd and again on 30th, six degrees north of Venus on 7th, about half a degree south of Mercury on 13th, six degrees south of Saturn on 19th and about seven and a half degrees north of Mars on 26th. The moon is at apogee or farthest from the earth on 10th and is at perigee or nearest to it on 25th. The lunar crescent becomes first visible after the new moon day in the evening of 13th. In Southern part of India the moon is likely to be visible one day earlier.

Solar eclipse

There will be an annular eclipse of the sun on 11th. Its partial phases will be visible in India except from the northern and north-eastern parts. Considering the earth as a whole the eclipse begins at 7h 16m and ends at 13h 11m I.S.T. Its duration for any particular place will, however, be much shorter. Its visiblity times for four major Indian cities are as follows:
Calcutta: begins 7th 45m ends 9h 32m;
Bombay: begins 7h 22m ends 9h 39m;
Delhi: begins 7h 45m, ends 9h 05m;
Madras: begins 7h 23m, ends 10h 04m I.S.T.

The earth is in autumnal equinox on 23rd.

The planets

Mercury (*Budha*), visible in the evening sky sets about an hour after sunset during the month. It is in greatest eastern elongation of about 27° on 16th. It passes about one and a half degrees south of Spica (*Chitra*) on 21st. It becomes retrograde on 29th. On 30th it comes too close to the sun to be visible. It passes from Virgo (*Kanya*) to Libra (*Tula*). Its visual magnitude varies from —0.1. to 1.0.

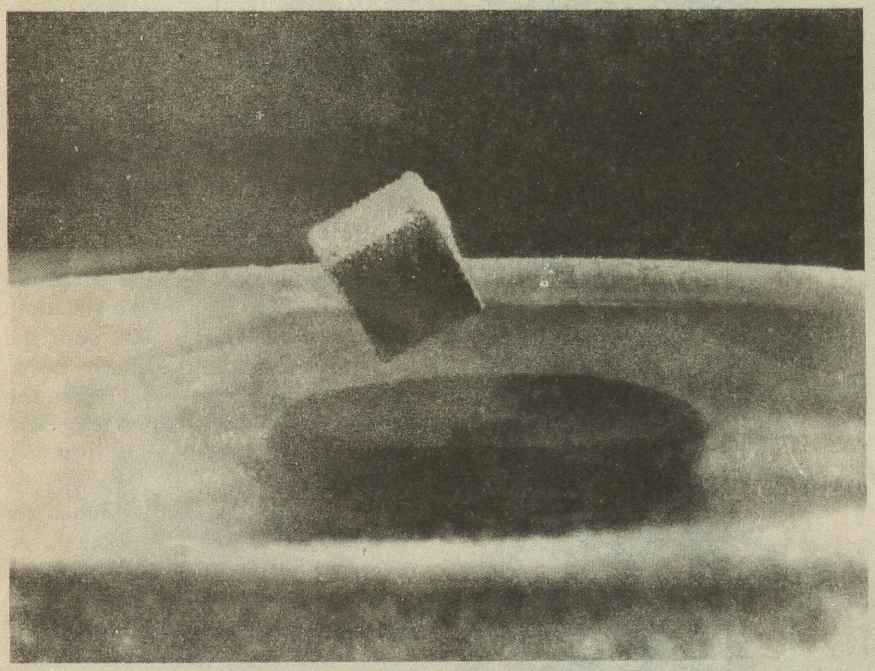
Venus (*Sukra*), visible in the morning sky, rises about two hours after local midnight during the month. It passes about nine degrees south of Pollux (*Punarvasu*) on 2nd. It moves from Gemini (*Mithuna*) to Leo (*Simha*) through Cancer (*Karkata*). Its visual magnitude is about —4.2.

Mars *(Mangala),* visible in the morning sky, rises about one and a half hours after sunset during the first half of the month and about half an hour after it during the second half being in

(*Continued on page 436*)

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SUPERCONDUCTIVITY — the journey from cold to hot



S.N. EKBOTE

This article aims at giving an overview of the field of high-temperature superconductivity with a brief historical sketch of the conventional superconducting phenomenon

ABOUT a year and a half ago the discovery of materials carrying resistanceless current (i.e., superconducting) at temperatures well above the boiling point of liquid nitrogen (77 K) was so sudden and dramatic that not only the scientific community but every common newspaper reader felt the warmth of an abrupt eruption of the sleeping volcano of superconductivity. An unprecedented torrent of scientific and popular articles, interviews and discussions on television, radio and in newspapers beseiged almost everyone of us. Ever since the discovery of superconductivity by Kamerlingh Onnes in 1911, the realisation of superconductivity at room temperature, or even at liquid nitrogen temperature, had been a dream of scientists. It was well known that due to its vast potentials for both scientific progress and practical applications high temperature superconductors could revolutionise the technical world. But because of the long stagnancy in the field of enhancement of critical temperature T_c (the temperature above which superconductivity is spontaneously destroyed), as evident from the fact that the highest T_c until the autumn of 1986 was only 23.2 K — that of Nb_3Ge discovered in 1973, materials researchers were not very hopeful for the discovery of high T_c superconductors, and the unauthorised and non-reproducible high T_c claims appearing every now and then, further darkened the scenario.

In October 1986, a paper by J.G. Bednorz and K.A. Muller of IBM Zurich, Switzerland, reporting a new class of superconductors (La-Ba-Cu-O) superconducting at about 10 degrees higher than the previous record appeared in a West-German journal [*Z. Physik.* B—Condensed Matter, **64**, 189-193, (1986)]. Many of the researchers, fed up with such unreproducible reports, did not pay much attention to it, but at the same

Dr. Ekbote is Scientist, Low Temperature Physics Division, National Physical Laboratory, New Delhi-110012; he has been working in the field of superconductivity for the last 15 years.

time the confirmation and further work on these cuprate superconductors with a perovskite structure was in progress. In February 1987 the substitution of Y in place of La by Paul Chu and his group at the University of Houston, U.S.A., brought them a T_c of 92 K and that was the spark which ignited the world-wide excitement in the scientific community and fired the imagination of the general public. During the last year the scientific advancements have been so large and rapid that every week a new superconductor with higher T_c was being announced and researchers were using every communication media for their first claims or for the first reports of their experimental achievements. Of course, a number of unproven, non-reproducible and at times even erroneous and crummy results were also published, and now, after more than a year, when the scope and limitations are being realised to a certain extent by active research groups, the picture of high T_c superconductors is becoming much clearer. This article aims at giving an overview of the field of high temperature superconductivity with a brief historical sketch of the conventional superconducting phenomenon.



Karl Alex Muller and Johannes Georg Bednorz, who have been awarded the 1987 Nobel Prize in physics for their work in superconductivity

The phenomenon until it was 'hot'

The term superconductivity was coined for the phenomenon in metals in which an electric current can flow without producing any wasteful heat. This property of total absence of resistance to electric current was first observed in mercury at 4.2 K — the boiling point of liquid helium, by Kamerlingh Onnes at the University of Leiden, Holland in 1911. This raised great hopes among scientists and utilisation of superconductors for the production of magnetic fields was one that looked most promising. This thought of making high-field magnets from persistent currents in a superconducting coil had crossed Onnes' mind immediately after the discovery and he had tried a small solenoid made of lead wire. However, to his and others' disappointment, it was soon realised that at certain values of currents (J_c) and magnetic fields (H_c) the superconductivity gets quenched and the first few attempts of making solenoids of superconducting compounds were very baffling. Almost all the superconducting materials known at that time were having very low H_c and J_c, and were therefore of very little use for practical applications. (Low J_c is one of the major problems the high-temperature superconductors are facing.)



Paul Chu of the University of Houston, U.S.A.

In 1933 W.Meissner of Berlin and R.Ochsenfeld added a new dimension to the phenomenon of superconductivity by discovering that the superconducting state is a state of perfect diamagnetism. But this was not the exact situation. It was found that magnetic field does penetrate the superconductor but only upto a thin layer at the surface and this distance was termed the penetration depth (λ) which is of the order of 1000 Å in elemental superconductors like Hg, Pb, etc., and several microns in compounds and alloys like Nb_3Sn, Nb_3Ge, etc. The total expulsion of magnetic flux from the interior of a superconductor does not allow a magnet to remain on the surface of bulk superconductor and it floats in air. This was a rare laboratory experiment as demonstration of superconductivity required liquid helium which was not an easily available facility. But with today's high temperature superconductors it has become a common experiment. Almost every article, including this one, shows a picture of the levitated magnet which has become a sort of an emblem of high T_c superconductor research (opposite page). This property first gave a confirmation test for the superconducting state as scientists realised that the loss of resistance alone could be due to many other electronic instabilities. Secondly, it opened up the possibility of a completely new era of technological

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advancement. The superfast magnetically levitated trains are an outcome of this very property. One can say that the first age of the superconductivity era (up to early forties) ended with simple laboratory level investigations, some phenomenological theoretical attempts, which include the C.J. Gorter and H.B.G. Casimir's (1934) two-fluid model and F. London's (1935) famous idea about the energy gap between excited (normal) and condensed (superconducting) electrons, but without any successful practical applications.

The scenario changed rapidly after the Second World-War and a remarkable growth both in applied and basic understanding of superconductivity was recorded within a span of next thirty years. In the late fifties and early sixties B.T. Matthias and J.E. Kunzler at the Bell laboratories discovered a new class of high-field superconductor with very high current carrying ability. Such superconductors, known as type II superconductors, are generally compounds and alloys like Nb_3Sn, NbTi, Nb_3Ge, $PbMo_6S_8$, etc. Unlike type I or elemental superconductors they do not abruptly go under superconducting to normal transition on the application of magnetic field, but remain superconducting to a very high magnetic field even with the penetration of magnetic flux. Some of the important high-field superconductors are listed in Table 1. During the decade of sixties these superconductors practically moved superconductivity from laboratories to factories, and today fields in excess of 17 tesla can be very easily produced by superconducting magnets. These magnets have shown their superiority not only in laboratories but in high-energy research also where they are gradually replacing the conventional type magnets made of normal good conductors (i.e. copper), the power consumption of which is enormous. Towards the end of this period the highest T_c achieved was that of Nb_3Ge equal to 23.2 K and the highest H_{c2} of about 60 tesla of the Chevrel phase compounds was recorded in small specimens.

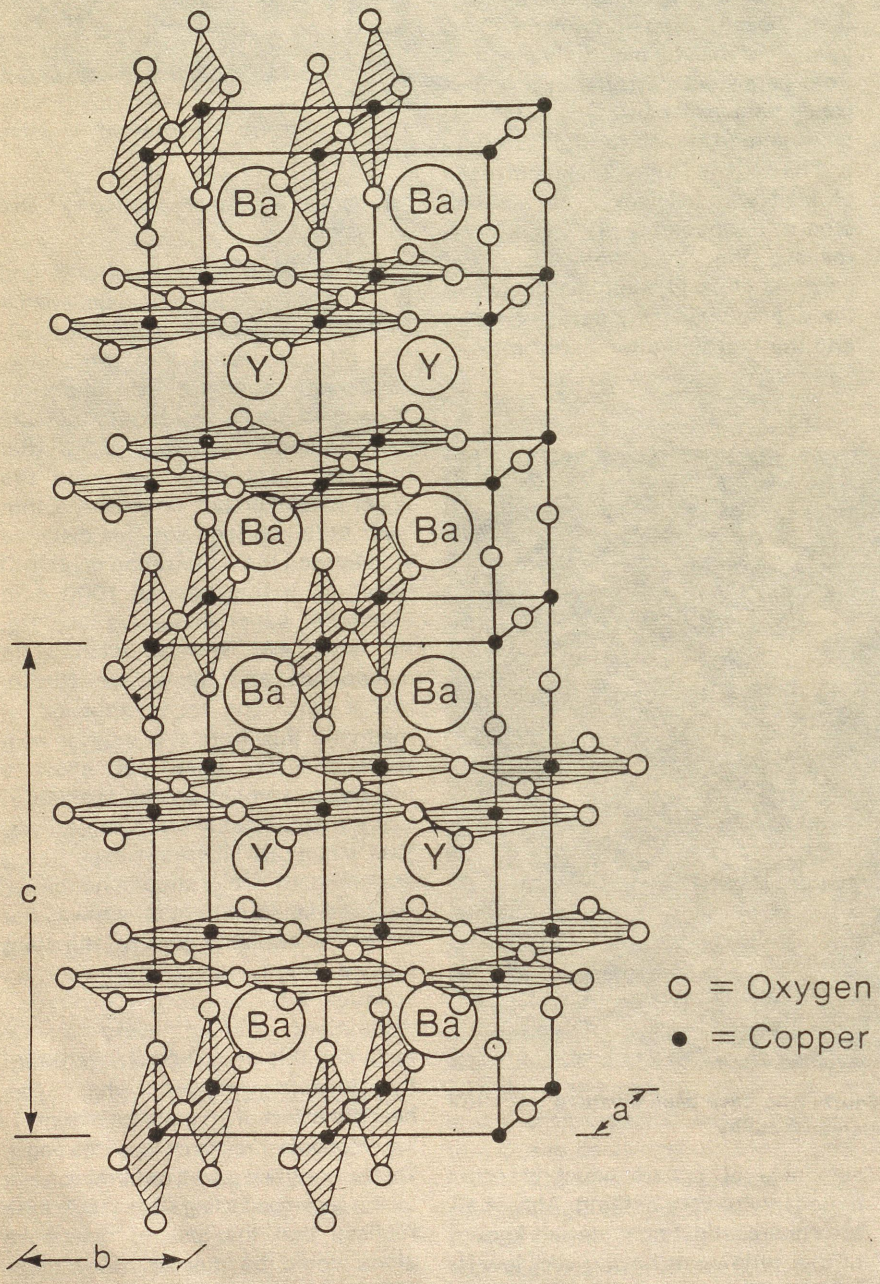


Fig. 1. Model of the structure of $Y_1Ba_2Cu_3O_x$ illustrating the two-dimensional Cu—O sheets and the one-dimensional Cu-O ribbons

A period of understanding

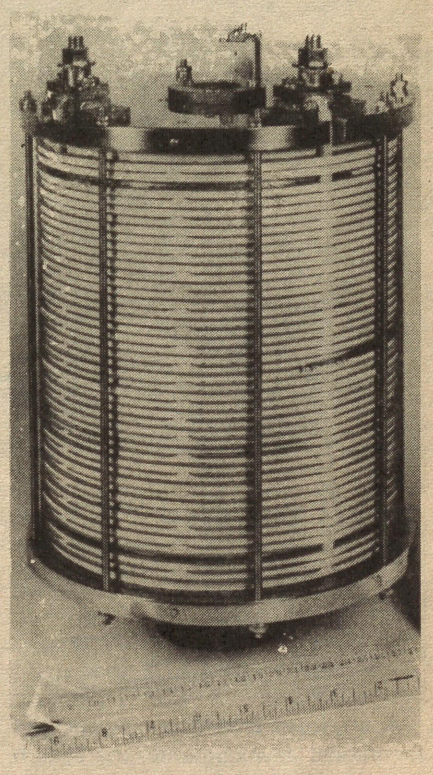
The search for new and usable superconductors which started slowly in 1950s had become so independent and complete by the late sixties that the basic side of superconductivity started falling apart, and superconducting alloys and compounds became just engineering materials—no longer of interest for the hard-core physicists. At the same time the basic understanding of the phenomenon of superconductivity was taking shape. H. Frohlich in 1950 independently suggested the importance of lattice-vibrations in the formation of the superconducting state. He pointed out that the attractive interaction between electrons due to their coupling with the vibrations of the ionic lattice can result in a ground state; and despite many limitations he could qualitatively predict the dependence of T_c on isotopic mass of the ion forming the lattice. Similar abortive efforts with different mathematical tools were also made by J. Bardeen in the same year, but due to the single-particle approach



Superconducting magnets for research purposes can be purchased on a regular commercial basis. Fields produced by these range between 5-15 tesla (50-150 kilo-gauss) over volumes in the range 1/100-1 litre. A typical small superconducting solenoid with its cryostat is shown above (*Courtesy:* **Oxford Instrument Co. Ltd. of U.K.)**

like that of Frohlich, he too could not go very far. Simultaneously it was experimentally observed that the change in ionic mass affects T_c. This isotope effect made theorists think that the electron-phonon interaction might be the cause of the superconducting state. The real breakthrough came in 1956 when in a short communication L.N. Cooper showed that an attractive interaction between two electrons having opposite spin and momentum results in a ground state and that such an electron correlation can be called an 'electron pair'. Using this idea J. Bardeen, L.N. Cooper and J.R. Schrieffer put forth a microscopic theory of the superconducting state in 1957, popularly known as the BCS theory. This theory has two fundamental assumptions: (1) below the critical temperature T_c the ground state is made up of two collective electron-pairs; and (2) the interaction responsible for pairing is due to the polarisation of crystal lattice by electrons. The first assumption (that of electron-pairs), has not only been proven, but has been widely used in different areas of physics like the superfluid He^3, nuclear structure, etc., but the second, i.e., the actual reason for electron-pairing has always been a point of dissatisfaction and now in new high T_c materials both of these are being examined critically. The BCS equations have been greatly modified and extended by many workers like A.B. Migdal, L.P. Gor'kov, Y. Nambu, G.M. Eliashberg, etc. Some very important developments that took place in the mid-sixties are: the determination of phonon density from the electronic density of states from tunneling spectra (J.R. Schrieffer *et al.*), the determination of phonon spectral form (W.L. McMillan and J.M. Rowell), McMillan equation for T_c, the inclusion of Coulomb interactions in superconductors (J.C. Swihart, P. Morel & P.W. Anderson), tunneling of electron pairs (B.D. Josephson), etc. The discovery of superconduct tunneling and the Josephson effect not only gave an entirely new basic concept but started a new field of applications as well. Josephson showed that if there is a small barrier ($\sim$10 Å) or weak-links between two superconductors, it is possible to have a superconducting current flow by tunneling of electron-pairs through the barrier which can be sustained upto certain critical values. This led to the development of Josephson-switches used in high sensitivity instrumentation (see applications).

In the above mentioned period, i.e., 1950-67, some elegant phenomenological theories were also put forth. In 1950 V.L. Ginzburg and Landau, using the two-fluid model of superconductors in which at all temperatures below T_c, normal and super electrons are present and that all superconductors can be described by the same wave function, worked out a theory of superconductivity. Although the phenomenological approach of Ginzburg and Landau did not touch the basic nature of superconductivity; it expressed a better picture of superconductors under magnetic fields and fluctuation effects near T_c. Their equations have been able to predict the Meissner effect and they have shown that between normal and superconducting regions of a material the surface-energies are positive. This result had also indicated the possibility of negative surface-energies which was later elaborated in the excellent work of A.A. Abrikosov who was the first to predict theoretically that some superconductors, later on called type II, can exist in a state which is neither completely superconducting nor completely normal (i.e., the 'mixed' state) over a range of magnetic fields determined by H_{c1} and H_{c2}, the lower and the upper critical fields respectively. It is this remarkable characteristic which makes type II superconductors so attractive for practical applications. In 1960, L.P. Gor'kov derived the same equations through the BCS formulation and thus, the GLAG (Ginzburg, Landau, Abrikosov, and Gor'kov) theory became a prominent theory of type II superconductors.

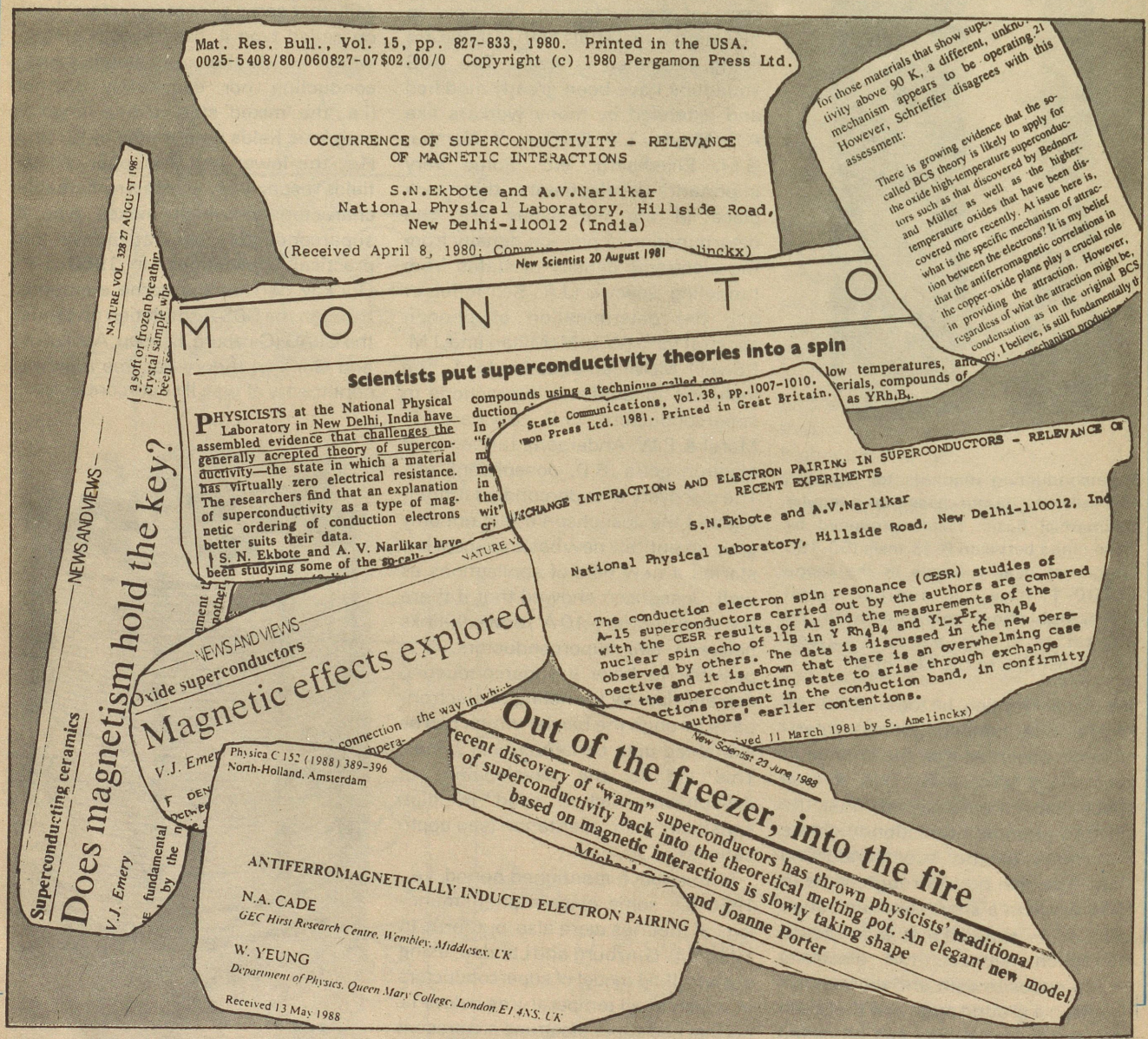


One of the highest-field superconducting magnets constructed to date. Nb_3Sn magnet, 158 kilo-gauss at 4.2 K, 165 kilo-gauss at 3.0 K, 26 mm bore, outer diameter 23 cm, and the magnet is 27 cm long. (From: Fietz *et al., IEEE Trans. Magn.* **MAG — 10, 246 (1974).**

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Pairing through magnetic interactions: an Indian model

RECENTLY, several reports have appeared in scientific literature which claim magnetic interactions to be at the root of high-temp. superconductivity. But, unfortunately, none of them mention about the work of two Indian scientists S.N. Ekbote and A.V. Narilikar of NPL who as early as 1980 had proposed a model on the basis of experimental findings to explain superconductivity through magnetic interactions as can be seen in the reproductions below. These authors also had in their book *'Superconductivity and Superconducting Materials'* (1983) predicted the possibility of high T_c superconductors through magnetic interactions.



Apart from the technological and theoretical developments, the search for high T_c materials was in full swing until 1973. Superconductivity was discovered in many compounds of entirely different classes of materials and crystal-structures. For example, metallic compounds like the A-15s (Nb_3Sn, Nb_3Ge, V_3Si, etc.), B-I compounds such as NbN, b.c.c. alloys like NbTi, etc., were all showing superconductivity and compounds of the perovskite family $BaPbBiO_3$, $SrTiO_3$ were also exhibiting the phenomenon. tions, etc., were putforth. It is striking electronic and structural properties like very high electron-mass (sometimes as high as 100 times that of electron mass) such as UPt_3, semiconductor-like band-structures, organic chain-structures like $(TMTSF)_2X_6$, Chevrel phase compounds like $PbMo_5S_6$, compounds like Y_3Co_7, were also discovered and all sorts of investigations were carried out. The impact was twofold: (1) T_c was raised to 23 K; and (2) the varied careful experimental

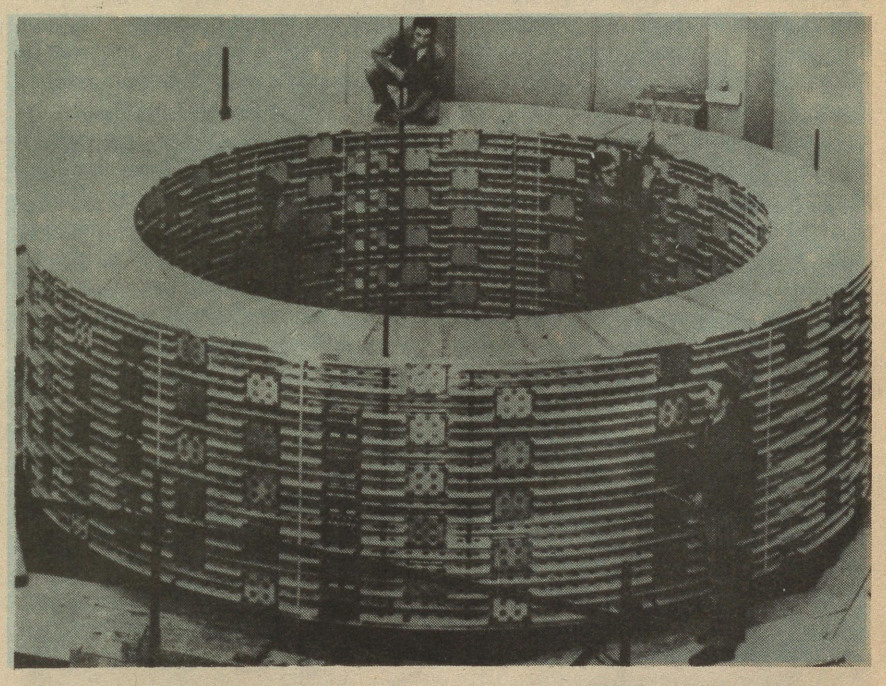
studies revealed that the underlying assumption of the different theories including the BCS theory could not satisfactorily cope with the observed anomalous properties of superconductors. This led theorists to invoke new mechanisms of electron pairing and formulations of electron correlation through excitonic, plasmon, bipolaron, super-exchange and exchange interactions, coulomb interactions, etc., were put forth. It is striking that all these mechanisms, including the phonon mechanism of BCS theory, have failed in predicting any high T_c superconductors, while Matthias's famous thumb-rule according to which one expects high T_c when the ratio of valence electron per atom is close to 5 and 7, has worked for almost all conventional high T_c superconductors including Nb_3Ge, and it has not been explained by any theoretical attempts yet.

1973-78 was a period in which the superconductor technology was growing in a steady way and developing moderate market for superconducting magnets of NbTi and Nb_3Sn and for other devices like SQUID, etc., and materials-researchers were trying reluctantly and desperately looking for some breakthrough. In most of the labs superconductivity became just a subject of academic luxury. This is obvious from the fact that between 1983 and 1986 only about 700 papers were published every year. Thus, we see that after being left in the cold-storage for more than 13 years, in 1987 the phenomenon suddenly started zooming towards the hotter region.

The new era

Superconductors in perovskite structures have existed since 1975 and T_c around 15 K was recorded in these materials — $BaPbBiO_3$ is an example of a superconductor belonging to this class. But practically, the perovskites were never considered potential candidates for high T_c research. Of course, due to their anomalous properties like the absence of specific heat jump, broad inductive transitions, high amount of frozen-in flux, etc., studies on these materials were pursued for academic interest by theoreticians and academic research oriented workers. It is really surprising how and why this idea of looking for high temperature superconductivity in these materials came to the mind of Bednorz and Muller. After the discovery Muller himself recollects that in 1983 he had a feeling that these perovskites could be converted into high T_c superconductors and he started his work with Bednorz on co-precipitating metallic compounds like $LaCuO_4$. Soon they could sense from their experimentation that what they needed was probably a mixed valent state of Cu, i.e., Cu^{+2} and Cu^{+3} because Cu^{+2} produced an insulating compound, whereas Cu^{+3} gave a metal but not a superconducting one.

In 1985, C.Michel and his co-workers published a paper which was the turning point. Muller and Bednorz got the clue that doping of Ba in $LaCuO_4$ could give rise to a mixed valent Cu^{+2} /Cu^{+3} state; rest is the story of patience and hard work which culminated in the discovery of $LaBaCuO_4$ having an onset T_c of 35 K in April 1986. These Nobel prize-winning scientists had experimented with not hundreds but thousands of samples of varied proportion of elements and had tried many different processes to achieve the goal they eventually did.



The world's largest superconducting magnet is being constructed for the Big European Bubble Chamber at CERN (France). It comprises two solenoids of 4.7 metre bore spaced ½ metre apart to allow particle beams to enter at right angles to the field. The photograph shows one of the coils during construction (*Courtesy*: CERN)

The quest and haste for high T_c

The impact of Bednorz and Muller's paper in October 1986 in *Z.Phys.B* was startling. As rightly stated by the Nobel committee, this paper was the start of an 'avalanche'. Hundreds of laboratories all over the world were soon at work with materials similar to those of Bednorz and Muller. Within a month the importance of the work was realised and in December 1986 several groups from different places, like the University of Houston, AT&T Bell labs, the Bellcore of USA, the Academy of Sciences in Beijing, and others announced their contributions. The perovskite crystal structure (K_2NiF_4) and the bulk superconductivity of the new materials was first shown by Bednorz and Muller and the Japanese group. At the same time, reports of improved T_c of 48 K in $La_{1.8}Sr_{0.2}CuO_{4-y}$ and 70 K in optimised conditions were published by AT&T Bell labs, the Bellcore, and the Chinese Academy.

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1987 started with a very exciting discovery of T_c of 90 K in compounds of Y-Ba-Cu-O by Paul Chu and his group at the University of Houston. Chu's group first improved the T_c of La compounds by putting the samples under pressure and measuring the T_c which increased to 57 K and then getting a hint that probably a smaller ion can simulate internal pressure; replaced La by Y and achieved a T_c of 90 K. The same result with different compositions was reported by the Bellcore and the Academy of Sciences in China and many other groups afterwards.

Indian contributions to the high temperature superconductivity began in early 1987 and by the end of May the Indian Institute of Science, Bangalore, the Tata Institute of Fundamental Research and the Bhabha Atomic Research Centre, Bombay, the National Physical Laboratory, New Delhi, the National Chemical Laboratory, Pune, the Indian Institute of Technology, Madras, and so forth, had all announced the successful fabrications of their Y-Ba-Cu-O compounds with T_c around 100 K.

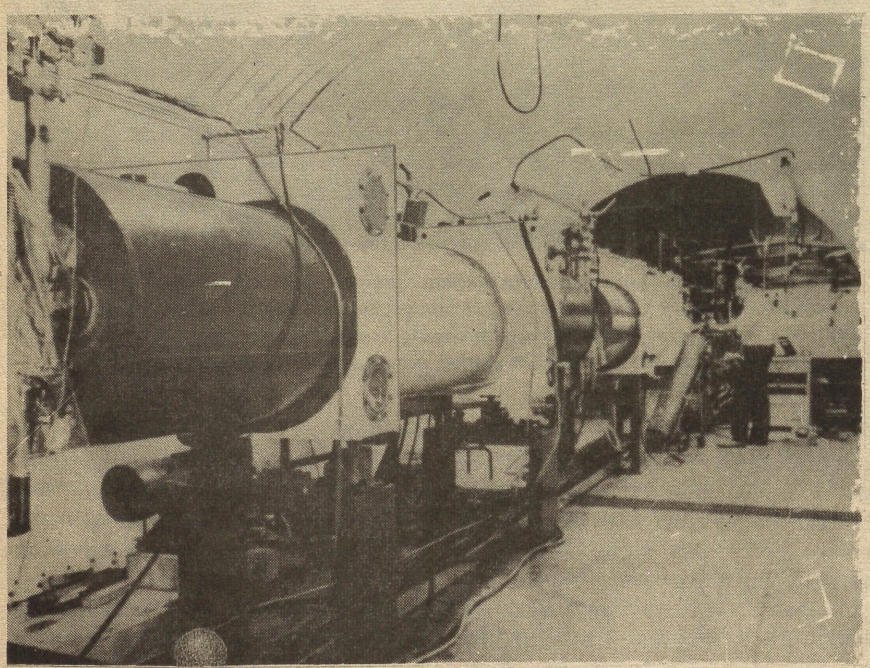
In Y-Ba-Cu-O system the important superconducting phase has been identified as $YBa_2Cu_3O_{7-Y}$ and it has been the most studied material of last year. This compound had the highest confirmed superconducting onset temperature of 100 K until February 1988, when, exactly after one year of its discovery, Bi and Ti-based superconductors (Bi-Sr-Ca-Cu-O and Ti-Ba-Ca-Cu-O)—the first high T_c superconductors containing no rare-earths, were reported. These rare-earth free materials have shown a higher T_c of 110 K and 125 K respectively with both Meissner effect and resistivity experiments.

During the last year several reports of T_c higher than 125 K have appeared from different countries such as the U.S.A., Japan, and India, and the maximum critical temperature reported todate is 67°C. Most of these reports are based on resistivity drops alone and some are also supported by the inverse a.c. Josephson experiments. Unfortunately, instability, irreproducibility, and the absence of Meissner effect are the three common short-comings of these higher T_c superconductors. In general, there are two views about these reports : (1) optimistic—which is based on the previous record of 125 K and suggests the possible improvement of T_c ; and (2) critical—which suggests that only resistivity drops can be misleading as pointed out by the IBM group [(J.B. Torrance *et al.,* IBM Research Reports No. RJ 5749 (58088)] that sharp drops in resistivity can be due to artifacts of the contact resistance. Whatever may be the case, T_cs above 125 K are yet to be confirmed.

Processing and characterisation

Synthesis and processing of superconducting perovskites like the $BaPbBiO_3$ was well understood and in general they could be prepared by solid-state reaction of appropriate oxides or carbonates in several steps of grinding and firing; followed by pressing and sintering. The sintered materials are porous and inhomogenous and their quality is affected by oxygen pressure, fluxes, etc. Single-phase high T_c superconductors $YBa_2Cu_3O_{7-y}$ and $La_{2-x}Ba_xCuO_4$ can also be obtained by adopting the same procedure more or less. Both these materials can be prepared with the same ease but demonstration of superconductivity at liquid nitrogen temperature by the yttrium compound had made this class more popular and Paul Grant of IBM has commented that the preparation of high T_c superconductors has become a high-school project now.

The most simple and reliable method for the preparation of Y-Ba-Cu-O superconductor can be summarized as follows: the oxides of yttrium and copper (Y_2O_3 and CuO) and carbonate of barium ($BaCO_3$) are mixed in the appropriate atomic ratio of 1:2:3 for Y:Ba:Cu. These are then ground in a pestle and mortar. The mixture is heated in air for 10—12 hours at 900°C in an alumina crucible. (Alumina crucibles are better than quartz as they are non-reactive and are preferred over platinum crucibles which are very expensive.) The calcinated powder is then re-ground and pressed into pellets. These pellets are again kept at 900°C for sintering for several hours. If the oxygen pressure is not sufficient the pellet might show superconductivity at 77 K, otherwise a good flow of oxygen will ensure a T_c above liquid nitrogen. A careful study by several workers has shown that the sharpest and the highest T_c is obtained when the sample is heated in an oxygen atmosphere, allowed to cool to



A prototype section of the superconducting accelerator at the Brookhaven National Laboratory under test, showing two dipole coils in their cryostats within a mock-up of the accelerator tunnel (*Courtesy*: Brookhaven Laboratory, U.S.A.)

room temperature from the sintering temperature of 900°C over several hours. The exact oxygen content in $YBa_2Cu_3O_{7-y}$ is very crucial and it has been shown that if y is geater than 0.5, superconductivity in these compounds may not be observed. The processing experiments have indicated that on quenching (or even fast cooling) from 900°C the tetragonal phase is retained which is harmful for superconductivity in Y-Ba-Cu-O compounds. This criteria for high T_c, however, does not appear to be true as superconductivity in tetragonal phases obtained by partial substitution of Y by Al or Fe in Y-Ba-Cu-O compounds has also been reported. Nevertheless, slow cooling through 600°C is still considered essential for superconductivity. A similar procedure can also be adopted for preparing the non-rare-earth high T_c superconductors Bi_4-Sr_3-Ca_3-Cu_4-O, generally known as 4334, and the Tl-Ba-Ca-Cu-O (2223), but by processing at appropriate calcination and sintering temperatures, usually 885 ± 5°C. Unlike the Y compounds the sintering temperature for these materials is very crucial and not over a range of 200°C. These are very new compounds and processing conditions are yet to be optimised.

The publication of more than 2000 papers in only one year (1987) on high T_c superconductors is an indication of how extensively these materials have been studied. It seems everyone in the field has used every single facility that was available to him for characterisation of these materials. Starting from very common and essential studies like the resistivity and Meissner effect experiments, most sophisticated and uncommon experiments like the muon-spin rotation, H_{c2} measurements under magnetic fields upto 100 tesla, high resolution electron microscopy and so forth, were carried out and are still in progress. Samples of Y-Ba-Cu-O were studied most; mainly because of the ease with which they could be synthesized and the high operating temperature. Even a microcosm of the available data is beyond the scope of this review but some characteristics which are un-equivocally accepted are summarized below.

The bulk nature of superconductivity in the main high T_c superconductors (La-Sr-Cu-O, Y-Ba-Cu-O, Bi-Sr-Ca-Cu-O, Tl-Ba-Ca-Cu-O) as shown by zero resistance and Meissner effect has been well established by now. As of today, the highest critical temperature satisfying both these criteria is 125 K, that of Tl-Ba-Ca-Cu-O and the lowest is that of the La compound equal to 35 K. Very recently a compound containing no copper, i.e., the first non-cuprate high T_c oxide superconductor showing a T_c of 28 K has been reported (an oxide of Bi containing potassium and calcium). A relative graph of resistivity variation with temperature of these superconductors is shown in Fig. 2. As stated previously, T_cs higher than 125 K (sometimes as high as 500 K) were claimed mainly on the basis of temporary resistance drops and were never really supported by any Meissner effect demonstration.

Studies on the effect of pressure and other agencies like the impurity substitution, defects, etc., on the critical temperature of new superconductors are far from complete. Crystal structure is the only well studied and most important aspect of oxide superconductors. X-ray and neutron diffraction studies have revealed that the structure of all these superconductors stems from the same class of perovskite structure with the general formula ABO_3, which refers to the mineral $CaTiO_3$. The common feature of cuprate superconductors is the Cu-O planes between the atoms of La and elements replacing La, viz., Y, Bi, Tl, etc. In general, it is accepted that CuO_2 planes play an important role in the occurrence of high temperature superconductivity. Prior to the discovery of Bi and Tl compounds it was observed that the La compounds of 35 K have only sheets of CuO while the Y compounds have Cu-O sheets along with Cu-O chains in the b-axis, and these chains were considered responsible for the higher T_c of the Y compounds. This inference is now losing its ground as the Bi and Tl compounds are showing still higher T_cs and here the Cu-O

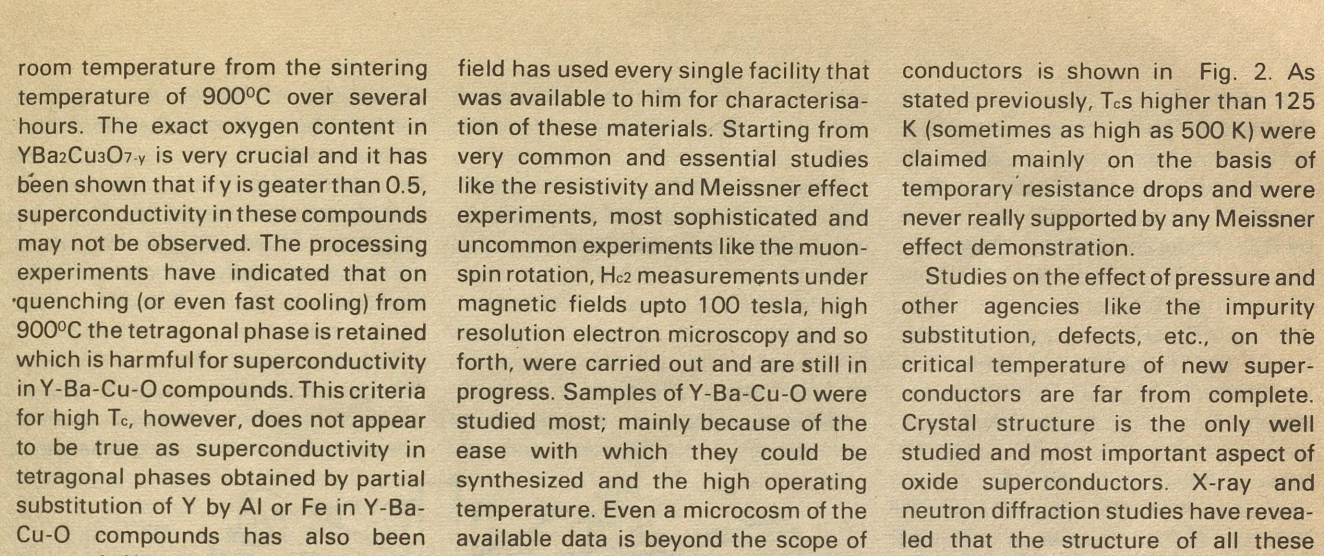


Fig. 2. Resistivity Vs. Temperature curves of the four new high T_c oxide superconductors. Curve A is for the La-Ba-Cu-O superconductor (After J.G. Bednorz and K.A. Muller, Z. Phys. B - *Condensed Matter,* 64, 189-193 (1986). Curve B is for Y-Ba-Cu-O superconductor (After M.K. Wu *et al., Physical Review Letters,* Vol. 58, No. 9, 2nd March (1987). Curve C is for Bi-Sr-Ca-Cu-O superconductor (After H.W. Zandbergen *et al., Nature,* Vol. 332, p. 620, 14th April (1988). Curve D is for Tl-Ba-Ca-Cu-O superconductor (After L. Gao *et al., Nature,* Vol. 332, p 623, 14th April (1988)

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chains are absent. In fact, in the Tl and Bi-based high T_c superconductors more than two square planar CuO layers have been found between Tl-O and Bi-O layers. It has been suggested by P.W. Anderson and his co-workers (*Nature,* Vol. 333, Page 121, May 1988) that T_c increases with the number of Cu-O layers present between the Bi- and Tl-oxide layers. Similarly, it was thought that the orthorhombic distortion in the tetragonal K_2NiF_4-type perovskite structure was essential in these compounds for high T_c; but this too does not prevail as high T_c superconductivity has been observed in tetragonal compounds in which copper has been partially substituted by Co. The maximum extension of unit cell is of 30 Å in c-axis in Bi-Sr-Ca-Cu-O compounds. In Y-Ba-Cu-O superconductors the c-axis is 11.7 Å and the a-and b-axes are nearly 3.7 Å. The extended c-axis lattice parameter gives rise to twinning is a general thinking.

The crystal structure studies have revealed that perhaps the role of La and other substitutions of La is mainly to support the crystal structure and that they have very small interaction with the ground state as any magnetic element when replaced by La does not drastically affect superconductivity. This result appears to contradict the traditional thinking which originates from the BCS theory that magnetic impurities are deleterious to superconductivity. Similar contradictions have been observed in conventional superconductors like; the Chevral phase compounds: MMo_6X; where M = Pb, Eu, Sn, etc., and X = S, Se. In this connection, it is interesting to note that perovskite superconductors; conventional or high T_c, have always been showing large deviations from accepted theoretical ideas. For instance, the specific heat behaviour—the near absence of a sharp jump at the transition temperature, or just normal metal-like behaviour in high T_c perovskites is in much controversy. The same behaviour was also observed in the previously known perovskite superconductor $BaPbBiO_3$. The sharp resistive but broad inductive transitions, large frozen-in flux, large hysteresis in magnetisation measurements are some examples of the well known anomalies of perovskite superconductors.

Similarly, small coherence length, high H_{c2}, co-existence of magnetic order and superconductivity, the granular nature of the material, etc., appear to be anomalous properties but in reality it is not the case. A much talked about finding is the observation of low isotope effect in La-Sr-Cu-O and Y-Ba-Cu-O_x superconductors; very little change in T_c is observed when ^{18}O is substituted for ^{16}O instead of the expected $T_c \propto M^{-1/2}$ (M=ionic mass) variation. This appears to be important and in contradiction with general expectations, but then again, all kinds of deviations have already been found in conventional superconductors. For example, Ru, Os and Zr of the transition metal group show negligible isotope effect and α-uranium of the actinide group has a positive exponent; it, therefore, exhibits inverse isotope effect. A unique and unambiguous theoretical explanations is yet to come. In the same way, the interpaly of magnetism and superconductivity has been detected in high T_c superconductors by neutron diffraction. This was suggested by Matthias in late fifties and experimentally confirmed in early seventies in some Chevral phase compounds.

The descrepancies in the values of the gap coefficient in high T_c Superconductors is another puzzling area. The appearance of energy gap between normal and paired electrons is an important characteristic of any superconductor. The gap to critical temperature ratio: $2\Delta / KT_c$ gives an indication of the coupling strength in the BCS theory; if the value is less than 3.5, superconductor is supposed to be weak-coupling, and when it is more than 3.5 the superconductor is strong-coupling. In the La-Sr-Cu-O and Y-Ba-Cu-O compounds the pairing has been probed by various workers using far-infrared and point-contact tunneling

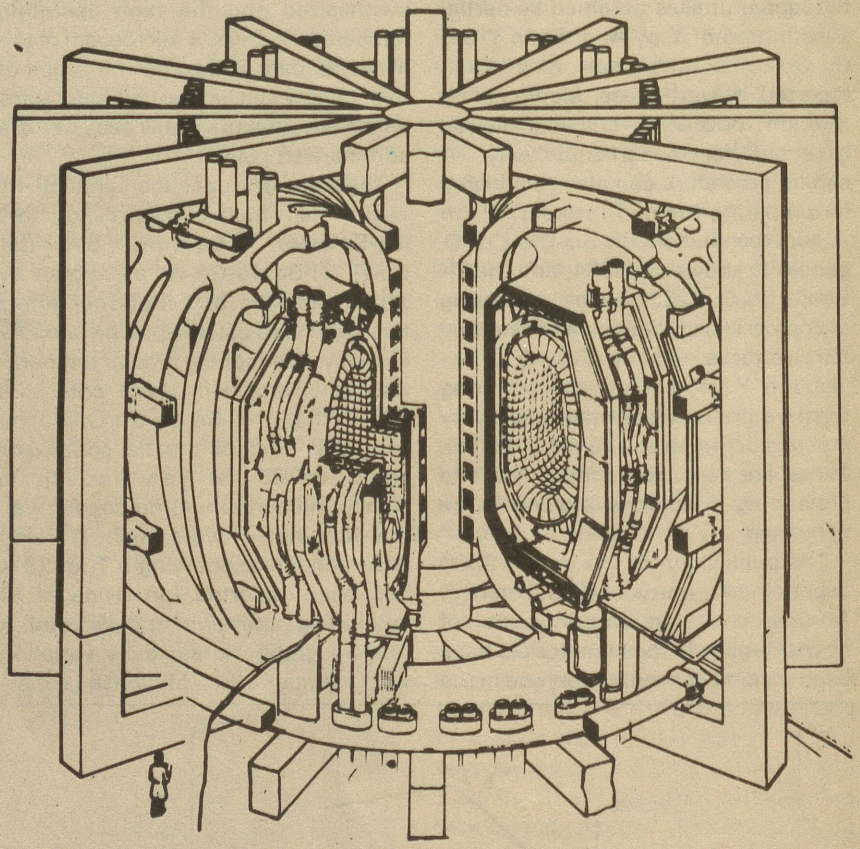


Fig. 3. Magnetic confinement of hot deuterium-tritium plasma for controlled thermonuclear fusion: the figure shows an artist's impression, based on conceptual design for a 2500 MW fusion reactor of the tokamak type based on superconducting coils.

studies. There are descrepancies in the results obtained from tunnelling and infrared studies; the ratio is nearly 4.3-6 from tunnelling studies in single crystals; whereas from far-infrared experiments it is between 2.5 and 5. In single crystal experiments the direction of CuO plane also causes the anisotropy, as parallel to CuO plane the ratio lies between 4 and 6 and in the perpendicular direction it is between 3 and 4.7. Whether high T_c superconductors are strong or weak coupling is still an open question. A careful study of the conventional superconductors reveals that all these unexplained anomalies were present in them also.

The extensive characterisation of high T_c superconductors has, nevertheless, put-forth a few aspects very firmly. From utility point of view; the relatively low J_c (of the order of 10^3 Amp /cm^2 in wires) even in low magnetic fields at operating temperatures of 77 K is the most disturbing limitation of these ceramic superconductors. The major efforts are channelised to improve the critical current densities of these materials. The anisotropy of J_c and H_{c2}—as high as 1 : 10 in two perpendicular directions even in polycrystalline samples further aggravates the complexities. A very interesting point of contrast is the enhancement of J_c with the absence of crystal defects, i.e., higher values of J_c are obtained for single crystals as compared to the polycrystalline material whereas in conventional high-current superconductors like Nb_3Sn and NbTi a high density of crystal defects was the prime requirement for high J_c. The anisotropy of H_{c2} in polycrystalline samples is itself a bewildering observation for both theoretical and experimental physicists. In the same way, the velocity of sound in conventional superconductors decreases below T_c while in high T_c oxides it increases by two-three orders of magnitude which is a noticeable deviation. The nature of carriers responsible for the ground state is another puzzling patch of experimental findings. Hall-effect measurements in high T_c superconductors suggest that the dominant carriers in these materials are 'holes', which is again a fact taking them away from conventional electronic superconductors.

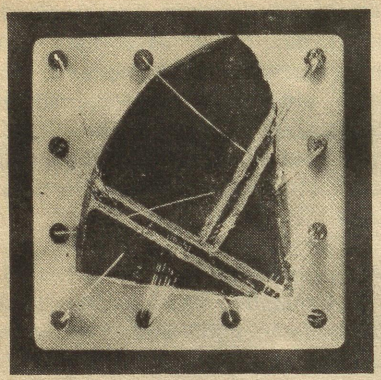
To epitomise, one can say that the round-the-clock working of dedicated experimentalists using various techniques such as the NMR, EPR, X-ray diffraction, positron annihilation, magnetic susceptibility, specific heat, ultra-sound attention, Raman spectroscopy, etc., has amassed data which encompasses many branches of solid-state physics. A well-aligned and conclusive picture of the high T_c superconductors will be a challenging task for theorists for quite some time to come.

A ceramic computer chip carrier coated with a high-temperature superconductive film. The film is said to allow the chip to carry 100 times more electrical current than previously believed possible. The increased conductivity is expected to lead to applications in circuits and computer-chip inter-connections, electronic devices, power transmission lines, electric motors and electromagnets.(Photo: U.S.I.S.)

Magnetism: friend or foe?

This question has been repeatedly asked since 1957 and is extremely relevant in high T_c superconductors where it is strongly considered that superconductivity may be due to the magnetic interactions. In 1957, when Matthias and his co-workers observed the possible co-existence of ferro-magnetism and superconductivity, and at times even enhancement of T_c by the addition of magnetic impurities, Matthias suggested the inseparability of d-electrons and high T_c. Until the early seventies, Matthias's group was the major group stressing the importance of magnetic interactions in the occurrence of superconductivity. Some of the theoretical groups had also tried the formation of ground state through magnetic interactions. The common drawbacks were the inexactness of the models, the absence of direct experimental evidences, and poor predictability and producibility of higher T_c. However, Matthias' unusual experimental observations and logical conclusions indicating the interplay between superconductivity and magnetism were unbeaten and always puzzled the pro-BCS theoreticians. In fact, Matthias' idea of superconductivity through 'ionic magnetic interactions' (by this he probably meant the magnetic interactions through localised states) was self-defeating. This model could not explain the very obvious questions like: Why all anti-ferro-magnetic materials were not superconducting? What was the exact nature of magnetic interactions and the ground state? and Why do magnetic impurities destroy superconductivity? etc.

A model based on direct experimental evidences regarding the involvement of exchange interactions with a creative role in the pairing of electrons was puts forth by Ekbote and Narlikar in 1980. This was a consequence of

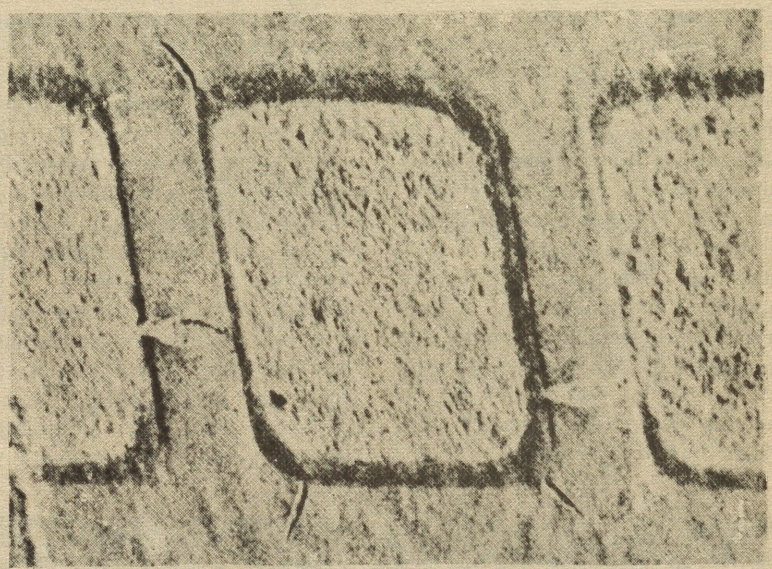


Thin film of high temperature superconducting material grown on strontium titanate.

than the existing limit, i.e., exchange interactions can be sustained at these temperatures (see, for instance, the book by A.V. Narlikar and S.N. Ekbote). Theoretical models have also been developed successfully by Schmidt, *et al.* and Kruger and others which show the possibility of superconductivity through exchange interactions. Between 1983-85, the positive role of exchange interactions in heavy electron materials like UPt_3, $CeCu_2Si_2$, etc., has also been established. On the other hand, from the very beginning of the discovery of the high T_c superconductors, it has been accepted by model, which is a mixture of singlet pairs at different sites and, one might say a manifestation of magnetic interactions. Later on, the detailed work of Anderson, G. Baskaran, Z. Zou and T. Hsu (*Phys. Rev. Lett.*, Vol. 58, Page 2790, 1987) suggested a tentative model which starts from the insulating anti-ferromagnetic state of La_2CuO_4 which they called the 'twitch' transition with RVB as the ground state. According to ABZH (Anderson, Baskaran, Zou and Hsu), on doping of La_2CuO_4 with Ba or Sr or Oxygen vacancies in Y-Ba-Cu-O, the insulating anti-ferromagnetic state gets converted into an excited RVB. In other words, the quantum spin liquid of excited electrons /holes has excitations called chargeless 'spinons' and spinless 'holons' which can move about, and the superconducting state might result from pairing of these excited holons and spinons. The observations of antiferromagnetic state in insulating Y-Ba-Cu-O also supports RVB. Still, there are many questions to be answered regarding the validity of the RVB model.

In the model suggested by J.R. Schrieffer and his co-workers [*Phys. Rev. Lett.*, Vol. 60, Page 944, (1988)] also, the superconducting state stems from the disordered antiferromagnetic state—known as the spin-bag model.

the first CESR (Conduction Electron Spin Resonance) and spin-wave resonance experiments carried out on a number of superconductors in the superconducting state by Ekbote, *et al.* They found that the CESR and spin-wave signals observed in the normal state of the superconductors vanished in the superconducting state (interestingly in Y-Ba-Cu-O sample similar CESR results have also been reported by C.N.R. Rao's group, *Pramana. J.Phys.*, Vol. 28, L 425, 1987). These observations in the normal and superconducting state gave the first clue that in the normal state these superconductors might have a highly correlated electron liquid in the conduction band and prominence of exchange-effects and that the ordered state in the conduction band is due to magnetic /(Exchange) interactions. The extensive experimental studies on different classes of superconducting materials like the A-15s, Chevrel phases, layered compounds, etc., and a comparative critical analysis of anomalous results strengthen their conclusion that electron-pairing might be due to the exchange interactions among conduction electrons. This could explain many experimental anomalies and answer the basic questions like why the localised magnetic moment or state destroy superconductivity, as it is clear that localised phenomenon would tend to polarise conduction electrons and hence break the electron-pairs, whatsoever be the attractive interaction. Interestingly, it was suggested by the author in 1983 that exchange interactions could lead to T_cs higher



Magnified more than 500 times, this is the first thin film high temperature superconducting electronic device—SQUID.

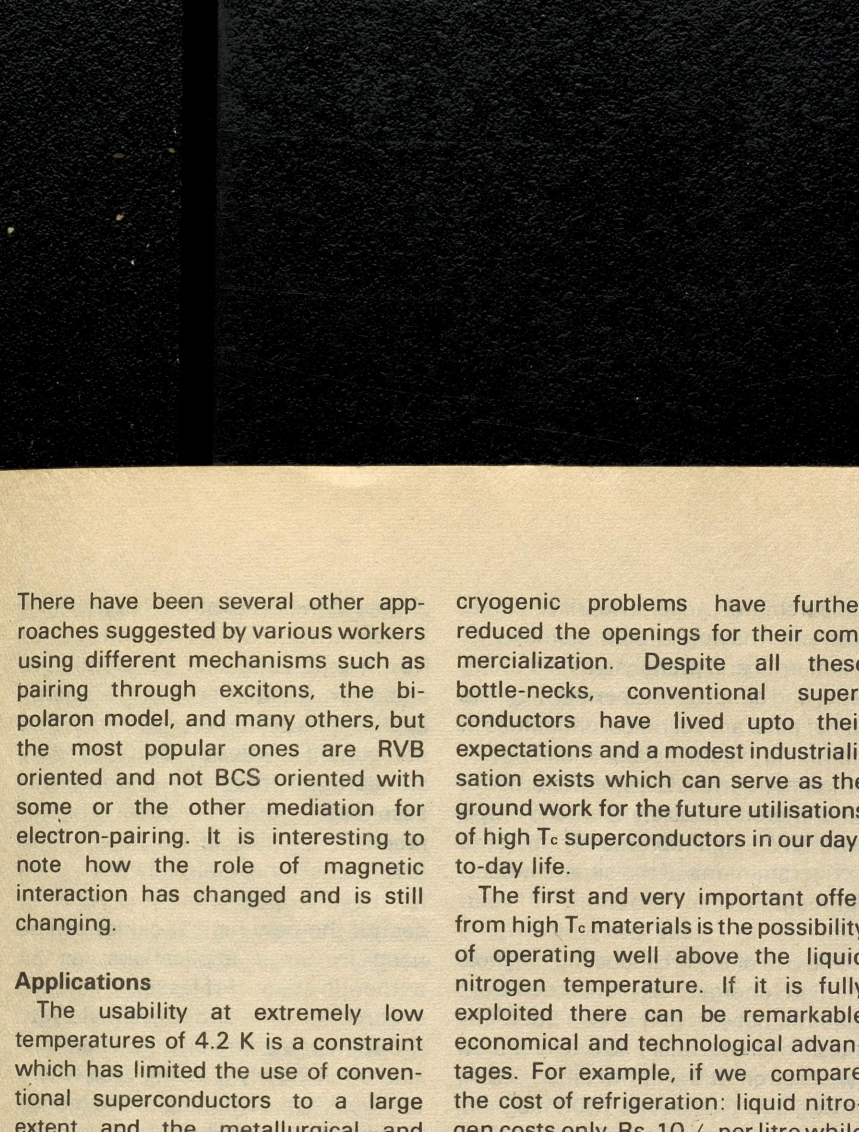
majority of researchers that these materials do not follow the conventional BCS phonon-mechanism. Surprisingly, this seems to be mainly on the basis of the observed higher T_c of oxide superconductors than the upper limit estimated from the BCS theory as at that time (March 1987) there were no other strong experimental evidences which could explain this change-over. The importance of magnetic interactions in the occurrence of higher T_cs was taken up by many workers after the pioneering paper of P.W. Anderson in March 1987 (*Science*, Vol. 235, Page 1196). In this article Anderson suggested the origin of superconducting state through the resonating valence bond (RVB)

There have been several other approaches suggested by various workers using different mechanisms such as pairing through excitons, the bipolaron model, and many others, but the most popular ones are RVB oriented and not BCS oriented with some or the other mediation for electron-pairing. It is interesting to note how the role of magnetic interaction has changed and is still changing.

Applications

The usability at extremely low temperatures of 4.2 K is a constraint which has limited the use of conventional superconductors to a large extent and the metallurgical and cryogenic problems have further reduced the openings for their commercialization. Despite all these bottle-necks, conventional superconductors have lived upto their expectations and a modest industrialisation exists which can serve as the ground work for the future utilisations of high T_c superconductors in our day-to-day life.

The first and very important offer from high T_c materials is the possibility of operating well above the liquid nitrogen temperature. If it is fully exploited there can be remarkable economical and technological advantages. For example, if we compare the cost of refrigeration: liquid nitrogen costs only Rs. 10 /- per litre while liquid helium costs at least a 1000 times more. Apart from this, the insulation required for cryostats, etc., will also be highly reduced. The applications would also depend upon the usuable temperature, some metallurgical properties of high temperature superconductors, and their response to high current and high magnetic fields. If one tries to envisage the applications of high temperature superconductors it will cover the entire field of electricity and magnetism. The high field magnets, power-transmission, Josephson devices and instrumentation, etc., are some example of previously studied and commercially viable applications.



To make a superconducting ceramic tape like the one displayed here by Bell Labs scientists; various elements are ground by hand in a mortar with a pestle (Photo: U.S.I.S.)

The old superconductors

The routine applications of superconductivity have been dominated by the superconducting magnets since 1962-63, a dream which came to reality after nearly half a century of the discovery of superconductivity. The first successfully operational superconducting magnet was made with Nb wire in 1957 which produced a field of only 0.7 tesla (1 tesla = 10 kilo-gauss). The next attempt was with Nb_3Sn in 1962-63 which produced 7 tesla and after that, within a span of 15 years, superconducting magnets producing fields in excess of 17 tesla have come in use. Today, the major funding is for the fabrication and purchase of superconducting magnets in different areas starting from laboratory uses to large-scale magnets used in high-energy particle physics experiments. In general, high-field superconducting magnets are wound with conductors of Nb-Ti alloys and the intermetallic compound Nb_3Sn and they serve the purpose of many crucial components of a variety of systems. The design, magnitude of the field, homogeniety, etc., of the magnet would depend on the particular requirements.

The widespread use of superconducting magnets can be seen in systems like body-scanners based on the magnetic resonance imaging, particle accelerators and bubble-chambers, etc., for high-energy physics experiments, small compact magnets for use in research laboratories, the superfast magnetically levitated trains,

ship-propulsion, motors and generators and similar magneto-mechanical machinery, magnetic separation, magnetic confinement of plasma for the thermo-nuclear fusion experiment (TOKAMAK) etc. Of these, the magnetic resonance imaging instruments are now available commercially, large-scale magnets for the high energy experiments like the particle accelerators have been built on the prototype basis and satisfactorily tested, while others have yet to enter a common man's life.

The first magnetic resonance imaging (MRI) magnet was delivered in 1980 only and within a span of next six years, i.e. today, it has dominated the commercial market of superconducting materials and devices. These magnets do not use the superconducting capabilities of Nb-Ti wires to their full extent. The field required is only about 2.5 tesla and the current density required for that is quite low. However, the high homogeneity and stability of the field and reliability of the superconducting magnets are the three qualities which have established the superiority of the systems based on superconducting magnets over those of the resistive or permanent magnets. The use of a superconducting magnet also ensures a superior image quality.

In high-energy physics experiments superconducting magnets are used to control the beams of charged energetic particles. These particles can be accelerated, deflected and focused by the large fields produced by the superconducting magnets and can help in understanding the microscopic nature of matter. Large bubble-chambers are devices in which the high magnetic fields are used to deflect particles, thus forcing them to follow a curved path and the curvature and direction of their track determines the momentum and charge of the particle. Here, superconducting magnets are gaining importance mainly because of the enormous saving in running costs. Since magnetic fields are required over very large volumes; for instance, the world's largest bubble-chamber at CERN (The European Organisation for Nuclear Research) in France, comprises of two solenoids having a bore-diameter of 4.7 metres and produces a field of 3.5 tesla, and although the normal magnets do not pose any technical difficulties in producing such fields, their power consumption would be of the order of 50 or more MW as compared to only a few KW required mainly by the refrigeration unit of the superconducting magnets.

The use of superconducting magnets in high energy particle accelerators requires not just one or two but many more coils smaller in size. The proton synchrotron at the Fermi lab in U.S.A. having 500 GeV needs 1000 magnets arranged in a 2 km diameter. The bending of the beam and the required variation of the magnetic field are the two major difficulties restricting the frequent use of superconducting solenoids, as changing fields can be deleterious to superconductivity. Prototypes of these dipole-coils are under test at the Fermi Lab and the Brookhaven National Lab.

NMR analysis of chemical and biological specimens is the most important aspect of research and industry. In the past 20 years it has given a small but steady market to superconducting solenoids. Apart from this high magnetic fields in small bores became a very effective tool for laboratories. Studying the basic nature of different problems under high magnetic field in different materials like the metals, semiconductors, plants, tissues, etc., has revealed many new facts.

Apart from the high field applications described above there are some low field applications that are important and for which if high T_c oxides can be utilised a good amount of power can be saved. The superconducting power transmission line is one such example of low field or low energy application. With conventional superconductors, except for the prototype demonstration at the Brookhaven National Lab of USA in 1983 the superconducting power transmission line has not been able to reach a level of consumer's market, mainly because of the cryogenic and material problems. This prototype project of the Brookhaven lab was for a 3-phased 1000 MVA line, which used Nb_3Sn tape-conductor on aluminium stabiliser. Another area in low energy applications of superconductors is that of resonant cavities used as secondary standards of frequency and in linear accelerators. Superconducting high Q resonant cavities of Nb having very low rf losses have already been used for these purposes, but it is yet to be seen if the new high T_c oxides can be used in these applications; as an authentic study of rf losses in ceramic superconductors is not available yet.

Superconducting electronic devices is another slowly growing area where the weak-link tunneling phenomenon is utilised. As described previously, the phase-difference between two superconducting slabs separated by a thin oxide barrier (such as Sn-SnO-Sn) depends upon the critical current of the device and the application of a current exceeding the critical current or a magnetic field to the Josephson device switches the device from zero to some finite voltage. The a.c. Josephson effect, i.e., the oscillations in super-current when an external voltage is maintained across the junction, or conversely, when the junction is exposed to an a.c. signal, the current-voltage characteristics develops a step structure. This has been used in oscillators and detectors. The Josephson switches based on the above effects are quite attractive and superior to semi-conductor switches by their response time which is of the pico-seconds 10^{-12}s. Another way of utilising Josephson junctions is the Superconducting Quantum Interference Device or SQUID, in which two Josephson junctions are connected in a ring as weak-links and current flow in the ring is sensitive to magnetic flux applied. Both a.c. and d.c. SQUIDS are flux-to-voltage transducers producing output voltage in the response of magnetic flux. This makes it a sensitive magnetometer which can detect, as of today, at 4.2 K 10^{-13} gauss /cm^2. Conventional instruments are far inferior in comparison to SQUIDS. They are now used in medical research and geo-physics for magnetic response of the heart, brain, etc., and for rock magnetism in geophysical research.

And now the 'wonder' superconductors

It is obvious from the conventional practical applications of superconductors that apart from the enhanced superconducting properties like T_c, H_{c2} and J_c the metallurgical properties like the processibility, stability, mechanical properties, economic viability have to be critically assessed. An example of this is the non-usability of Chevral phase compounds despite their highest H_{c2} and moderate J_c values among the conventional superconductors (see Table 1). A good amount of effort in making wires out of the these materials has gone in vain due to their brittleness and non-processibility. Unfortunately, ceramic superconductors at this moment also fall in the same category. These materials are not ductile and cannot be easily drawn into composite wires. It is, therefore, difficult to use them even for simplest high-field magnet winding for laboratory uses. The low J_c in zero applied magnetic fields at the operating temperature of 77 K makes the picture further gloomy. This has become very evident in case of Y-Ba-Cu-O where the critical current density (J_c) decreases by about two orders of magnitude at 77 K by the application of magnetic fields as small as 10^{-2} tesla. The enhancement of J_c under magnetic field at 77 K is one of the crucial requirements of the day and most of the potential applications would depend on this.

Another main hindrance to the practical use of oxide superconductors is the high contact resistance. For J_c measurements and magnetic applications contact resistivity should be less than 10^{-5} ohms cm^{-2} and for electronic instrumentations values of the order of 10^{-10} ohm cm^{-2} and are desired. Low resistivity contacts in Y-Ba-Cu-O and Tl-Ba-Ca-Cu-O have been achieved by deposition of a layer of noble metals on the contact surface. The granular structure, low cooper pair dimension (ζ), anisotropy in J_c and H_c, etc., are the stumbling blocks reducing the pace of advancement. The only answer to all these difficulties is that a better understanding of the new materials is required, as conventional approaches may not be helpful. At this stage it seems that the low-field applications such as the Josephson devices will take the lead over the high field applications and here atleast the advantage of higher operating temperature can be fully exploited. Some preliminary attempts of making SQUIDS and Josephson devices using Y-Ba-Cu-O films though not very successful, are definitely encouraging.

Putting all these obstacles together the importance and promises of high temperature superconductors cannot be reduced because once the basic understanding of these materials comes through, the critical parameters will automatically be controlled, and with the available technical background these materials will take over the commercialisation. But at this moment in the opinion of Edward Engler of IBM [Research Report No. RJ5723(57702)1987], 'the realisation of zero resistance is only the start of the journey and a long hard way lies ahead to achieve the goals'.

Epilogue

Even a cursory glance at nearly 75 years of progress of superconductivity is enough to give an impression of the vastness and importance of the phenomenon of superconductivity. Starting from the appearance of zero resistance in mercury to the perovskite Tl-Ba-Ca-Cu-O, every new experimental observation has indicated an extension of superconductivity to diversified fields. Electron-phonon interactions in metals, crystal structure stability, magnetism, etc., are broadly the areas which have benefitted extremely during this period due to the theoretical developments in the understanding of superconductivity. In order to utilize superconductors

Table 1. Important superconductors and their critical parameters

Material	*T_c (K)*	*H_c H_{c2} (O) (Gauss)*	*J_c (Amps. cm^{-2}) (at 4.2 K in appl. field of 4 tests*	*Year of Discovery*
Hg	4.1	410	—	1911
Pb	7.2	800	—	1913
Nb	9.2	2,000	—	1930
Nb_3Sn*	18.1	2,80,000	2×10^6	1954
NbTi*	9.5	1,60,000	3×10^5	1961
V_3Ga*	14.5	2,50,000	2.5×10^6	1966
Nb_3 (Al, Ge)		4,40,000	10^4	1966
$PbMo_5S_6$	15.0	6,00,000	10^3	1972
Nb_3Ge	23.2	3,80,000	10^4	1973
$(La,Ba)\ CuO_4$	35.0	5,50,000 **	—	1986
$YBa_2Cu_3O_{7-}Y$	92.5	38,00,000 **	10^6 ***	1987
Bi-Sr-Ca-Cu-O	110.0	55,00,000 **	10^5 ***	1988
Tl-Ba-Ca-Cu-O	125.0	—	10^4***	1988

*available commercially for magnet fabrication.
**Estimated values. Experimental values available only upto 10,00,000 gauss.
***J_c values are at 77 K and in zero applied field.

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commercially, the low temperature technology has also gone through tremendous advancements, and today, it is not very far behind the room temperature technology. Now with perovskite high temperature superconductors a fresh spurt in the basic understanding of the phenomenon and the superconductor technology has arisen, and despite all scepticism everyone in the field and outside has a gleam of hope of living in the transformed world of 'wonder superconductors'.

Further reading

(1) References up to 1983 can be found in '*Superconductivity and Superconducting Materials*', A.V. Narlikar and S.N. Ekbote, South Asian Publishers, New Delhi, (1983).

(2) Wilson, Martin N., *Superconducting Magnets,* Clarendon Press, Oxford (1983).

(3) Clark, John, Small scale Analog Applications of High Transition—Temperature Superconductors, *Nature,* Vol. 333,p.29, 1988.

LETTERS (*Continued from page 420*)

More electronics

Sir, I have been reading *Science Reporter* for a long time. I am sorry to inform you that you are not concentrating on mathematics and electronics. Please try to publish more on these subjects.

Md. Shafiuddin
M.Ed. Student of MKU
R.B.H.V. Mancherial 504208 (A.P.)

More biographies

Sir, I thank you for the sincere effort to maintain the high standard of *Science Reporter.* The April issue was one of the best in recent years. Your column 'Science for the Young' was superb. I enjoyed the article by Dilip M. Salwi on Gerald Durrell. In the past also you had published informative stories on Nilratan Sircar, J.J. Audubon, Dian Fossey, Nikoloi Vavilov, Miriam Rothschild, etc. I look forward to more biographies of renowned scientists.

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STARS AND PLANETS (*Continued from page 421*)

opposition with the sun on 28th. It is in Pisces (*Mina*). Its visual magnitude varies from —2.4. to —2.8.

Jupiter (*Brihaspati*), visible in the morning sky, rises about two hours before local midnight during the first half of the month and about three hours before it during the second half. It is in Taurus (*Vrisha*). Its visual magnitude is about —2.5.

Sani (*Saturn*), visible in the evening sky, sets about half an hour before local midnight during the first half of the month and about one and a half hours before it during the second half being in quadrature with the sun on 19th. It is in Sagittarius (*Dhanus*). Its visual magnitude is about —0.5.

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

SCIENCE SPECTRUM (*Continued from page* 459)

related satelite DNA on Y chromosome) and with lower affinity to Tdx. In XY mammals, the repressor is bound by these chromosomes and Tdx expression is turned on and leads to testes development. However, in XX animals, there is no sink for repressor and Tdx is repressed and this leads to development of ovaries. The model suggests that (a) Y chromosome appears to be sex determining without carrying structural genes for sex determination; (b) Bkm satellite might serve as male determinant by functioning as the repressor binding sequence. The model explains the observed sex phenotypes of various sex determination mutants in different mammals and thus has been widely accepted. However the occurrence of major sex determination structural genes on Y chromosome still remains enigmatic.

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The use of radioisotopes has brought about sophistication, improved product quality and introduction of new techniques of production in almost every sphere of industrial activity

RADIATION AND RADIOISOTOPES IN INDUSTRY

S.N. KAK

THE peaceful applications of atomic energy in various aspects of economic development have made rapid strides in the recent past. With increasing familiarity with the potentialities of radiation and radioisotopes, there is almost no area of development, be it industrial, research, agriculture, medicine or energy, where they do not play a vital role. Their use in industry had an early and rapid development. Practically, every industry today is using radioisotopes and radiation in one form or the other. Technology based on radiation and isotopes is essential for industrial modernisation. Introduction of this technology saves raw materials and energy, improves product quality and operational safety of plants and helps safeguarding the environment, all of which lead to social and economic benefits.

Radioisotopes as tracers

A small amount of radioactive substance is added to a process and its progress as a radioactive tracer is followed. Tracer information is interpreted through a signal which can be electrical, e.g., the output of a detecting device or the variation in the darkness of a nuclear emulsion as in autoradiography. In case of leak detection in a heat exchanger, which consists of flow of liquids in two circuits, the existence of a leak is proved when a tracer injected in the first circuit is detected in the second circuit.

More sophisticated tracer applications benefit from systems analysis. In a chemical plant, for instance, there is a constant flow of water in a mixer. A small amount of a radio-tracer is injected at the entrance of the mixer and the

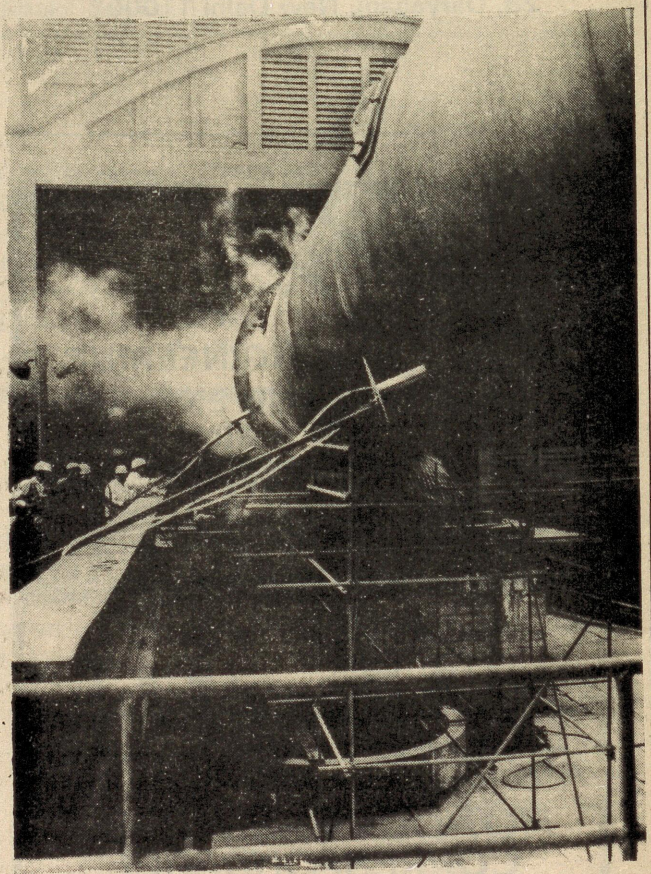


Fig. 1. Radioactive tracers to follow the reaction in a cement plant

Dr. Kak is scientist at Regional Research Laboratory, Canal Road, Jammu Tawi

concentration of the tracer is measured at the exit. This radio-tracer technique is used to calculate the variation of concentration of the chemical at the exit point of the chemical plant by knowing the variation of concentration at the entrance. Similarly, rate of loss due to wear or corrosion of a processing equipment of an industrial plant is monitored through radio-tracer technique. In this technique, the testing material is activated with very low doses of radio-tracer that do not disturb plant operations. By monitoring the changes of radioactivity levels, the rates of wear and corrosion is established.

Radioactive tracer techniques have several advantages. Firstly, their concentration can be measured with detectors located outside pipes or vessels. Secondly, measurements on samples taken from a flow are simple and independent of the matrix of samples. Lastly, a radioactive tracer is unique in the sense of labelling a specific element or chemical species. Generally, tracer techniques are used in industrial plant operations to check the performance of processing equipment and to improve production efficiency by saving energy and utilizing raw materials more effectively.

Radioisotope instruments

The greatest impact of radioisotopes on industry has been through the introduction of radioisotope instruments. The advantages of using such instruments are: (a) The measurements can be made without direct physical contact with the substance being measured; (b) Isotopic sources need very little maintenance; and (c) Cost /benefit ratios are excellent. Many instruments pay for themselves through savings in 2 to 6 months of operation.

Level gauges containing radioactive sources are in wide use. They are in operation in all industries, where levels of substances (gaseous, liquid or solid) have to be checked. Radioisotope level gauges are most useful where heat, pressure or corrosive substances, such as molten glass or molten metal, make it impossible or difficult to use direct contact gauges. Radiosotope thickness gauges are used when it is desirable to avoid contact between the materials, such as continuous sheets of paper, plastic film, metal, etc. Density gauges are used where automatic control of liquid, powder or solid is important, for example, in the manufacture of a detergent. Tobacco companies are one of the biggest users of radioisotope density gauges. Density

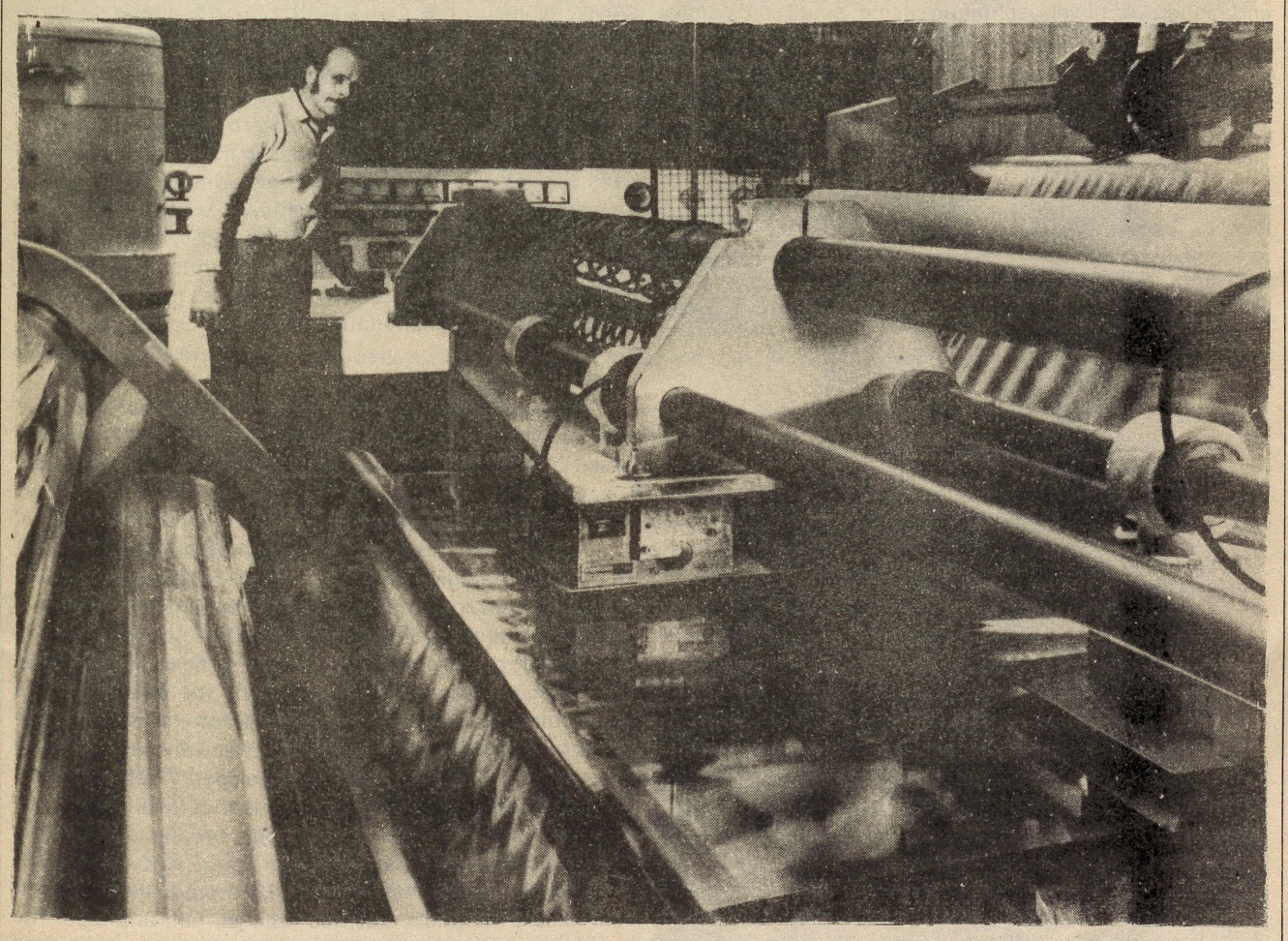


Fig.2. Radioactive thickness gauges to measure the thickness of plastic film

gauges are used to control the amount of tobacco that is packed into a cigarette.

Recent advances in modern nuclear technology have made a tremendous impact on industrial instrumentation. New radioactive sources, better detectors, analysers with greater resolution, and mini-computers have already extended the range of uses for radioisotope instrumentation. Such comprehensive instrumentation has now become the norm whenever new industries are started. For example, it is highly unlikely that a new plant for the manufacture of tin-coated steel sheets would not have sophisticated radiation gauges and the associated automatic measuring and controlling equipment. By installing a radioisotope X-ray fluorescence gauge in a galvanizing machine, 10% of tin can be saved. The cost of the gauge for process control is US $ 200,000 (approx.) but the investment can be recovered in a year depending on the capacity of the galvanizing plant.

Moreover, the product is of a better quality. Similary, X-ray fluorescence gauge is used in the continuous galvanization of steel strips, the coating of paper on both sides with polyethylene, and the manufacture of plastic film and paper. A novel technique using small radioactive source such as cobalt-60 for gamma scanning is being widely used in the petroleum, petrochemical and fertilizer industries to monitor functioning of process equipment such as fractionating columns, absorption towers and catalytic converters.

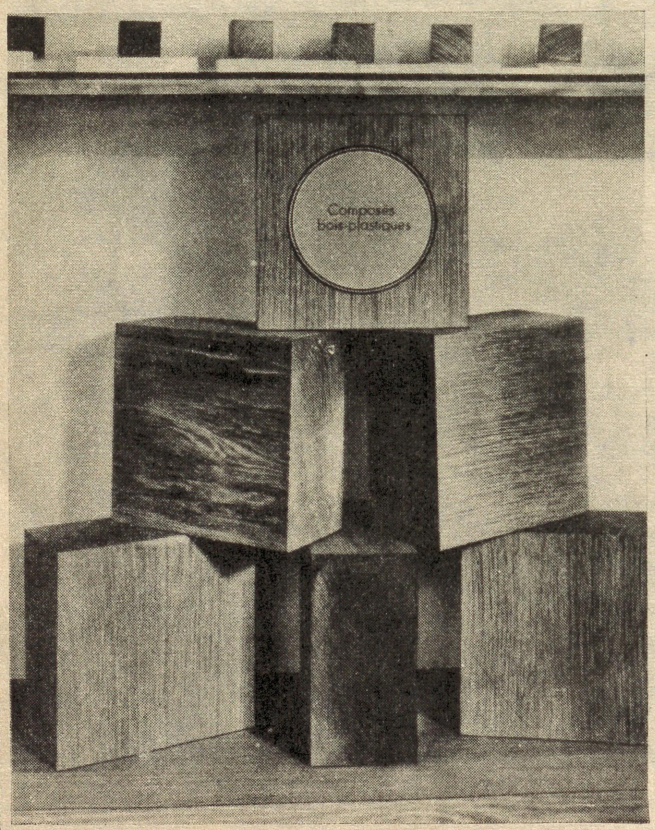


Fig. 3. Wood-plastic composite made by irradiation

Gamma radiography

Radiography that uses X-rays is a well-established technique. It is used throughout industry as a non-destructive quality control method in checking welds, castings, ceramics, etc. Certain radioisotopes emit gamma rays which can suitably replace conventionally produced X-rays. Sources of gamma radiation are usually shaped in cylindrical form. They are safely enclosed in some light metal capsules of 1-6 mm diameter. Several sources are available; some short-lived, others long-lived. An important application of gamma radiography is to check welds in pipelines. Every weld has to be checked. This can best be done when the radioactive source is inside the pipe and the film is placed outside the welds. For checking long pipelines, sophisticated self-propelled carriers which can be commanded from the outside have been built. The sources are mounted on the carrier, which can be remotely controlled. Practically all new pipeline systems for gas or oil are checked with such radioisotope vehicles.

Neutron radiography

Gamma radiography is based on absorption of gamma rays; the denser a material, the greater the absorption. Neutron radiography is founded on a different principle. The neutrons interact with the nucleus of atoms. The degree of absorption of neutron varies from element to element. Some light elements strongly absorb slow neutrons. The main application of this method is in the detection of small amount of low density materials within high density materials, which cannot be achieved with X- or gamma rays. Some other applications of neutron radiography are: detection of the position of washers in thick sections of dense materials, detection of voids in solid rocket propellants, and examination of printed circuit boards.

Autoradiography

Autoradiography is a method whereby radioisotopes give a photographic picture of themselves. This method is widely used in metallurgical investigations and biological research.

Radiation in production

Radiation can induce certain desired chemical reactions. It can, for example, be used in the manufacture of plastics or to graft plastics on to other materials. Cross-linkage of some polymers by process of chemical linkage between individual macro-molecules is induced by radiation. Thus, radiation is effective in transforming the polymer into a molecular structure with two important characteristics. It does not flow at higher temperatures and above the melting point rubber-like properties are developed. The first effect is of great importance for applications that involve wire and cable insulation, the second for production .of heat-shrinkable materials and polymer foam. Radiation cross-linking of polymers also is used for production of heat-shrinkable materials, such as tubings, film and tape. The products are irradiated and cross-linked to a predetermined level. After irradiation they are heated above the melting point, expanded in one or two dimensions, and cooled to

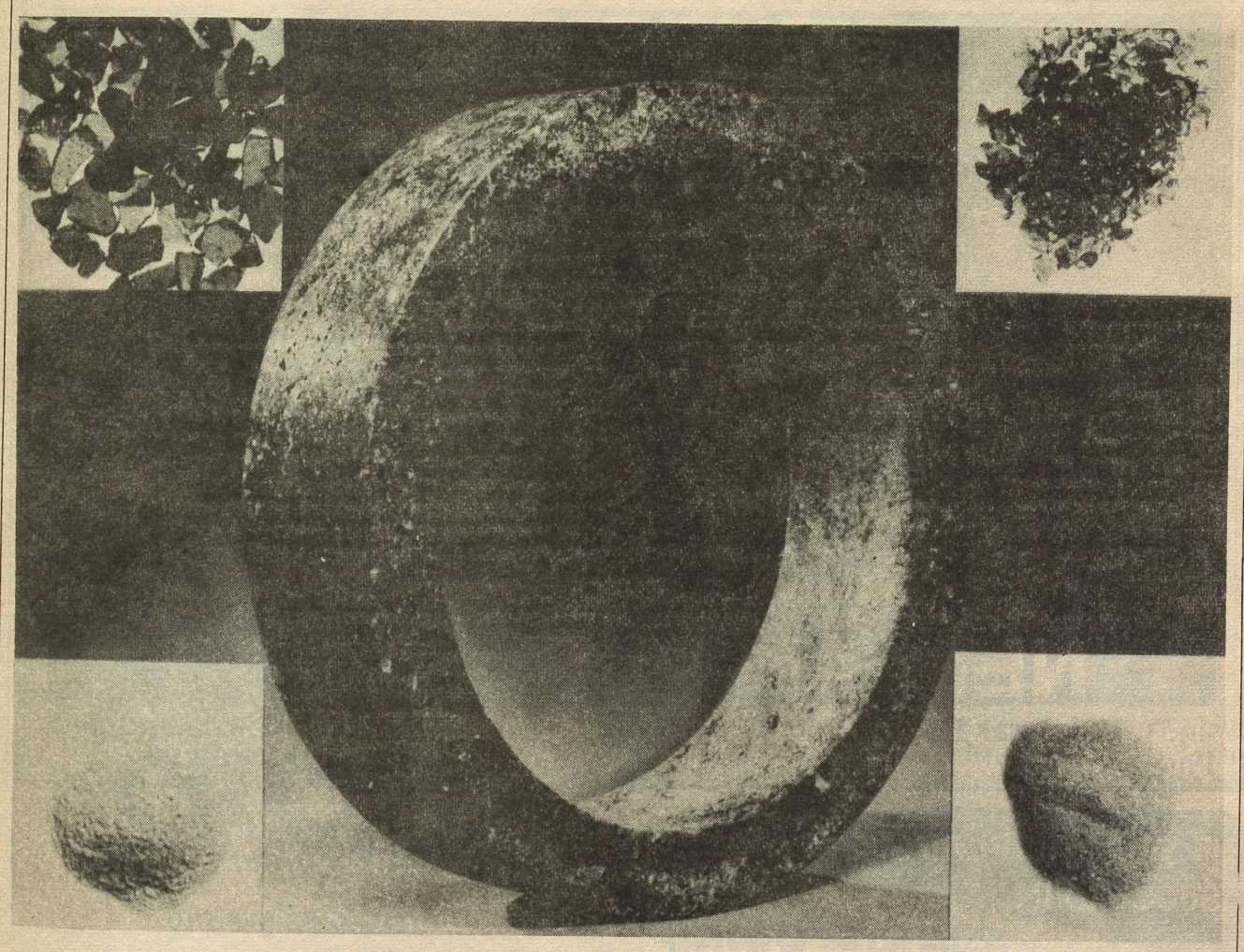


Fig. 4. Composites of concrete and plastic made by irradiation (*Photo Courtesy:* IAEA)

preserve the expanded shape indefinitely. The wood, automobile and printing industries make extensive use of electron-beam radiation to cure surface coatings. The advantages of this method are better insulation properties and high resistance to heat and solvents.

The rate of production of wire insulated with radiation cross-linked polyethylene and polyvinylchloride is increasing fast. Such insulation has better resistance to heat and chemical attack and increased resistance and is more compact. Such products are very frequently used in automobile industry, telecommunications, the aeroplane industry and in various domestic electrical gadgets.

Similarly, other industrial products are radiation cross-linked foam polyethylene used for thermal insulation, floor mats, crash padding and floating jackets. Weed plastic composites cured by gamma irradiation have been successfully used for flooring in places such as big departmental stores, airports, hotels where their excellent abrasion resistance, the beauty of natural grain and low maintenance costs are important factors. This latter technique is also being used in the conservation of objects made of stone and wood which are important to the cultural heritage of a country. At present, vulcanization of rubber sheets by radiation in the manufacture of automobile tyres is being used commercially by several tyre companies. Recently, a "super-absorbent" material manufactured by radiation grafting techniques has appeared in foreign markets. This material is capable of absorbing and holding large amounts of liquid. Products manufactured from it include disposable diapers and air-freshner elements.

With the growing use of radiation technology in various industries, the reliability of radiation facilities using cobalt-60 sources and electron beam accelerators has improved considerably in the past decade.

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IN nature, ozone is present in a layer in the stratosphere about 25 km above the earth's surface. The stratospheric ozone filters out most of the ultraviolet part of the spectrum of incident solar radiation thereby reducing its harmful influences on the biosphere. The stratospheric ozone may come down to earth's surface in low concentrations under conditions of vertical turbulence. Ozone is also produced by lightning. But both these natural sources are relatively harmless to vegetation as natural O_3 concentrations at earth's surface are usually only between 0.02 ppm to 0.03 ppm.

OZONE CAN DAMAGE CROPS

O.M. BAMBAWALE

Increasing levels of ozone in the lower atmosphere, apart from producing irritating smog, have also been instrumental in bringing about large scale destruction of crops

Ozone is also formed in the troposphere from other primary pollutants. It is produced in presence of sunlight from products of combustion of coal or petroleum, mainly the automobile exhaust gases. The concentration of ozone in polluted atmosphere often goes up 10 to 20 times the natural ozone levels. When ozone concentration is about 0.05 ppm for a few hours, sensitive plants like potato, tobacco and bean start developing injuries; when the value exceeds 0.10 ppm, the injury is more pronounced and more plant species get affected.

Accumulation of ozone as a pollutant

The following steps are involved in production of O_3 from the constituents of motor vehicle exhausts:

1. Nitric oxide is produced as a result of high temperature combination of atmospheric nitrogen and oxygen within the internal combustion engine. Nitric oxide is oxidized to nitrogen dioxide which takes place mainly by reaction with natural ozone.

$$NO + O_3 \longrightarrow NO_2 + O_2$$

2. Nitrogen dioxide dissociates in the presence of sunlight to nitric oxide and atomic oxygen.

$$NO_2 \xrightarrow{\text{sunlight}} NO + O$$

3. Atomic oxygen combines with molecular oxygen to re-form ozone.

$$O + O_2 \longrightarrow O_3$$

4. If no other pollutants are present, the highly reactive ozone will oxidize nitric oxide back to nitrogen dioxide and a steady state will be reached with no net accumulation of ozone. However, automobile exhausts also contain various unburnt hydrocarbons and aldehydes, as a result of insufficient combustion and these may form oxidizing free radicals by various processes involving oxidation and photodissociation. The free radicals thus produced also oxidize nitric oxide to nitrogen dioxide which leads to a net accumulation of ozone in the atmosphere.

$$NO + R\dot{O}_2 \longrightarrow NO_2 + R\dot{O}$$

Besides availability of bright sunshine, some other meteorological conditions are also required for accumulation of ozone in the atmosphere. High temperature increases the rates of reactions involved, and a low wind speed with reduced vertical motion of air, as in case of a temperature inversion, prevents dispersion of the primary pollutants before various reactions can take place. Ozone concentrations vary during the day and during the year in response to the amounts of auto emissions and above stated meteorological factors. Ozone levels are usually highest in the early afternoon and fall at night. Ozone and its precursors may drift long distances up to hundreds of kilometers into the countryside and thus increased ozone levels may be observed over large areas.

Injury symptoms

Ozone injury symptoms in vegetation are of four major types; (i) pigmented lesions, (ii) upper surface or both surface bleaching, (iii) bifacial necrosis, and (iv) chlorosis.

Ozone enters the foliage through the stomatal openings and attacks palisade parenchyma which is very sensitive to ozone. The affected areas collapse and dry out to form areas of dead tissue. Acute injury of this type generally results in a stippling or flecking on upper leaf surface. The colour of the

Sh. Bambawale is a scientist at Central Institute for Cotton Research, Nagpur-440 001

FATS IN NUTRITION AND DISEASE

ISHTIAQUE AHMAD

Little attention has been paid to the need for fats in nutrition. Consequently, people in developed countries suffer from overconsumption while those in developing countries suffer from underconsumption

THREE groups of naturally occurring organic compounds which are of fundamental importance to both animals and plants are oils and fats, carbohydrates, and proteins. They are essential nutrients without which life would not be possible.

Oils and fats belong to a larger group of naturally occurring substances called lipids. Lipids form a diverse group of compounds that have little in common except that they are soluble in organic solvents and insoluble in water, and most of them are derivatives of fatty acids. Oils and fats, waxes and phospholipids are important examples of lipids that are fatty acid derivatives. Steroids are also classified as lipids though they are not fatty acid derivatives and are quite dissimilar in structure to the rest of the group. Cholesterol is an important steroid which is present in body tissues and is found in some foods, notably egg-yolk. Other steroids which are related to cholesterol are vitamin D and some bile acids.

The distinction between an oil and a fat is simply that at normal temperatures oils are liquid and fats solid. However, this distinction is rather vague, as a 'normal' temperature cannot be accurately defined, and some oils such as palm oil are usually solid at the prevailing temperatures of the temperate climate.

Fats are esters of the trihydric alcohol, glycerol. The three hydroxyl groups of the glycerol molecule can each combine with a fatty acid molecule and the resulting ester is called a triglyceride. The simplest type of triglyceride results when the three acid molecules are all the same. For example, if three molecules of stearic acid react with a molecule of glycerol, the fat formed is tristearin (Fig. 1).

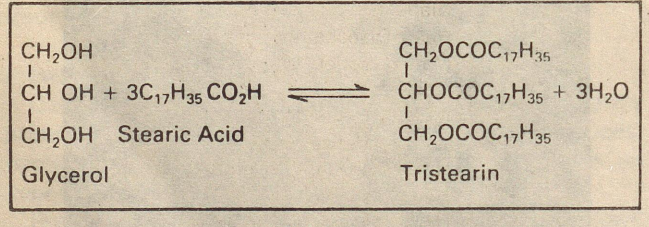


Fig. 1

Natural oils are almost always mixed triglycerides, each molecule containing more than one type of fatty acid. Most natural oils contain small quantities of a variety of combined fatty acides, although usually two or three predominate.

Natural oils contain mainly two types of fatty acids: (i) saturated acids, and (ii) unsaturated acids. Saturated acids are those in which carbon atoms are linked together by single bonds and unsaturated acids are those which have one or more double bonds in their molecules (Fig. 2).

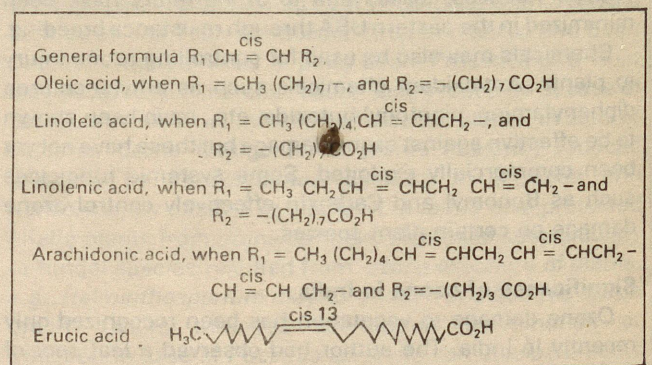


Fig. 2

Amongst the unsaturated acids, oleic acid is the simplest and most widely occurring acid which contains eighteen carbon atoms with one double bond in the centre of the carbon chain. Its name derives from the fact that it is the principal acid obtained when olive oil is hydrolyzed. It is also

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the main acid obtained when human fat is hydrolyzed.

Lipids play two important roles viz., (i) in the formation of cell membrane, and (ii) as a source of energy. The human body needs fat for energy and for storage as future food. Cooking media provide a large share of this requirement. They supply more energy, about 9.3 calories per gram, than proteins and carbohydrates which provide only about 4.5 calories per gram. Besides these important functions, fats in diets increase palatability and flavour of food and also improve their texture.

How much fat does a man need?

According to nutritionists, for an adult it is at least 22 kg/capita/year. But in India, the per capita consumption of fat is very low, only about 5 kg/year. Table 1 shows that

Table 1. Consumption of oils and fats (kg /capita)

	Average (1972-79)	*Projection (1985)*
Developed countries	19.9	21.1
Developing countries	5.0	6.4
World	9.3	10.4

consumption of oils and fats in developing countries is much lower than that in the developed countries because of their non-availability and high cost. There is a good correlation between the amount of fat consumed and income of an individual or a family. Developed countries like Western Europe and North America have the highest rate of lipid consumption. Within these countries, people with the highest incomes consume most calories as fat.

It is now generally accepted that some unsaturated fatty acids are essential constituents of the diet. There are some unsaturated fatty acids which the body needs but cannot manufacture for itself. Such acids are called essential fatty acids (EFA); linoleic, linolenic, and arachidonic acids are important examples. Only very small quantities (8.7 g) of essential fatty acids are required by the body and these (linoleic and linolenic acids only) are present in sufficient quantities in any normal diet. For example, butter on hydrolysis yields small amounts of both linoleic and linolenic acids. Humans require all the three above mentioned essential fatty acids as they are unable to desaturate monoenoic fatty acids towards the methyl end which only higher plants can do. But humans /animals can desaturate fatty acids towards the carboxylic end.

There is another fatty acid termed as erucic acid (Fig. 2) present in mustard and rape seed oils. If this fatty acid is ingested in excessive amounts, it causes growth retardation, and increased cholesterol metabolism. It also causes a serious disease in monkeys known as 'myocardial fibrosis'.

Fig.3 shows the major differences in pathways of

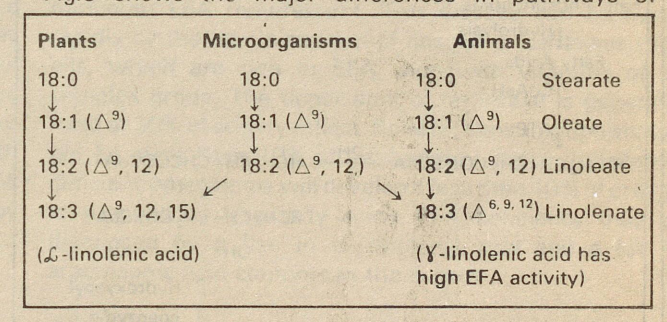


Fig. 3. Biosynthesis of unsaturated fatty acids

unsaturated fatty acid biosynthesis in plants, microorganisms and animals. In plants, a direct conversion of stearate to α -linolenate is possible. In animal tissues, such a transformation cannot take place because of absence of desaturation of oleate. Linoleate is converted to α -linolenate in plants and γ -linolenate in animals. Microorganisms have the capacity to convert linoleate to both α - as well as γ -linolenic acids.

The essential fatty acids that we take in our diets are converted to derived fatty acids within our body tissue. These essential fatty acids and derived fatty acids together are known as polyunsaturated fatty acids (PUFA). If PUFAs are present in the body in excess, they cause more incidence of tumors in mice. These additional polyenoic fatty acids in cell membranes may cause the formation of free radicals due to peroxidation of unsaturated fatty acids and may cause cancer. Therefore lipids must contain

Table 2. Role of dietary fats

Quantitative roles	*Non-nutritional roles*	*Possible clinical consideration*
High calories (9 cal /g)	Lubricating and levening	Obesity
Uniform digestibility	action	Diabetes
Water-free, storage of	Heat transfer medium	Heart Disease
reserve energy	Flavour and seasoning	Malabsorption symptoms
Qualitative roles		
Prevents premature sensations of hunger		Vitamin deficiency
Provides high satiety, palatability		Heart disease, EFA deficiency
carrier for vitamins A,D,E, and K.		Heart disease
contains EFA (Linoleic, linolenic)		Heart disease
Cholesterol, Erucic acid		Heart disease
Saturated fatty acids		Cholesterol absorption
Plant sterols		

antioxidants to inhibit peroxidation of PUFA (suitable ratio of antioxidant is 0.6 mg of α-tocopherol /g of PUFA).

High polyunsaturated acid levels in the diet lead in some instances to substantial increase in serum triglycerides (hypertriglyceridemia), a factor in coronary heart disease. This response is uncommon, but it is a cause for concern.

Fats in the diet are obtained in two forms, the 'visible' fats like butter, vanaspati, vegetable oils, and margarine,and 'invisible' fats which occur in foods like milk and eggs where the fat is in a highly emulsified form. When fatty

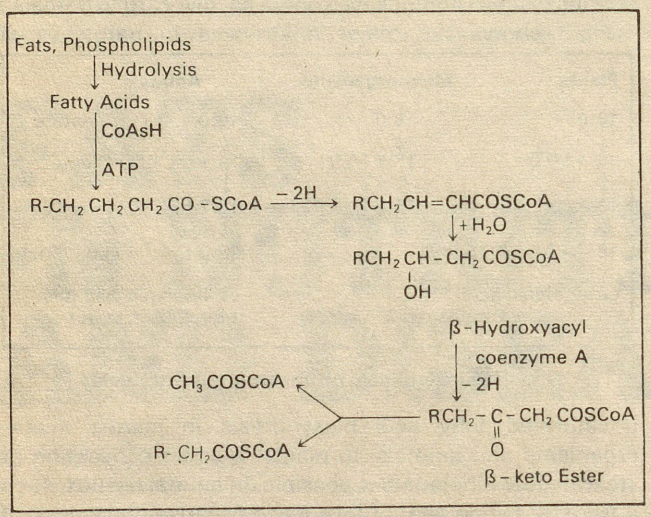


Fig. 4

foods are eaten they pass through the digestive system. In the small intestine they are partly hydrolysed by lipase—one fatty acid molecule being split off from a fat molecule at a time, so that the result is a mixture of free fatty acids and mono and diglycerides.As the hydrolysis is not complete, little free glycerol is produced. A part of the fat is not hydrolyzed at all, but is absorbed directly into the blood in a highly emulsified form.

Fat-soluble nutrients such as long-chain fatty acids and monoglycerides first enter the lymph fluid and then enter the blood stream where the two fluids come together.

Table 3

Metabolic relationship	*Type of fatty acid*	*Function*	*Food source*
ω_6 Series			
Linoleic Acid	$C_{18:2}$	Growth, Antidermatitis, Muscle	Vegetable oils
↓			
γ-Linolenic Acid	$C_{18:3}$	Phospholipids, Prostaglandins, Hypochesterolaemia	
↓			
Arachidonic Acid	$C_{20:4}$	Formation of physiological important chemicals	Animal fats
ω_3-Series			
α-Linolenic Acid	$C_{18:3}$	Growth, Brain phospholipid, Hypocholesterolaemia	Vegetable oils

Fats as energy source

The true digestibility of a fat is the principal determinant of its energy value. The available energy content of a feed fat depends upon numerous factors. For example, unsaturated fats will be digested more readily than saturated fats. Increasing the chain length of individual fatty acids has a depressant effect on digestibility.

Fatty acids are the major structural components of membrane lipids and are the biological molecules in which energy can be stored most efficiently. They exhibit a large number of structural variations, primarily in chain length and in the number and location of double bonds.

When the body uses fat as a source of energy, mainly when there is a shortage of carbohydrates, it draws upon its reserves of triacylglycerols found mostly in adipose tissue. The mobilization of fatty acids from triacylglycerols begins with a cAMP-mediated lipolysis. The released fatty acids are carried by plasma albumin from adipose to energy-deficient tissues. Inside the cells of these tissues, the fatty acids are activated to their acyl-CoA derivative and transported into the mitochondria by means of carnitine acyltransferase (enzyme) reactions. The mitochondrial acyl CoAs are degraded to CO_2, H_2O and energy by β-oxidation, tricarboxylic acid cycle and the electron-transport chain. The oxidation of fatty acid molecules takes place in steps, a fragment containing two C-atoms being removed in each step. If stearic acid is oxidised, for example, it is first broken down to palmitic acid, which is then oxidised to myristic acid, and so on, until butyric acid is reached. In each step the two carbon atoms removed from a fatty acid molecule appear as acetic acid. The butyric and acetic acids formed are oxidised to CO_2 and H_2O by a complex process.

What happens to linoleic acid in the body?

The whole phenomenon could be well understood by the schematic diagram shown in Fig. 5.

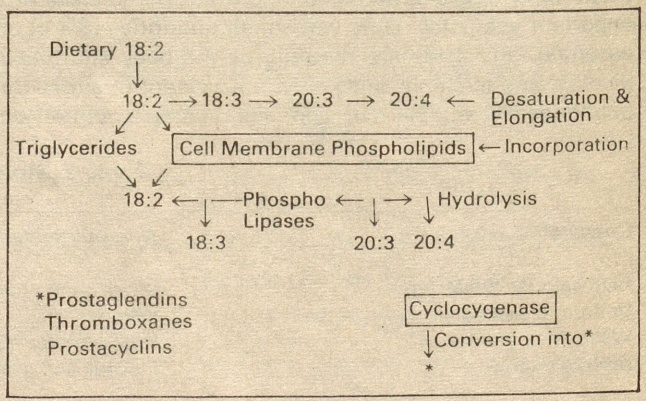


Fig. 5

Linoleic acid is the principal dietary essential fatty acid and is the parent of a whole group of polyunsaturated fatty acids. In animal cells, the C_{20} polyunsaturated fatty acid, arachidonic acid, which is a precursor for synthesis of PG_2 and TX_2 prostaglandins and thromboxanes, may be derived from the diet or from desaturation and elongation of linoleic acid. All reaction steps are enzymatically catalyzed ones.

Importance of prostaglandins

Prostaglandins are biologically active fatty acid-derived molecules, which are involved in contraction of smooth muscles, enzyme activity in lipid metabolism, body weight maintenance, skin texture, and proper kidney and liver function. Prostaglandins are also involved in the functioning of central nervous system, blood circulation, regulation of pulse rate, maintenance of blood pressure, and reproduction. They are reported to be effective in treatment of gastric ulcers and bronchial asthma. They inhibit platelet aggregation.

Prostaglandin synthesis is a continuous process; they are destroyed when blood passes through lungs. When they are present in excess amounts, prostaglandins cause swelling, redness, and pain associated with tissue inflammation. Aspirin is a drug which prevents formation of prostaglandins by blocking the reaction of oxygen with arachidonic acid. Another anti-inflammatory drug is cortisone which stops the formation of prostaglandins by reducing cell membrane release of arachidonic acid.

Dietary problems

People grow fat whenever the caloric intake exceeds its consumption. The excess is then stored as lipid. Many factors have been implicated in the condition, such as feeding habits in the first year of life, genetics, and the sudden lack of exercise associated with middle-age and a sedentary occupation. In certain cases, psychological factors or hormonal imbalances may be involved. Diabetes mellitus is a common disease which is characterized by an impaired utilization of carbohydrates. Fat is therefore excessively used in place of carbohydrates leading to associated problem like ketosis. In mild cases, dietary control is sufficient but more serious cases require insulin therapy in addition.

Chronic malnutrition involves a fat deficiency and consequently an EFA deficiency. Cystic fibrosis is a disease of children which involves faulty digestion and absorption of fats. Achrodermatitis enteropathica is an inherited disease of children characterized by malabsorption and dermatitis. The disease has been observed to involve changes in pattern of fatty acids of serum lipids.

Fats and coronary heart disease

Normal cholesterol concentration of human blood should be 250 mg /100 g. Patients suffering from atherosclerosis commonly have a high concentration of triglycerides and cholesterol. So, one can relate hypercholesterolaemia and coronary heart disease. Excess amounts of saturated fatty acids containing more than 10 carbon atoms increase the level of serum cholesterol, whereas excess of di-unsaturated fatty acids reduces its level. Therefore, a diet containing higher amounts of di-unsaturated (polyunsaturated) fatty acids and a lower amount of saturated fatty acids would help to keep serum cholesterol level lower. Stearic acid, like oleic acid, is much less hypercholesterolaemic than either of three saturated (lauric, myristic, and palmitic) acids. Thus, butter and coconut oil, which contain more of saturated fatty acids, are considered more hypercholesterolaemic in diet.

Atherosclerosis is a degenerative disease in which plaques of fatty material—atheromas—build up in the arteries. High blood pressure, strokes, and heart attacks are among the end results of the atherosclerotic process.

Phrenoderma, a nutritional deficiency disease of skin, is seen in Kerala, Karnataka, and Gujarat and is characterized by horny papular eruptions (roughness) on some parts of limbs, on the back and buttocks. It is caused by essential fatty acid deficiency. A daily intake of 15 g of visible fats in the form of vegetable oils has been recommended to meet minimum EFA requirement. This disease can be cured rapidly by the administration of linseed or safflower seed oils, which are rich in EFA, alongwith vitamins of B-complex group. The upper limit of fat intake is generally fixed at 30% of engery intake. Solid fat consumption should not be more than 10% of total energy intake. In infants, deficiency symptoms will develop if less than 10% of energy is supplied by free fatty acids. EFA deficiency may be diagnosed by a rise in ϑ -linolenic acid and a fall in arachidonic acid contents in the serum.

Conclusion

Without fat, it would be impossible to make up the caloric deficits found in the diets of the vulnerable section of our population, such as infants, children and pregnant and lactating women. While nutritionists have emphasized the need for calories, proteins, various types of carbohydrates, minerals and vitamins, it is unfortunate that little attention has been paid to the need for oils and fats in nutrition. About 80% of our oils are used for edible purposes as cooking oils and in the production of vanaspati and as bakery fats. Vanaspati is the largest processed food fat and consumes 20% of our edible oils.

The functions of oils and fats in human nutrition are widely recognized, but we find that they play opposite roles in developed and developing countries. In the former they cause harm because of overconsumption, while in the latter, people suffer due to underconsumption.

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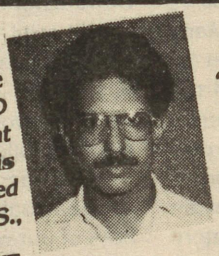
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The earth is getting warmer

FROM the time when man lived in caves and hunted with his bare hands, to this day when he can get most of his work done at the push of a button, the story of man's progress is indeed remarkable. But sadly, this progress has been at the cost of the environment that sustains him.

Extinction of numerous animals and plants with many more at the brink of extinction, erosion of soil, droughts, floods and lately the depletion of the ozone layer are only some of the consequences of man's blind pursuit of progress. After having altered the strategic ecological balance at several places, he now seems to be on his way to altering the global heat balance as well.

This has been the conclusion of several studies which have found a global warming of the earth over the years. This warming has been found to be intimately connected with rising Co_2 levels in the atmosphere. Viewed in context of a couple of studies that say that extreme heat led to the extinction of dinosaurs 65 million years ago, this revelation assumes great significance.

Gases such as Co_2 in the atmosphere prevent heat from leaving the earth, causing what is known as the 'greenhouse effect'. Scientists now estimate that rising levels of trace gases such as methane, nitrous oxides, ozone and chlorofluorocarbons may also together contribute as much to the greenhouse effect as does CO_2 alone. When the level of such gases rises they trap more heat near the ground leading to a corresponding increase in temperature.

The amount of CO_2 in the atmosphere has been increasing ever since the industrial revolution began. Over the last 30 years carbon emissions have greatly increased with the increasing use of fossil fuel energy in industry, transportation, power production and agriculture. According to the Worldwatch Institute of USA, fossil fuels burned to move people and cargo release more than 700 million tons of carbon into the atmosphere annually.

Besides, deforestation too has a crucial role to play in the maintenance of carbon dioxide levels. The earth's vegetation and soils hold some 2,000 billion tons of carbon, roughly triple the amount stored in the atmosphere. Consequently, when the forests are cleared the carbon contained in the trees and in the underlying soil is oxidized and released into the air, adding more CO_2 to the atmosphere. This release occurs rapidly if trees are burned but slowly if they decay naturally.

According to the Worldwatch Institute, since 1860 forest clearing has contributed 90-180 billion tons of carbon to the atmosphere as compared to 150-190 billion tons from burning of coal, oil and natural gas. According to present estimates, deforestation adds 1.0 to 2.6 billion tons of carbon annually or between 20% and 50% as much as the burning of fossil fuels.

Right now the concentration of CO_2 in the atmosphere is 345 ppm as compared to 315 ppm in 1958. The rising concentration of CO_2 now no longer remains an urban phenomenon where innumerable industries thrive. Rather, the gas is now slowly but surely being dispersed by air currents circulating throughout the northern and southern hemispheres. Scientists now predict that atmospheric levels of Co_2 will nearly double to 650 ppm by the year 2050.

Apart from Co_2 there are a host of other gases as well that are now known to add to the greenhouse effect. In 1975 it was discovered that Freon, a widely used chlorofluorocarbon (CFC), was an infrared absorber. Since then dozens of other trace gases have been found to be rivalling the effects of increasing Co_2. For instance, the amount of nitrous oxide is expected to increase by 20% till 2050. By the same time the concentration of methane is expected to double. Incidentally, termites are responsible for as much as 50% of the total atmospheric methane budget. Methane is emitted when termites digest woody vegetation. A single termite mound can emit 5 litres of methane a minute.

The rising levels of gases in the atmosphere have had their impact on the world climate as well. On an analysis of past temperature records, the Climate Research Unit at the University of East Anglia found a global warming of 0.05°C since 1860. And on an average 1987 was found to be the world's warmest year on record with 1981 and 1983 tied at second place just 0.08°C cooler. Scientists believe that even without any additional Co_2 buildup, the present atmospheric changes are enough to ensure a further 10°C increase during the next few decades.

If current energy trends continue the temperature rise could cause drastic shifts in the earth's climate. A global warming may cause changes in rainfall patterns, prevailing winds, and ocean currents, which might lead to severe storms. Further, since the rise in temperature is expected to be unevenly spread, it would lead to uneven distribution of evaporation and rainfall with a serious impact on agriculture.

However, according to a group of scientists, higher levels of CO_2 would enhance the growth of trees, causing them to remove more carbon from the atmosphere. This would have a dampening effect on the warming. But there is no convincing evidence to suggest that natural forests would respond in this way.

On the other hand ecologst George Woodwell in his paper "Forests and climate : Surprises in Store", *Oceanus,* 1986 /87 paints an altogether different scenario. According to him the rise in temperature resulting from a buildup of CO_2 and other greenhouse gases could increase the respiration rates of trees. When respiration outpaces photosynthesis, trees would release more CO_2. If this continues for an extended period trees would stop growing and ultimately die.

Apart from this, a hotter earth is more likely to witness a

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rising sea level with high temperatures melting glaciers and ice caps. Besides, as the earth warms the water in the oceans would also expand. Projections by the US Environmental Protection Agency show a rise in sea level by 2100 of between 1.4m and 2.2m. This would hurt most in Asia where rice is produced on low-lying river deltas and flood plains. Besides, several low-lying cities would be flooded.

Scientists even anticipate disappearance of many species of animals and plants that might not be able to adjust to high temperatures and altered seasons. So, with consequences as drastic as this, the warming of the earth presents a challenge to environmentalists the world over. This challenge can only be met at a global level, only then can the human community hope to survive the latest threat.

Hasan Jawaid Khan

Atmosphere—a source of fuels and chemicals

OUR atmosphere is a vast reservoir of carbon in the form of carbon dioxide. It contains as much as 708.5 gigatons (1 giga = 10^9) of carbon, while the vast biosphere (both terrestrial and marine) contains in total about 2400 gigatons. More and more carbon is being added to the atmosphere as a result of increased use of fossil fuels. For example, while in 1960, an estimated 2.61 gigatons of carbon were added to the atmosphere, this amount was 3.96 and 5.62 gigatons in 1970 and 1978 respectively.

Much of this carbon dioxide is in excess of the requirement of the biosphere. It causes the 'greenhouse effect', that is, an increase in the mean surface temperature of earth owing to poor thermal conduction by carbon dioxide molecules. It is estimated that if the current rate of increase (about 4.3% per year) in the consumption of fossil fuels is maintained, then the carbon dioxide concentration in the atmosphere would double by 2035 AD, which would cause an increase in the mean surface temperature of earth by about 2°-3°C.

The impact of such an increase in carbon dioxide level vis-a-vis the mean surface temperature of earth may bring about catastrophic changes in the climatic and non-climatic terrestrial conditions. In such an eventuality, the polar caps may melt to some extent leading to a rise in the sea level and to an inundation of all low-lying areas in the coastal regions. The ocean currents may also change causing a drastic alteration in the global climate.

Some scientists however think that the increased carbon dioxide concentration could beneficially affect the rate of photosynthesis. Controlled experiments in plastic tents and glass houses have shown that as the carbon dioxide concentration is doubled, the rate of photosynthesis increased by about 40% and the water requirement of the soil decreased by about 25%. But such observations have not been confirmed in case of all types of plants or in open atmosphere. The impact of carbon dioxide on agricultural output and plant growth is therefore still an open question. Meantime, its harmful effects are only too apparent.

So, the rapid increase in carbon dioxide level in the atmosphere is one of the biggest ecological problems facing mankind today. Some ways must be found to bring down this level without disturbing the necessary carbon dioxide balance of nature.

Possible solution

The solution lies in the conversion of the atmospheric carbon dioxide into simple carbon compounds such as methane, methanol, formaldehyde, formic acid, etc., which may be used as fuels in place of the present carbonaceous substances or as feed in the organic chemical industry. In either way, the precious carbonaceous fuels would be conserved or the rate of carbon dioxide released to the atmosphere would be reduced. Therefore, in the last several years, a tremendous interest in the inorganic fixation of carbon dioxide by catalytic, photocatalytic and photoelectrocatalytic methods has been generated all over the world.

Some reactions, which are being studied at present, are shown in Table 1. There have also been some more studies on similar reactions leading to the formation of ethanol, acetaldehyde, acetic acid, glyoxal, oxalic acid, etc., but these have not evoked much interest.

Dilemma

From Table 1 it is apparent that the reactions of carbon dioxide with hydrogen are thermodynamically much more feasible than those involving water or steam. Particularly, the methanation and methanol formation reactions (1 & 4) are highly attractive even at 25°C. But even though such reactions are within an easy reach and more efficient catalysts can be developed, there should be a serious consideration of the economic viability of such processes, because in all such examples of carbon dioxide reduction and incorporation as carbon compounds, hydrogen is a necessary reactant. For the more generalized reductions of carbon dioxide to hydrocarbons and carbohydrates, even greater mole ratios of hydrogen to carbon dioxide are required.

If so much hydrogen is generated as to react with carbon dioxide to form methane, methanol, etc., for fuel purpose, why not use that hydrogen directly as fuel? After all, the net reaction in the formation of methane from carbon dioxide

Table 1

	H^0_f	G^0_f
(1) $CO_2(g)+4H_2(g)=CH_4(g)+2H_2O(g)$	—160.7	—113.0
(2) $CO_2(g)+H_2(g)=HCOOH(g)$	+ 31.0	+ 59.0
(3) $CO_2(g)+2H_2(g)=HCHO(g)+H_2O(l)$	— 7.9	+ 47.3
(4) $CO_2(g)+3H_2(g)=CH_3OH(aq)+H_2O(l)$	—130.5	— 8.8
(5) $CO_2(g)+H_2O(l)=HCOOH(aq)+\frac{1}{2}O_{2(g)}$	+316.7	+296.7
(6) $CO_2(g)+H_2O(l)=HCHO(aq)+O_2(g)$	+563.6	+521.8
(7) $CO_2(g)+2H_2O(l)=CH_3OH(aq)+\frac{3}{2}O_2(g)$	+727.8	+702.9
(8) $CO_2(g)=CO(g)+\frac{1}{2}O_2(g)$	+283.2	+257.3

(These thermodynamic values, $\triangle H^0_f$ and $\triangle G^0_f$ in kilojoule/mole at 25°C, are to be corrected for the actual partial pressure of carbon dioxide and oxygen in air).

and hydrogen, and its subsequent combustion, is simply the combustion of hydrogen. Of course, the storage, transportation and use of hydrogen as fuel are beset with problems such as very low boiling and flash points and a negative Joule-Thomson coefficient. Moreover, the compounds methane, formaldehyde, methanol, etc., formed by the reactions 1-4, may be used as raw material for other chemicals. But the production of hydrogen is very energy intensive and costly.

The present route to the large scale production of hydrogen involves either steam reforming of natural gas /naphtha or partial oxidation of coal or fuel oil, followed by the catalytic conversion of carbon monoxide into carbon dioxide and hydrogen by reaction with steam. The unreacted carbon monoxide and the large quantity of carbon dioxide thus produced are then removed from the resultant gas mixture to give pure hydrogen. These processes, particularly the steam reformation or partial oxidation generate a mixture of carbon monoxide, carbon dioxide and hydrogen. They are however so much energy-consuming that in a modern ammonia plant, even after the introduction of several energy-saving technologies, about 28-32 gigajoules of energy are required for every tonne of ammonia produced.

Moreover, as the reactions in the current methods of hydrogen production require a concurrent generation of carbon dioxide as a sink for excess oxygen, the dilemma in the present attempts for utilization of carbon dioxide as a source of fuels and chemicals is complete. Stated briefly, an oxygen sink is required for the formation of C-H bonds from carbon dioxide but the sink is carbon dioxide itself.

Artificial photosynthesis

The dilemma can be resolved, however, if one realizes that an alternative means of storing the unwanted oxygen in these reactions exists in the form of metastable molecular oxygen. Precisely, this happens in photosynthesis. Using sunlight, carbohydrates and oxygen are produced by the chlorophyll in plant cells from carbon dioxide and water.

The problem is therefore to carry out the photosynthesis artificially in the laboratory upto a certain stage, say, upto the formation of formic acid, formaldehyde or methanol. Some scientists are of the opinion that before the chlorophyll-containing cells were evolved, simple organic compounds were possibly synthesized in this way from carbon dioxide and water by the catalytic action of inorganic oxides in presence of sunlight.

Presently, this type of artificial photosynthesis is possible in the laboratory. It has been observed that when carbon dioxide is slowly bubbled through an aqueous suspension of fine powders of platinum, ruthenium, etc., loaded on titania, and the whole mixture is intensely illuminated by solar radiation, small quantities of formaldehyde, formic acid, methanol, ethanol, etc., are formed in the solution in varying proportion. The formation of these compounds is also facilitated if, in addition to illumination, a pure semiconductor like p-gallium arsenide is used as cathode in place of the above catalysts and a current is passed through the cell.

Table 1 indicates that the reactions of carbon dioxide with water involve a positive free energy change. It is clear therefore that the positive free energy barrier in these reactions is overcome with the help of an external (solar and /or electrical) energy. In other words, these reactions offer not only a means for conversion of carbon dioxide into useful chemicals but also a means for the storage of solar and electrical energy. Naturally, the more endergonic (sum of free energy of products more than that of reactants) a process is, the more energy is stored per mole of the product. In this respect and in view of the diverse end uses, two processes appear to be very attractive for further development. These are: (1) the formation of methanol by reaction 7 (Table 1); and (2) the decomposition of carbon dioxide into carbon monoxide (reaction 8, Table 1).

Methanol seems to be a key chemical of the future. It can be used as fuel directly, or it can be converted into a host of other important substances, including gasoline. Carbon monoxide, on the other hand, is a feed in Fischer-Tropsch

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and many other organic chemical syntheses. It can also be used to generate hydrogen by the well-known water gas shift reaction: $CO + H_2O = CO_2 + H_2$. This hydrogen may be used as feed in fertilizer and petrochemical industries.

It may be mentioned here that since air contains comparatively a very small concentration (335 ppm) of carbon dioxide, the separation of carbon dioxide from air by cryogenic methods may not be economically viable. At the same time, air cannot be used as such, because the catalysts will be deactivated by oxygen. However, it has been found that some tetra-aza cycloalkane-type complexes absorb carbon dioxide selectively from air at room temperature and give up this carbon dioxide when slightly heated. Incidentally, similar tetra-aza complexes act as electron transfer agents during the photochemical reduction of carbon dioxide. Also, there is a strong resemblance between these macrocyclic compounds and chlorophylls, particularly in respect of the arrangement of nitrogen atoms around the central metal atom.

Current status and problems

Basically, any oxidation-reduction reaction requires a transfer of electrons from one reactant to another. The process of photosynthesis (formation of carbohydrate from carbon dioxide and water) involves a transfer of four electrons for each molecule of carbon dioxide incorporated. This occurs in two stages through a series of intermediate steps which are yet to be fully understood. Electronically, the reduction of carbon dioxide into methanol or the decomposition of carbon dioxide into carbon monoxide can be written as :

$$CO_2 + 6H^+ + 6e \longrightarrow CH_3OH + H_2O \qquad E^0 = -0.38\ V$$
$$CO_2 + 2H^+ + 2e \longrightarrow CO + H_2O \qquad E^0 = -0.52\ V.$$

The design of systems capable of performing photochemically these reactions requires photogenerating species of sufficiently negative redox potentials, finding suitable electron donors and devising efficient catalysts for polyelectron transfer. Obviously, such systems are likely to be complicated and would consist of : (i) a photosensitizer (a species that absorsbs the light of required wavelength and becomes excited—a function similar to that of chlorophylls); (ii) an electron relay which extracts electrons from the excited photosensitizer and transports them to the catalyst surface; (iii) a catalyst which offers its surface for the adsorption of the reactants and participates in the subsequent electron transfer between the reactants leading to the formation of products; (iv) an electron donor which donates the requisite number of electrons to the photosensitizer to bring it back to its unexcited (ground state) level so that it is ready to receive a fresh quantum of light.

In most experiments, tris-bipyridyl (ruthenium) $^{2+}$ -ion and methyl viologen have been found to be the most efficient photosensitizer while complexes of rhodium, cobalt, ruthenium, etc have been found to be the electron mediators and triethanol amine, ascorbic acid, etc., the most common electron donors, Similarly, colloid platinum, or powders of platinum, ruthenium, etc., loaded on titania have been found to act as efficient catalysts. In some experiments, these titania-based catalysts acts as 'three-in-one' that is, they themselves perform the role of photosensitizer, electron mediator and catalyst without the intervention of any other species.

The mechanism of formation of carbon monoxide and hydrogen from carbon dioxide and acidic water is schematically shown in Fig. 1. Fig. 2 shows schematically the action of a metal-loaded semi-conductor particle.

Without going into details, the present attempts for

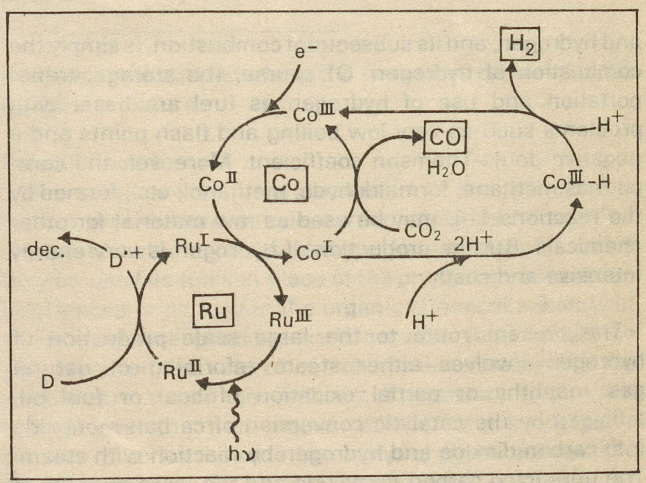


Fig. 1. Schematic representation of the reaction mechanism for simultaneous and competing CO and H_2 generation by photo-induced CO_2 and H+reduction. System : (Ru bipyridyl)$^{2+}{}_3$(photo-sensitizer)/$CoCl_2$-bipyridine (electron mediator and catalyst)/ Trialkyl amine (sacrificial electron donor); solvent-acetonitrile

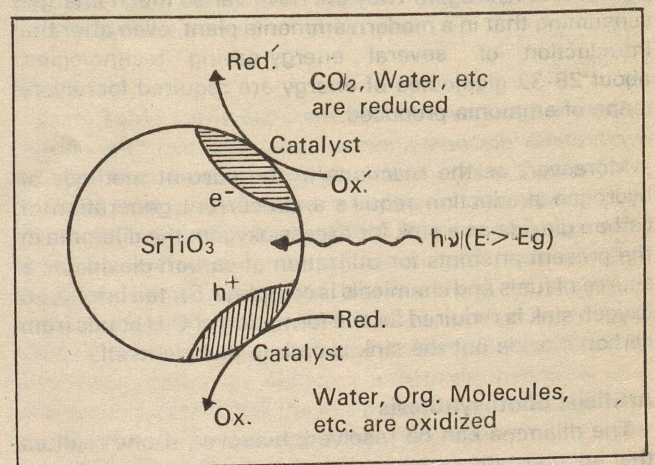


Fig. 2. Schematic diagram showing the simultaneous oxidation-reduction reaction at two different sites on the metal-loaded semiconductor particle or on a semiconductor particle like $SrTiO_3$. The electron-hole pair ($e^- - h^+$) is generated by the action of band gap (Eg) radiation on the catalyst particle

photocatalytic reduction of carbon dioxide are, however, beset with three major problems: (i) the photo-catalyst systems so far developed are not very stable and are deactivated after a short duration; (ii) the rate of conversion achieved so far is too small for any commercial application; and (iii) the wastage of a valuable chemical product such as triethanol amine, ascorbic acid, etc., because these substances decompose after the electron donation. It appears that such processes would be commercially feasible, if the catalyst efficiency is increased manifold and / if particularly water is used as electron donor by the following reaction:

$$2H_2O \longrightarrow 4H^+ + O_2 + 4e \qquad E^0 = +0.82\ V$$

This requires the photoproduction of an oxidized species of redox potential higher than + 0.82 V and the development of a redox catalyst capable of mediating the above reaction.

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Surfactants increase efficacy of pesticides

SURFACTANTS are finding increasing uses in applied as well as in allied fields. The importance of surfactants in the field of cosmetics, metal and mineral technology, in textile, paper, leather, synthetic rubber, polymer, plastic, paint and petroleum industries is well established. Their usefulness in agriculture to improve the physical properties of fertilizers and soils and in bringing about quick germination of seeds is also being gradually recognised. Several kinds of spraying composition which are used for combating insects, fungi and other enemies of plant kingdom have surfactants as important components. Another use of surfactants is in washing fruits and vegetables to remove harmful spray residues before they are sent for marketing.

Pesticides

To start with, let us define surfactant as a substance that tends to migrate to a surface or interface from the bulk phase. A pesticide is a chemical that is toxic to any undesirable organism such as weeds, insects, rodents, fungi and bacteria. Most pesticides are sold in the market in the form of concentrates which are diluted by the user in the oil or water and then applied over large areas. Emulsifiable concentrates are mostly used, but water-soluble concentrates and wet table powders are also used. A surfactant is an essential ingradient of an emulsifiable concentrate. The presence of a surfactant will influence; (i) dispersibility and stability of the concentrate in water, (ii) physical properties of the spray solution, and sometimes (iii) the activity of the toxicant towards the pest.

A large number of surfactants are available and many of them have been used successfully in pesticidal formula-tions. Manufacturers of concentrates of pesticides supply formulation mannuals which provide details of constituent ingredients in pestcides.

Emulsifiable concentrates

An emulsifiable concentrate comprises a water insoluble organic toxicant, an organic solvent and an emulsifier. The concentrate, when put in water, spontaneously breaks up into small oil droplets that suspend in aqueous phase. The emulsion thus formed is called oil-in-water or O/W emulsion.

Non-ionic and anionic surfactants are mainly used alone or in combination. A surfactant molecule consists of a water-soluble (hydrophilic) and a oil-soluble (lipophilic) portion. ·The alkylbenzene sulphonate, $R.C_6H_5SO_3Na$ ionises in water and the polar end of the molecule ($—SO_3^-$) contributes to the hydrophilic character while the hydrocarbon portion, $R.C_6H_5^-$, contributes to the lipophilic character. In a non-ionic surfactant, $R.C_6H_5^-(OCH_2.CH_2)_nOH$, the $(OCH_2.CH_2)_nOH$ is the hydrophilic portion and $R.C_6H_5^-$ is the lipophilic portion of the molecule.

A stable emulsion can be prepared by using a surfactant (an emulsifier) with the proper balance of hydrophilic and lipophilic properties in the pesticidal concentrate. The hydrophilic and lipophilic balance, commonly referred to as HLB, fosters the movement of the surfactant from the bulk of the oil phase to the oil-water interface where it forms a film that prevents the coalescence of the drops and thereby stabilises the emulsion. HLB is estimated by determining whether or not the surfactant will emulsify a particular oil. It is generally advantageous to use a mixture of two or more emulsifiers in the system while making an emulsifable concentrate.

Stability of an emulsion

The stability of an emulsion is related to the length of time the dispersion remains homogeneous. For applying a high-volume of spray (over 100 gallons per acre) to foliage, it is always desirable to have a relatively quick-breaking emulsion in which the oil-droplets separate quickly and deposit on foliage allowing the aqueous phase to run off. Such type of emulsions are prepared by reducing the amount of emulsifier in the concentrate.

In recent years, the popularity of low volume sprays (50 gallons per care or less) has considerably increased. An

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emulsion consisting of a dispersed phase with a particle size 0.5×10^2Å to 1.5×10^2Å is usually stable. For foliar agricultural sprays using modern equipments, stability usually be just enough to ensure a uniform distribution of the pesticide over the target.

It has been found that approximately 0.02 percent surfactant (by weight) is sufficient to influence the spray characteristics of the solution. Spray solutions are applied to foliage by forcing the solution through a nozzle that breaks the spray up into fine particles. Air-blast sprays are very popular as they produce extremely fine particles.

Once a pesticide has been deposited on foliage, it is necessary that the material resists weathering and is not washed off by rain. Wetting agents which increase deposit, also increase the probability of wash-off.

Effect of surfactants on pesticidal activity

Use of surfactants to enhance activity of herbicides is well established. In one of the countries approximately 30,000kg of surfactants were used with herbicides in 1960 which rose to over 2,50,000 kg in 1963.

Surfactants have been shown to enhance the activity of various herbicides, viz., 3-(3, 4-dichlorophenyl)-1, 1-dimethylurea (Diuran); 2, 2-dichloropropionic acid (Dalapon); 3-amino—1,2,4-triazole (Amitrole); disodium monoethyl arsonate, dichloropropion-anilide; 2,4-dichlorophen-oxyacetic acid; 2,4-dinitro-6-sec-butyl phenol and others.

To be active on a particular weed species, a herbicide must be absorbed in the foliage and then translocated throughout the plant. Surfactants help penetrate herbicides into the plant thus making them more effective.

Insecticides and fungicides

Highly active insecticides, viz., copper compound, nicotine, pyrethrum, chlorinated hydrocarbons (DDT, Chlordane, Toxaphene), etc., are used in many insecticidal formulations. Surfactants aid in forming a uniform film of insecticide on the desired surface. Solid insecticides may be applied by dusting or by spraying in the form of an aqueous dispersion. The sticking power of insecticidal dusts are improved by adding small quantities of certain solid surfactants which are of gummy nature. They act merely as adhesives. In the case of a water-soluble toxicant, wetting agents are generally employed to improve wetting and spreading in aqueous sprays. Smaller concentration of a toxicant in the spray is sufficient to destroy insects. DDT, one of the extensively used insecticides, is used along with various ionic and non-ionic surfactants. Some surfactants enhance the activity of insecticides and fungicides. It is reported that Triton X-155, a non-ionic agent, enhanced the activity of Malathion on two-spotted spider mites. Some non-ionic surfactants enhanced the activity of dinitro-*o*-cyclohexylphenate. Cationic surfactants increased the activity of a carbonate insecticide also. They inhibit the growth of fungi.

There are many suface-active agents which themselves possess valuable insecticidal property. Potassium soaps of C_{10} to C_{14} fatty acids are suitable for combating aphids and other softbodied insects. Non-ionic agents of the fatty acid hexitol ester type, alkylaryl sulphonates, sodium lauryl sulphate, and the long chain cationic surfactants such as diethyl dodecyl benezene ammonium chloride, zinc salts of petroleum sulphonic acid are some of the examples of surface-active insecticides. Another type of compounds, which contain surface-active as well as toxic radical in the same molecule, are nicotine salts of alkylaryl sulphonates, long chain alkyl nicotinium halides, and mercurated derivatives of sulphosuccinic esters.

Surfactants have also been used as fungicides, herbicides, and seed disinfectants. Herbicidal emulsions prepared from an active toxicant such as 2,4-di-chlorophenoxyacetic acid (2,4-D), organic solvents (pine oil, petroleum oil, diacetone alcohol, etc.) and emulsifying agent such as alkylaryl sulphonates and dethylcyclohexyl ammonium chloride are used for the control of weeds. Fatty alkyl sulphates, soaps and alkylaryl sulphonates have been widely used for the preparation of arsenical herbicides and fungicides. In formulating copper phosphate fungicides, fish oil soap has been found as a suitable depositing and sticking agent. Quaternary ammonium compounds acts as active fungicides.

The insecticides which are sprayed on fruits and vegetables must be removed before marketing as they are poisonous to humans. Alkaline soap has been employed to remove DDT from oranges. A mixture of alkylaryl benzene sulphonate along with an oil-soluble oleate soap has been found to be effective in removing DDT residues. Since alkylaryl sulphonates and sulphates are themselves toxic, they must be used to wash fruits and vegetables only by rinsing.

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Predicting the end of the world

ALL everyday matter, such as the paper you are holding, is made up of protons and neutrons. These are so similar to each other in nature that physicists often refer to them under the collective name of nucleons. A fundamental goal of high energy physics is to achieve a grand unified theory (GUT) of all the known forces of nature. Such GUTs purport to explain the origins and mechanisms of the universe, and indeed its possible future.

That the nucleon might be unstable and likely to decay is one of the profound predictions of GUTs. The decay of the

proton implies that all matter is ultimately unstable and will eventually transmute into pure energy. Consequently, a measurement of the proton lifetime is, in a certain sense, a measure of the lifetime of the universe itself.

The *Soudan 2* nucleon decay experiment is a multinational collaboration between Britain's University of Oxford and the nearby Rutherford Appleton Laboratory, with the United States' Argonne National Laboratory in Chicago, the University of Minnesota,and Tufts University in Boston. The aim of this experiment is to determine if nucleons do indeed decay and, if so, to put a limit on their life.

Looking for nucleon decay experimentally poses several practical problems, the solutions to which have come both from the academics and technicians in the various research institutes and from British and American industry. The first problem stems from the fact that other experiments have shown that the proton has a lifetime for radioactive decay exceeding some 10^{31} years. (The universe is only 10^{10} years old, and so less than one in 10^{21} protons had decayed so far.)

Obviously it is impossible to observe a single proton for 10^{31} years, but it is possible to observe 10^{31} protons for one year. A thousand tonnes of matter contain 6×10^{32} nucleons, so if the proton lifetime is 1×10^{32} years, six protons should be seen to decay in any one year. The detector itself therefore needs to be at least a 1000-tonne precision-built instrument.

Honeycomb of steel

Another difficulty is that the secondary products of the cosmic radiation that continually bombards Earth can induce reactions inside the detector which look exactly like nucleon decay events. This radiation is intense on the Earth's surface but does not penetrate deep underground. In order to avoid this surface radiation, the *Soudan 2* nucleon decay detector is being installed in a purpose-built laboratory 700 metres below ground level. The location of this unusual laboratory is a disused iron mine in the remote village of Soudan, northern Minnesota, in the United States.

When complete, the detector, technically called an iron calorimeter, will have an active mass of 1100 tonnes, consisting of 256 identical (1 m × 1 m × 2.5 m high) modules. The calorimeter was designed by Dr John H. Cobb of Oxford University, and has a unique honeycomb geometry that enables the position of any charged particles sensed by the detector to be precisely determined. Each module is built from 1 m × 1 m × 1.6 mm uniform corrugated steel sheets which are stacked 241 sheets high to form the honeycomb pattern.

Purity and precision

The steel honeycomb array is lined with 16 mm Hytrel resistive plastic tubes which are captured inside a heat-sealed laminate of 125 μm Mylar. Thin copper strips on the laminate run perpendicular to the tubes and maintain a uniform electric field along the length of each one. The resistive tube and insulating Mylar assembly is known as a bandolier.

The tubes are filled with a mixture of argon and carbon dioxide gas which forms the active component in the detector. Charged particles produced by reactions such as nucleon decay inside the detector will cross the gas-filled tubes to collide with, and remove electrons from, the gas molecules. This process is called ionisation and the freed



Soudan-2 nucleon decay experiment. Inset shows honeycomb geometry of the calorimeter

electrons are referred to as ionisation electrons. These drift down the tubes, carried by the uniform electric field, and are detected by sets of anode wires and cathode strips located at either end of the honeycomb stack.

Starting date

Construction of each module begins with a load plate laid down on an assembly jig. Steel sheets are added one at a time while the bandolier is fanfolded in between the corrugations. An important aspect of the stacking is to maintain high accuracy in the positions of each steel sheet and bandolier.

Precision is necessary because the profile of the finished stack is crucial to the performance of modules, both individually and with respect to each other. When a single stack is complete, a top load plate is added and the whole assembly is subjected to a pressure of 10 tonnes/m². This compression compensates for the build-up of cumulative errors that may have occurred during the stacking process.

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British modules are constructed and tested at the Rutherford Appleton Laboratory, and then despatched to Soudan. The first group of eight modules was turned on in March 1987 and is currently taking data while the remainder of the detector is being built. A substantial part of the entire detector is scheduled to be completed and running by 1989.

After several years, the *Soudan 2* experiment should be able to explore further the limits on matter stability that have an influence on the choice between different GUT theories.

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DNA probes as diagnostic tools

PRESENTLY there are about 3,000 known kinds of genetic defects, caused either by gene mutations or by chromosomal aberrations. These advances in our knowledge of a wide range of inherited human diseases mean that we can now detect the defects in single genes that underlie diseases such as Huntington's Chorea and cystic fibrosis. The new techniques for isolating and analysing genes may also enable us to diagnose an individual's predisposition or susceptibility to illness such as heart disease, where many factors contribute to its development. The ability to diagnose these diseases, reliably, even before symptoms develop, could eventually lead to effective therapies. As a majority of researchers are convinced that virtually all diseases are somehow rooted in DNA - either the DNA of the patient or the DNA of infectious agents, such as viruses and bacteria - a logical first diagnostic step would be searching body fluid samples for aberrant or alien genes.

In keeping with this view, DNA tests are fast becoming a commodity traded in the medical market, much like pregnancy tests. The US Food and Drug Administration (FDNA) has approved about seven gene probes for diagnostics since 1985. These include probes that detect herpes virus and legionella.

Gene probes are short stretches of DNA that home in on a particular defective gene. Moreover a gene probe can be a piece of DNA or RNA isolated from an organism, or a short sequence (as oligonucleotide) synthesised in the laboratory that matches up with the target sequence. "DNA probes" work on the principle that two complementary strands of DNA attract each other and bind together. In case researchers know the DNA sequence of the target aberrant human gene or of the target infectious organisms, they can "manufacture" strands of the target DNA to use as a probe. They can do that by isolating a part of the aberrant gene or a part of the disease-causing organism's DNA, then inserting the isolated DNA strand into harmless bacteria. As the bacteria multiply, so does the inserted DNA. The target DNA is then removed from the bacteria and purified. Another method of manufacturing strands of target DNA is by synthesizing it from scratch with off-the-shelf chemicals, often using a sophisticated "gene machine".

Thus, purified or synthesized probes can be used to search for target DNA in samples of tissue or body fluid, such as blood, urine or amniotic fluid. In a typical diagnostic procedure, a small fluid sample is withdrawn from a patient and treated with a chemical or heat. All the double stranded DNA in the sample, normal and abnormal, separates into two single strands. The probe is then added to the sample. If a strand of the target DNA is present, the probe binds to it. In the past practically all DNA probes were tagged with radioactive isotopes. To find out whether a probe had bound to a target DNA, researchers had to use X-ray film or "gamma" counters. Recently, however, biotechnology companies have moved away from radioactive isotopes because of their short shelf life, the need for complex and costly instrumentation and the inherent disposal problem. The newer approach is to employ enzyme tags that cause color change or fluorescent tags that glow under microscopes.

The versatility of DNA probes makes them attractive in a variety of applications, some are designed to diagnose infections in people or livestock, such as human immunodeficiency virus or salmonella. Others identify restriction fragment length polymorphisms (RFLPs) in the human genome that are associated with inherited diseases such as cystic fibrosis or Huntington's chorea. Inherited diseases like sickle cell anemia and cystic fibrosis are caused by gene mutations. In both cases, screening tests for the mutant gene could detect the disease. Some biotechnology companies in USA offer gene probes for both of these diseases. Besides, diagnostic methods that use DNA probes also have important potential in (i) detecting bacterial resistance to antibiotics, (ii) plant diagnostics, such as in screening seed stocks for diseases and for ensuring that plant propagation material is free from both virus and viroids, (iii) tissue typing which is required for crossmatching between organ donors and recipients; (iv) disease susceptibility testing i.e. susceptibility to cancer and some kinds of heart diseases; (v) food testing for contamination of a particular group of bacterial pathogens such as Salmonella and camphylobacter.

Since medical genetics in its various ramifications is gradually gaining considerable importance in this country, the introduction of "DNA probes as diagnostic tools" would

be valuable in the clear, early and accurate diagnosis of hereditary diseases. Nevertheless, the introduction of these tools on a wide scale poses serious ethical problems, beause through these tests we shall be able only to diagnose but not treat or prevent the development of the disease. Thus, we should take into consideration social consequences of such developments before genetic testing is introduced.

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The role of the Y chromosome

GONADAL sex determination in mammals involves differentiation of testes or ovaries from an indifferent (neuter) embryonic gonad. The occurrence of Y chromosome in XY embryos leads to development of testes while its absence causes formation of ovaries in XX individuals. Chromosomal basis of sex determination is well accepted but there is little information about the number, location and mode chromosome.

Y chromosome is small in size and consists of two segments, one that does not fluoresce and is genetically active and a second that fluoresces and is genetically inactive. The sexual phenotypic similarity between human beings having a deletion of short arm of Y chromosome (46, XYp^-) and Turner's syndrome (45, X) has revealed that genetic information for male development is located on the short arm of Y chromosome. During the last two decades, use of somatic cell hybridisation technique has led to the assignment of a large number of genes on X chromosome and the X-loci seem to be conserved in diverse mammalian species. Surprisingly, so far not even a single Mendelian gene has been assigned to the Y chromosome. However, the general belief is that there are few male determining genes on Y chromosome. The occurrence of a noncoding, highly repetitive satellite DNA unique to mammalian Y chromosome has been recently reported. The Bkm satellite (Banded krait minor satellite DNA) was first isolated from the banded krait and now is known to occur in varying amounts and in different locations in diverse eukaryotes from yeast to man. Bkm satellite has served as a useful molecular marker of sex chromosomes but its relationship to male determining genes still remains unclear.

The central question in the mammalian sex determination is the manner in which the Y chromosome confers maleness. In the last decade, much speculation has been focused on the possibility that H-Y antigen might play the role of male determination. H-Y antigen was discovered in mice and has been shown to be conserved in all mammalian species tested. H-Y antigen is responsible for the female's rejection of male tissue transplants between members of highly inbred mice strains. The association of H-Y antigen & Y chromosome is based on dose-related studies i.e. human males with 47, XYY and 48 XXYY karyotypes bind about twice as much antibody as do males with only one Y chromosome (46, XY). Susumo Ohno suggested evidences for association of H-Y antigen (Y-Histocompatibility antigen), testicular development and the presence of short arm of Y chromosome. It was proposed that Y—linked gene (s) of mammals produce H-Y antigen which becomes localised at plasma membrane and determines by cell recognition the induction of testes differentiation. It is not clear whether Y-linked gene (s) code for H-Y antigen or are involved in the regulation of the expression of an autosomally linked gene which codes for the H-Y antigen. Thus the data on genetic basis of H-Y antigen are inconclusive. On the contrary the studies on sex determination mutants in mice have revealed that the presumed association of H-Y antigen and testes differentiation does not hold true, i.e., neither H-Y antigen is invariably associated with phenotypic maleness nor is the absence correlated with femaleness. Thus, H-Y antigen is possibly a consequence rather than the cause of male determination.

The role of Y chromosome is currently being investigated with a number of putative autosomal and X chromosomal sex determination mutants in mice, goat, wood lemming and humans. In wood lemming, *Myopus schisticolor,* a mutation in the X chromosome leads to transformation of XY individuals into fertile females. Autosomal recessive mutations have been reported in goats & man which transform individuals into phenotypic males. In human beings, sex determination mutations (autosomal dominant or X-linked recessive mutations) have caused transformation of XY individuals into phenotypic females. For most of such sex determination mutants, the genetic basis in terms of loci involved is not clear. The existence of such mutants shows that Y chromosome is not sufficient to ensure normal male development and that Y-autosome interactions could be involved in determination of maleness.

Data on sex determination mutants has necessitated a reassessment of the role of Y chromosome in mammalian sex determination. Recently, Professor H. Sharat Chandra of I.I.Sc., Bangalore (Mol. Gen. Genet. 193: 384) has suggested a model of mammalian sex determination which involves a passive role of Y chromosome. According to this model, the product of Tdx (testis-determining gene on X chromosome) is essential for male determination. An autosomal locus codes for a repressor that binds with high affinity to the repeated Y chromosome sequence (Bkm

(Continued on page 436)

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Woolier sheep

A new type of alfalfa can boost wool growth when fed to sheep. The genetically engineered, protein-rich alfalfa has been developed by scientists of the Commonwealth Scientific and Industrial Research Organization in Australia.

The scientists transferred a gene which codes for sulphur-rich amino acids from a pea seed to leaves of the alfalfa plant. Wool growth is limited by supply of sulphur containing amino acids. The pea albumin proteins unlike most others resist breakdown in rumen so that almost all the nutritive value can be absorbed by sheep.

Tastier and tangier milk

NO amount of pestering, requesting or even scolding can make some children drink milk, making it a perennial problem for parents. But not any more. Scientists of the Agricultural Research Service in the US seem to have found a solution to this problem—carbonated milk! Call it soda milk if you will.

It is made by bubbling carbon-dioxide gas through a mixture of water, powdered nonfat dry milk and flavouring or apricot juice. It gives you that tingling, refreshing sensation of carbonation that you get in soft drinks. What's more, you are also getting calcium, protein and vitamin C from the milk and juice.

Down with push-ups

PUSH-UPS, when practised on a hard surface, may damage the nerves and muscles of the hands. This was brought to light by doctors in North Carolina, USA (*Journal of American Medical Association*, Vol 259, p 45) who reported the case of a healthy 38-year old man whose left hand wasted away after doing push-ups regularly for several weeks on a hard floor.

The doctors also warned that this problem is associated with other activities that involve undue pressure on the hands such as riding a bicycle, grasping the handles of crutches, or striking jammed window frames. They advised people against doing push-ups on hard surfaces, and to completely do away with them as soon as weakness or pain in the palm develops.

Fading sun brightens up again

WHEN in the early 1980s it was found that the sun was fading at a rate of 0.018 % per year, it was a cause for worry. For although not large enough, such a decline if continued for a few decades would have affected climate, ultimately leading to a little ice-age had the decline continued for a century.

But the sun seems to have taken a turn around and is now brightening up again (*Science, 24 June 1988*). A distinct increase in solar irradiance has been measured by the radiometer monitoring the sun's output from the *Nimbus-7* satellite. The reversal could well suggest the existence of an 11-year solar cycle. The solar irradiance had touched the rock bottom at about the time of the sunspot minimum in the autumn of 1986 but the trend is now upward.

Salt substitutes for insulin

IN a surprising series of experiments a group of scientists at the Weizmann Institute of Science in Israel have found a simple salt that mimics insulin action in animals. Whole-animal studies have shown that addition of a simple vanadium salt to the drinking water of diabetic rats reduced blood sugar and excessive thirst.

Other pathological conditions in these rats were also reversed, including the animals' continuous loss of weight, poor uptake and metabolism of glucose in body tissues, their reduced ability to store fats, and the depressed response of their tissues to insulin stimulation.

The vanadium salt could well turn out to be a safe alternative to insulin which has to be self-administered producing sharp swings in insulin and sugar levels in the blood. Besides, exposure to an overdose may even lead to fatal insulin shock.

Space chicks

THE space shuttle Discovery blasts off next January, and on board will go 32 fertilized chicken eggs in a special incubator as part of an experiment to see if embryos can develop normally in space (*Science,* Vol 240, p 1411, 1988). After return, the eggs will be compared with a control batch on earth at the Kennedy Space Center in Florida.

While on earth, gravity pulls the yolk to the bottom of the egg, an absence of any such force in space could be beneficial for the eggs. Scientists believe that under weightlessness the yolk will hang suspended in the middle of the egg, resulting in more efficient embryonic development and a better chicken.

Self destruct insecticide

WORKERS at the University of Urbana-Champaign, USA have developed a class of cheap, biodegradable and resistance-proof insecticides that kill insects by turning their own metabolism against them (*Scientific American,* April 1988). While other insecticides attack the nervous system, this one accelerates the production of protoporphyrin, a metal-transporting substance which in large quantities fatally disrupts the insect's metabolism.

The insecticide has proved effective in the laboratory against two of the most destructive agricultural pests in the world - the corn earworm and the cabbage looper. The effectiveness of the insecticide is further increased if the insects are exposed to light. Most insects die within 10 seconds after exposure to light while in the dark they die within 48 hours.

Yawn and survive

YAWNING is known to be infectious in nature. Malcolm Weller, a consultant at Friern Hospital in London, now believes that the infectious nature of the yawn increases the chances of survival of animals in the wild (*The Lancet*, Vol 1, p 950, 1987).

According to Weller, yawning encourages animals to go to sleep together with obvious benefits. Apart from keeping each other warm the individual is at less risk from predators while it is with others than if it were alone. Besides, the individual spends the same hours hunting and resting as its companions consequently increasing its efficiency.

Sterilised milk deficient in calcium

HEATING milk to high temperatures makes the calcium in it less soluble and so reduces the amount the body can absorb. This was disclosed by two researchers, Christine Egan and Michael Rennie of Dundee University, USA, who have advised against the reliance on sterilised milk as a source of calcium for growing children and pregnant women.

In experiments on rats, Egan and Rennie found that the amount of calcium absorbed into the blood from sterilised milk was 20 % less than the amount absorbed from pasteurised milk. This, they suggested, was because in fresh milk calcium is bound to a protein called casein which keeps the calcium soluble by preventing it from forming insoluble salts. But when milk is heated to a high temperature the ability of casein to keep calcium soluble is reduced.

Friendly virus

CONTRARY to popular belief that all viruses are deadly, an investigator has found a virus that saves the host animal from developing a lethal autoimmune disease by attacking renegade white blood cells (*Scientific American*, April 1988).

Michael B.A. Oldstone of the Institute of Scripps Clinic in La Jolla, USA reports that a form of lymphocytic choriomeningitis virus (LCMV) prevents diabetes in non-obese diabetic mice, which are genetically predisposed to develop the disease. The virus inteferes with the animals' immune system, blocking a self-destructive attack on insulin-producing cells in the pancreas. This finding has raised exciting possibilities of someday exploiting viral products to fight disease.

Hasan Jawaid Khan

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Ascaris: common human intestinal roundworm

ASCARIS is a common intestinal roundworm found in man all over the world. A World Health Organization report (1979) estimates its prevalence in about a quarter of the global population (no less than 900 million human cases). Such a high prevalence is probably because of the high fertility of the female worm which lays nearly 240,000 eggs a day over its life-span of about one year (which are evacuated in host's faeces and deposited in the soil); and also because of the capacity of the eggs to resist adverse environmental conditions for a long time. Further, the mode of infection being contaminative, the spread also tends to be very simple as it directly depends upon the existing sanitary and hygienic conditions of the environment.

Ascariasis is a common parasitic disease caused by *Ascaris lumbricoides,* which lives within the lumen of the human small intestine. When alive, the roundworm appears reddish-yellow but the dead worm looks milky white in colour. The adult female is about 35 cm in length with a straight tail end, while the adult male is smaller with a curved tail end. In general they look more or less like a common earthworm.

Although the disease is widespread in both temperate and tropical countries, owing to the faecal-oral mode of infection it is more prevalent in countries where sanitation facilities are inadequate and human excreta are used as manure in vegetable farming.

How the disease spreads

Fertilized eggs laid by female worms in the intestine of the infected person pass out with the host's faeces at an early stage in their development. In suitable environmental conditions, i.e., in warm and moist soil with proper aeration, they develop into embryo in a period of 2-3 weeks before they become infective. However, in adverse environmental conditions the eggs may remain viable for as long as 7 years or perhaps longer, but direct sun-light can destroy them in a few weeks. Children or adults on contact with contaminated things may ingest the infective eggs, particularly if they eat



Fig. 1. The roundworms, *Ascaris lumbricoides* expelled from a child's intestine, following drug treatment

Ascariasis and associated controversies

	The belief	*The truth*
1.	It is more common in developing countries with favourable climatic conditions.	Although it is more common in developing countries, yet communities with high infection rates have been reported in developed countries, too.
2.	It is more prevalent in humid tropics.	This is because, the humidity ensures long viability of the fertilized ova and in turn enhances the probability of infection.
3.	The disease occurs more frequently among rural peoples.	True, because usually they lack indoor toilet facilities and understanding of personal hygiene.
4.	Existence of vegetable gardens attached with the house affect its rate of infection in the family.	Even houses without attached vegetable gardens can have comparatively more infection rate, if there prevails an unhygienic environment in the house.
5.	Generally there appears a tendency to consume more sugar, when a person harbours the roundworms.	This is because, the adult worms inside the host's intestine steal a considerable amount of carbohydrate to meet their metabolic requirement, which in turn causes deficiency of sugars in the host body.

without washing their hands and finger-nails.

Consumption of unwashed and improperly cooked green vegetables is the most common method of transmitting the disease. Flies, too, can transmit infective eggs by settling in turn on uncovered faeces and exposed food. Drinking contaminated water and eating food prepared unhygienically are further factors responsible for its quick spread.

Roundworms spare no one, adults or children, but they are more common in poor young children and infants as usually they pollute the soil by defecating wherever they please and then, while playing on the contaminated soil, carry the eggs on their hands into their homes, often contaminating food and drinking water.

Once ingested the eggs hatch in the small intestine, liberating tiny larvae (250 μm × 14 μm), which bore their way through the mucosal wall into the portal vein system. They then pass through liver, and heart to reach the lungs, where they break out from villi of the lung capillaries, ascend the trachea, get swallowed through epiglottis and descend through oesophagus to reach once again their final habitat in the small intestine. They now attach themselves to the intestinal wall and attain maturity to start their life-cycle. The total time from ingestion of infective eggs to the maturity of the worms inside the host body takes about 50-55 days.

Symptoms and diagnosis of the disease

Although 85 per cent of Ascaris infections may be asymptomatic, the severity of illness does not depend upon the size of worm burden. Even a single worm can cause as serious a problem to its host, as when several worms are harboured. Mild infection causes irriation of sensory receptors in the gut mucosa; moderate infection contributes to malnutrition as the adult worms rob food from the host's intestine, which leads to loss of appetite and weight loss of the host. When the number of worms is large, there may be abdominal discomfort with severe pain and in later stages anemia may develop.

The diagnosis can be done by examination of a sample of the patient's stool, which reveals great quantities of the characteristic ovoid eggs (60μ ×40mμ) under a simple microscope. Generally the eggs appear in the host's faeces 60-62 days after getting the infection. A recently evolved technique of diagnosis includes plain radiography, which outlines the worms within the patient's intestine.

What happens to people with Ascariasis

During its migratory phase in the host, the worm affects the liver, bile ducts and pancreas, destroying their tissues

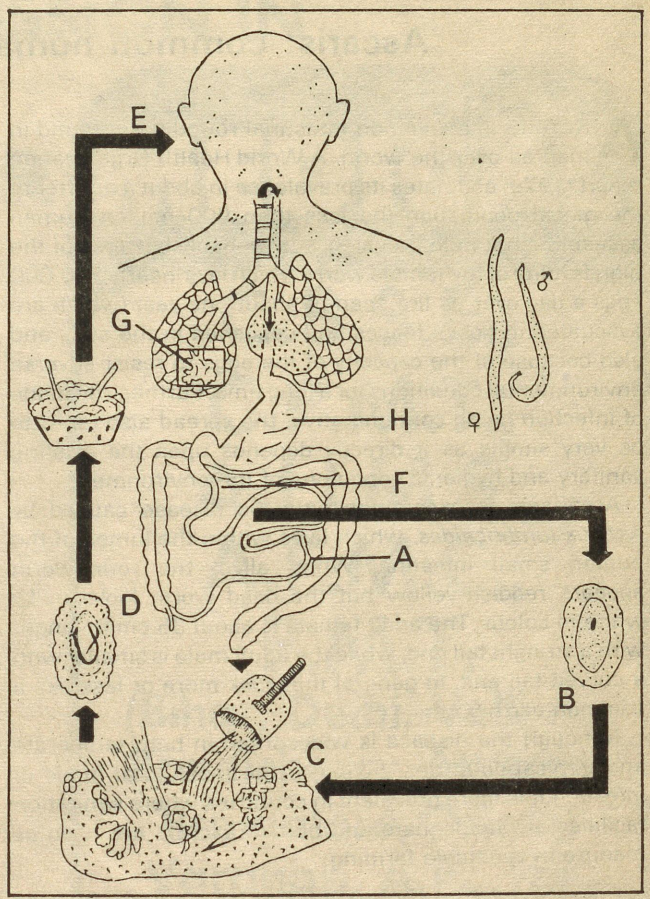


Fig. 2. Life cycle of *Ascaris lumbricoides*. The adult worm lives in the small intestine (A); The daily output of eggs by female (B); On leaving human body eggs adhere to various objects, green vegetables may be contaminated by human faeces (C); Development of larva within the egg (D); Ingestion of infective eggs through contaminated food and water (E); Hatching of eggs in the jejunum (F); Migration of larvae to lungs (G); Return of larvae to oesophagus and stomach through trachea, larynx and pharynx (H); the arrival of larvae in small intestine where they attain maturity (A)

Ascariasis control programmes

IN response to the immense and growing burden of diseases in the human populations, the World Health Organization (WHO) in collaboration with the World Bank and the United Nations Development Programme (UNDP), long before has taken initiatives in mobilising the world resources for the launching of ambitious programmes to activate scientific man-power in the control of tropical communicable diseases, including Ascariasis.

In India, the National Institute of Communicable Diseases (NICD), with its Headquarters at New Delhi, since its establishment is actively engaged in the programmes of research in monitoring and control of Ascariasis, an important communicable disease in the country. According to the NICD recommendations, personal hygiene and sanitation are more important than the climate and topography in transmission of the infection, hence much attention should be laid on the aspect, in order to eliminate worm infections from society.

Quarantine and quarantine regulations

IN many regions of the world certain diseases are endemic, i.e., are always present in the population. Thus, it is evident that, diseases spread from a point of infection, and travellers usually spread a disease. In view of this fact, regulations were made in many countries to isolate travellers on their arrival from other country to make sure they brought no disease germs with them. This isolation was called quarantine, and quarantine regulations are still enforced. A person in quarantine is usually isolated long enough to see whether any disease developed.

and thus affecting their physiological activities, as the larvae pass through these organs on their way to lungs. In the respiratory system the migrating larvae cause a variety of clinical symptoms, ranging from a mild cough to severe lung infection accompanied with chest pain and spitting of blood from lung capillaries, and at times leading to pneumonia. Too many worms may lead to blockage of the intestine (as the worms way be so numerous that they become twisted into bundles), poor growth and memory loss in the host. Anaemia may also develop, making the host liable to catch other diseases which sometimes may even prove fatal.

How to avoid the worms

There is no single method for complete eradication of all worm-linked diseases, but measures like ensuring better personal hygiene, proper disposal of human excreta together with environmental sanitation and contamination-free municipal water supply can go a long way in controlling the spread of the worm. Further, raw stems, green vegetables, fruits and roots, grown by the use of human manure should be thoroughly washed and cooked properly before being consumed. There are several medicines available which kill the worms and cause their elimination from the body. But the treatment should be given in accordance with physician's advice.

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OZONE DAMAGE (*Continued from page 445*)

manual iodometric method the weekly daytime (11.00 am to 2.00 pm) average concentrations ranged between 0.056 ppm to 0.104ppm during 31 October to 31 December, 1983 at Jalandhar. The iodometric method is prone to interferences from other oxidants present in the atmosphere. However, 90 % of the measured concentrations are believed to be due to ozone. At Chandigarh, ambient ozone was measured with an ozone-specific monitor during autumn 1984-85. A maximum of 0.08 ppm O_3 was measured during the season. These measurements show that phytotoxic levels of ozone ($\geq$0.04 ppm) are encountered during the potato season in Punjab.

Typical ozone injury symptoms, as seen on potato leaves under natural field conditions, were produced by artificial ozone fumigation (0.14 ppm) of potted potato plants. Ozone type of injury symptoms have been noted by the author in Punjab on maize, tomato, wheat and beans.

Ozone and its precursors drift long distances to hundreds of km from the source of origin. With increase in the volume of motor traffic the problem is likely to aggravate in near future in India thus warranting thorough evaluation of the extent of impact of ambient ozone on crop plants.

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Nikolai Miklоucho-Maclay—a humane explorer

HE declared that all human beings, whether the "civilized" white men or the "savage" inhabitants of jungles, are essentially the same. Human beings differ from one another due to local customs, cultures and laws, he claimed. This may sound obvious today but about a century ago people, especially Europeans, never thought so. Non-white people of the world were believed to be inferior—even not human beings. This man had however high regards for the so-called savages of the world because they did not possess the evil qualities of a European. In his own life-time, he tried his best to unite the Papuans of New Guinea against the colonial designs of the white men who were bent upon their exploitation using violence and trickery. He was a white man, not a politician but a mere anthropologist and explorer, who lived like a hermit, travelled extensively and never worried about comforts or money. He also rectified maps and wrote exactly what he observed about the Papuans. He portrayed them neither as Gods nor Demons but as human beings. Today, a 300-kilometer long northeastern coast of what is now known as Papua New Guinea, along the Astrolabe Bay, where he lived for several years, is named in his honour. He was also the first to propose the establishment of biological stations in all corners of the world. His name is Nikolai Miklоucho-Maclay, a Russian by birth but a humanistic and explorer at heart.

Nothing much is known about the childhood of Maclay. Even his date of birth is not exactly known. It is said that he was born on July 17, 1846, in a town near St. Petersburg, U.S.S.R. His father was an engineer who died when he was in his teens. It was his mother who was his sole source of inspiration. She taught him the values of freedom and democracy in those days when peasant revolt against serfdom was in the offing in Czarist Russia. Some literary figures of the time who urged young people to take active interest in social problems and sciences also influenced his thinking. He was expelled from the Lyceum (Academy) because he used to attend revolutionary youth meetings. Later, in 1864, St. Petersburg University rusticated him for participating in student unrest. In fact, he was debarred from joining any institution of higher learning in Russia. He pursued studies in natural sciences at various universities in Germany. He also went on several zoological expeditions to Canary islands, Morocco and the Red Sea. The real turn in his life came when at the young age of 25 he decided to visit alone the little known island of New Guinea, near Australia. Its plants, animals, tropical forests, inhabitants and uncharted regions had attracted his attention. With some personal savings and the Russian Geographical Society's financial support, he set sail for New Guinea.

New Guinea

On September 20, 1871, the Russian ship *Vitiae* entered the Astrolabe Bay and laid anchor on the coast of New Guinea. At a suitable spot a hut was built and young Maclay was left on shore with two servants. When the ship sailed away, most passengers thought that Maclay had chosen death by requesting the Captain of the ship to drop him there amidst savages. In fact, Maclay himself anticipated death any time on that primitive corner of the world. To ensure that his studies of the island did not go waste if he died, he indicated to the Captain of the ship the spot where he would hide the records of his studies. It was indeed a bold and courageous act on part of young Maclay to stay alone on that island, cut off from civilization, amidst savages whose language was not known to him. Moreover,

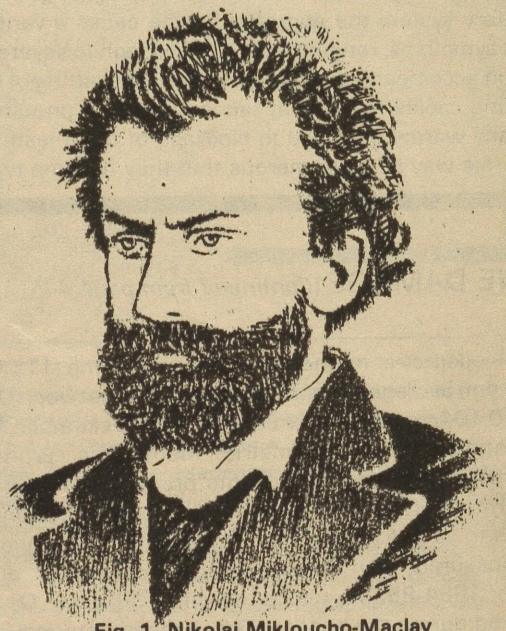


Fig. 1. Nikolai Miklоucho-Maclay

his servants turned out to be more a liability than a helping hand. In his subsequent expeditions, he always went alone.

Maclay knew that only through trust and understanding would he be able to live among the local inhabitants, the Papuans, because he considered them human beings and had basic faith in humanity. He did not even take a gun when he visited a Papuan village for the first time! He knew he would resort to it on slightest provocation. His visit to the village was met with hostility but he coolly lay down to sleep under a shady tree near the village! He also ignored a spear intentionally or unintentionally thrown at him. His subsequent visits to other villages were also looked upon with fear and suspicion. He therefore changed his tactics and allowed the inhabitants to visit him in his hut. Curiosity drove them in flocks to the hut. Maclay befriended them by offering them small presents. For a few months he did not use his gun for hunting wild pigs because shots would alarm the natives. Eventually, one native, Tui, became his

fast friend and assistant when he cured him of a fatal illness. Through pantomime and gestures he taught Maclay the Papuan language. Of course, this method of learning the language often led to awkward and sometimes hilarious situations. Similarly, gestures caused confusion and misunderstandings.

It took Maclay at least two months to win the confidence of the Papuans. At last, they gave him a formal invitation to visit their villages and homes. He took this opportunity to study the villages, the life of the natives and their homes in details. He also drew their sketches. In their homes he discovered carved, wooden idol-like things "Telums" which were gladly offered to him as gifts. In due course, he started attending their festivals, ceremonies and funeral rites. He noted down each and every detail about their clothing, ornaments, method of working, their superstitions and charms, and collected all their artifacts and art works which would throw light on their cultural traditions and society. He also drew pen or pencil portraits of his acquaintances. Soon, Maclay was revered as the "Man from the Moon". He was even given the status of a village elder, asked to settle down permanently and take some native wives. His fame as a village doctor who could cure the ill and wounded also spread fast in the neighbouring region. Meanwhile he continued the explorations of the interior of the island in the company of Tui. He climbed steep cliffs, crossed swift mountain streams, walked through tall, blade-like grasses

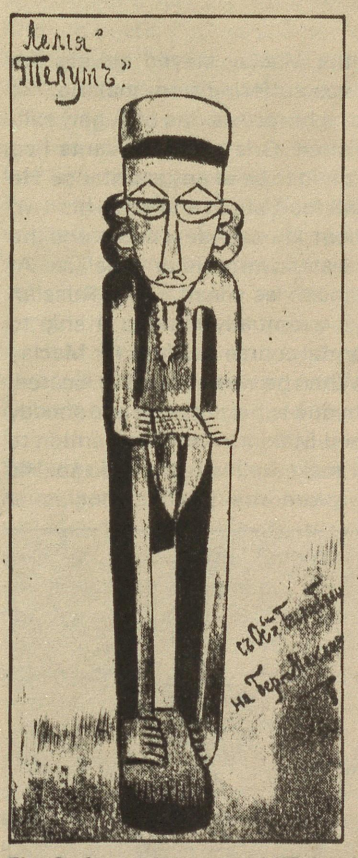


Fig. 3. A wooden, carved "Telum" of the Papuans

and traversed winding, maze-like paths through dense forests. He also mapped the region, collected specimens of plants and animals, and conducted meteorological observations.

Maclay found that the society of the Papuan was free from the vices of Europeans. There was no poor or rich among them. Jealousy, malice or selfishness were not present. Huts were never locked because there was no thief. He therefore considered them superior to the white men. This opinion was exactly opposite to what white men then had about the Papuans. They were considered the intermediates between white men and apes - not human beings. The white men felt that they (Papuans) were incapable of becoming civilized people and so justified colonisation and slave trade. Moreover, no white man had mixed with the natives with the aim to study them. The misconceptions about them therefore continued to be perpetuated until men like Maclay showed otherwise. But his observations and opinions were never taken note of because they were not in tune with the colonial and other designs of the white man. For instance, Maclay clearly proved that the Papuans belonged to the human species when he showed that their tufted hair was simply a matter of hairdo and not a feature indicative of their inferior status as was then believed. Bomboo combs were employed to make the hairdo which made the normal size of their head look much bigger.



Fig. 2. Maclay's first hut on New Guinea..It is his own drawing (All drawings from B.N. Putilov's biography on Maclay)

Trip to Malaysia

For more than 15 months Maclay stayed among the Papuans. By this time he was suffering from malaria, his hut had developed a leak and his provisions of sugar, salt, matches and ink were finished. One of his servants had died and the other was too timid to be of any assistance. He had therefore to cook his own food, stitch and wash his own clothes and mend his wornout shoes. A few books and the photos of his mother and sister were his only solace. At home he was taken almost as dead. The Russian Geographical Society could eventually instruct a ship to take a diversion from its normal course and look for Maclay on the New Guinea coast. When he was eventually located, nobody could recognise him due to his ill health and shoddy clothes. In 1873, he reached Manila with the intention to return home but could not make up his mind to do so. His curiosity drove him to explore the interior jungles of

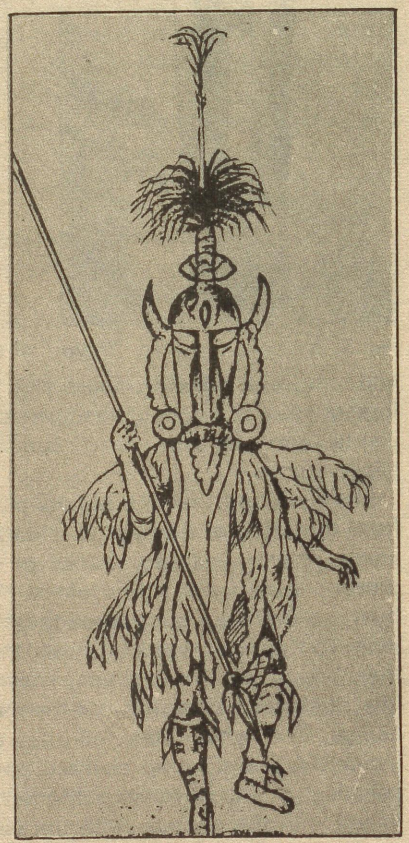


Fig. 4. A Papuan performing a ritual dance

Malaysia where primitive people belonging to the Melanesian race, a subgroup of Negroes, lived. Once, one of his anthropologist friends had suggested him to study them if he could ever get an opportunity to do so. And Maclay was not ready to miss it, though he had no money to maintain himself in the civilized world.

His studies showed that the Papuans and those primitive people were racially the same. Both had similar customs and rituals. In other words, the Papuans also belonged to the Melanesian race. On his subsequent trip he explored the interior of Malacca peninsula where no white man had earlier set his foot. It was an arduous journey through leech-infested regions, overflowing rivers and streams, and reluctant guides. Sometimes he had to walk barefoot, sometimes ride an elephant, and sometimes employ rafts and boats to cross rivers and streams. Here he came across what were then called "Orangutan" —the people of the forest, who led a nomadic life. Mysterious tales and fantastic stories about them were in circulation among the people who had seen them. Maclay wanted to see them with his own eyes and find the truth about the wild stories narrated about them. Again, he made a detailed study of their life and society. Their blow-pipe-like weapons "Sumpitan" and "Head-hunting raids" particularly fascinated him. Through his studies Maclay concluded that those primitive people also belonged to the Melanesian race but were likely to become extinct because they were interbreeding fast with the local Malay tribes which belonged to the Mongoloid race. He wrote articles in various foreign journals urging people to save such rare class of people from extinction.

Fight for Papuan Union

Meanwhile Maclay was deep in debt because he had no personal source of income. But he never took money from anyone or any society as donation. He did not take money even from the Russian Geographical Society because it would them ask him to conduct studies that interested its members. He always took loans from private banks. When he left Malaya he had a debt of 1000 florins. He did not even heed the advice of a doctor who told him that the climate of New Guinea would prove fatal to him. Next time he disembarked on the southwest coast of New Guinea. He observed that the natives, the Kowiai Papuans, were sea nomads but they did not lead nomadic life due to any racial or ethnic reasons as was believed then. They led nomadic life due to political and social circumstances. He traced the root cause of those circumstances to the presence of the white man, who supplied wine, gun-powder and fire-arms to whip up the inter tribal rivalries among the natives and then expliot them to gain his own ends. Slave trade prospered to provide labour to work in his plantations and pearl-collecting stations. Often, murders and looting went unchecked and culprits roamed scot-free. Once Maclay himself fell a victim to their trickery. During his absence, natives looted his hut and destroyed his collection. He caught the gang leader singlehandedly and handed him over to the local authority. It was at this juncture that he became worried about the influence of white man on New Guinea.

After his second trip to Malaysia, when Maclay returned New Guinea again - the last time in his life - he had some different ideas up his sleeves. He wanted to unite the natives to form the Papuan Union for their fight against the colonial designs of the British and the Germans. He went from village to village urging the chiefs to unite against their

common enemy. He also made efforts to improve their standard of living by teaching them elementary medical knowhow, providing them better metal implements to plough their fields, and introducing them to new crops and fruits. He also trained them on how to keep poultry and domesticate sheep. To create sympathy for the Papuan cause among the British and Russian public, he wrote long letters in newspapers. He also met missionaries and local authorities. His was then the sole voice against the might of the British Empire. It was a rare case of a scientist who fought at political level to save his subjects from falling into the pit of slavery.

In 1878, Maclay reached Sydney, Australia, where he worked in the laboratory of the famous entomologist William J. Macleay. Using the specimens of skulls of different human races available there, he did a comparative study of their brains. He also concentrated on the Papuan art whose specimens he had brought from New Guinea. It was here that his idea of establishing a biological station took shape, though it had been in his mind for a long time. He felt the necessity of such a station especially for explorers-cum-scientists like him who visit a country to study its flora and fauna and need some basic laboratory facilities to pursue their studies locally. He himself had to set up from time to time a make-shift laboratory in the homes of his well-wishers or even total strangers. Such biological stations, he desired, should be established in all remote corners of the world; their doors open to all those who would like to utilise their facilities. After much negotiations with the local societies Maclay eventually managed to establish a biological station at Watson Bay near Sydney in 1881.

Return home

Finally, Maclay reached home in 1882 after eleven years of absence. The Russian Emperor had to pay his debt accumulated over the years. He was welcomed everywhere and the public flocked to listen to his stories of adventure and findings. His collection of customs, musical instruments, idols, arrows, and paintings of the Papuans was also displayed. The press made him a hero and his findings were publicized. His talk of the equality of all races and universal botherhood and appreciation of the simple way of life of the Papuans were received with mixed reactions. They impressed the great Russian writer Leo Tolstoy who wrote to him," the experience you have gained in communication with savages forms a whole epoch in the science that I serve, the science of how people should live with one another. Write your story and you will do mankind a good turn". But the authorities gave a cold reception to his ideas. Nevertheless, he continued his fight for the cause of the freedom rights of the Papuans. He met the Russian Emperor and pleaded their case. In 1886 he even placed an advertisement in newspapers inviting volunteers who would assist him in his efforts to free the Papuans from the yoke of the British Empire. More than 400 people volunteered to join him but the Emperor eventually backed out. Meanwhile, the British annexed New Guinea. It was only in September 1975 that the island again gained independence as Papua New Guinea. Maclay was only 100 years ahead of his times!

Suffering from rheumatism, neuralgia and severe migraines and unable to eat or sleep, Maclay nevertheless continued his task of writing down his diary of exploration. However, before he could complete it he died in April 1888. His diaries were published in due course, which continue to inspire men to follow his footsteps. Today, in his honour there are the Maclay Museum at Sydney University, Miklоucho-Maclay Institute of Enthnography in Moscow and Leningrad, and Miklоucho-Maclay Society of Australia.

Dilip M. Salwi

Science quiz

Tick the correct answer:

1. The Wild Life week is celebrated in India in :
   (a) 1st week of September
   (b) 1st week of October
   (c) 3rd week of October
   (d) 2nd week of March
2. White tiger was first discovered in :
   (a) Kaziranga(Assam)
   (b) Rewa(M.P.)
   (c) Kanha (M.P.)
   (d) Hazaribagh(Bihar)
3. Flamingo city of India is located in :
   (a) Gujarat
   (b) Assam
   (c) West Bengal
   (d) Kashmir
4. The largest endangered bird in India is :
   (a) Flamingo
   (b) Vulture
   (c) Great Indian Hornbill
   (d) Great Indian Bustard
5. The area declared as a "Biosphere Reserve" is :
   (a) Nilgiris
   (b) Gulf of Mannar
   (c) Nokrek
   (d) Manas
6. The largest antelope in India is :
   (a) Indian Gazelle
   (b) Nilgai
   (c) Chausingha
   (d) Black Buck
7. The smallest deer in India is :
   (a) Swamp deer
   (b) Spotted deer
   (c) Mouse deer
   (d) Barking deer

Somnath Bhakat
Suri-731101(WB)

Mathematics in a kite shop

ON the morning of sankranti festival, Makarand went to a kite shop. The shopkeeper was opening his small shop. Initially, he suspended two kites as shown in Fig. 1.

The kite on Makarand's left was worth rupees two. The other was worth three rupees. He then put a giant kite over these kites as shown in Fig. 2. It was worth five rupees. Makarand exclaimed, "Oh! its price is exactly equal to the sum of the prices of the smaller two kites!" "Yes", said the shopkeeper, "because the paper needed for making the giant kite was exactly equal to the paper needed for making the smaller two". The shopkeeper continued his work without knowing that his statement confirmed a beautiful mathematical fact noted long ago by an ancient mathematician Pappus.

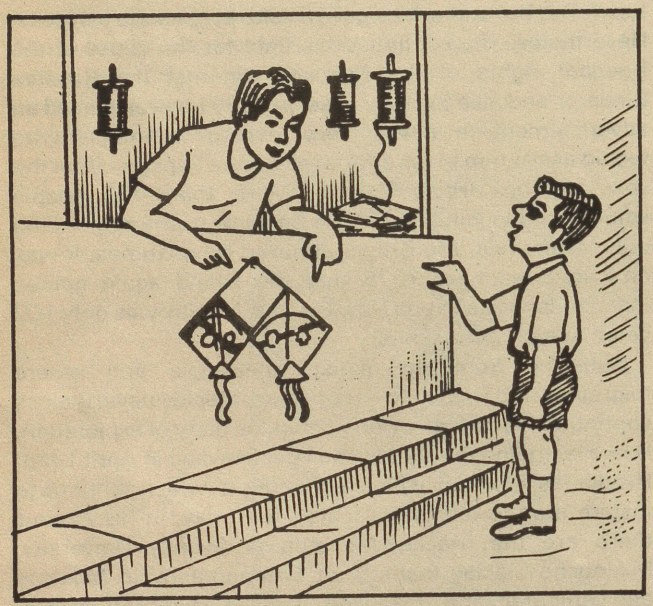


Fig. 1

Pappus' theorem states that if two parallelograms ABCD and EFGD are constructed on two sides of a triangle DCG and if AB and FE meet in H, then the lines CI and GO, both drawn parallel to DH meeting AB and EF in points I and O respectively, will form a new parallelogram CGOI with an area equal to the sum of areas of the two parallelograms ABCD and EFGD (see Fig. 3).

In the above example, the two small kites constitute two parallelograms (actually each forms a rhombus which is a special type of parallelogram) and all conditions stated in Pappus theorem are seen satisfied in Fig. 2. So the giant kite must occupy an area which is equal to the sum of the areas occupied by the two small kites. In other words, the paper needed for making the giant kite is equal to the total paper needed for making the two small kites. Now, a simple proof of Pappus theorem. Look at Fig 3.

Proof: (a) To show that CGOI is a parallelogram

As CI ∥ DH and GO ∥ DH

It implies that CI ∥ GO .....(i)

Also CIHD is a parallelogram and GOHD is also a parallelogram. Implies

CI ≅ DH ≅ GO

or CI ≅ GO .....(ii)

From (i) and (ii) CGOI is a parallelogram; (b) To show that the area of CGOI is equal to the sum of areas of ABCD and EFGD.

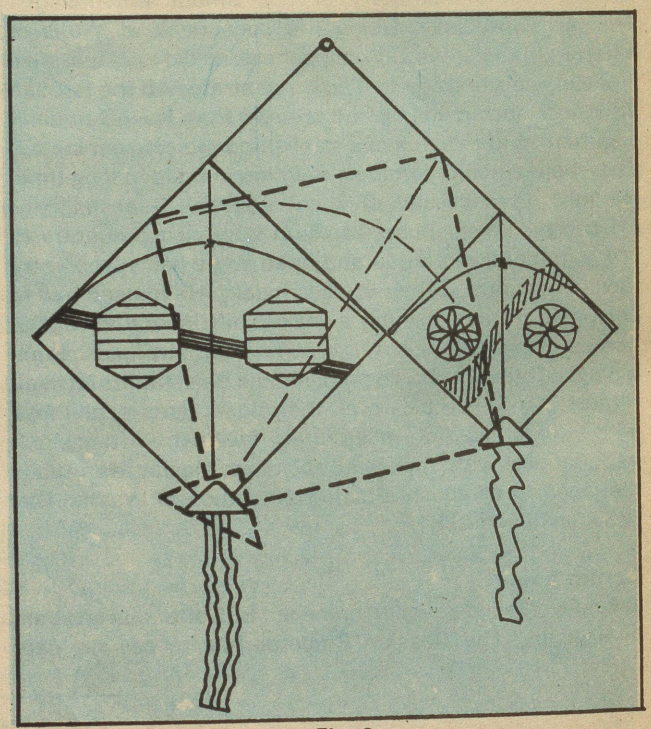


Fig. 2

Since ABCD and CIHD are two parallelograms with same base and same height, their areas must be equal (since area of a parallelogram is obtained by multiplying its base with its height), i.e. , Area of (ABCD) = Area of (CIHD) .....(iii)

For the same reason

Area of (EFGD) = Area of (GOHD).....(iv)

Adding (iii) and (iv)

Area of (ABCD) + Area of (EFGD)

= Area of (CIHD) + Area of (GOHD)

=Area of (IRDC) + Area of (GORD)

+Area of △ IHO ..... (v)

Now consider △ IHO and △ DCG

CG ≅ IO (being opposite sides of a parallelogram)

also since IO ∥ CG, and BH ∥ DC

We have ∠ HIO ≅ ∠ BZC ≅ ∠DCG (corresponding angles)

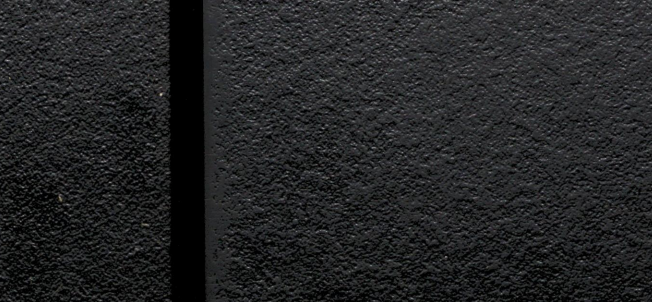


Fig. 3

Similarly since IO ∥ CG and DG ∥ HF
We have ∠ HOI ≅ ∠FYG ≅ ∠DGC
Hence△ IHO is congruent to△ DCG
Hence the area of △ IHO = The area of △ DCG .....(vi)
From (v) and (vi) we get
Area of (ABCD) + Area of (EFGD)
= Area of (IRDC) + Area of (GORD)
+ Area of △ DCG
= Area of (CGOI)

In Pappus' theorem if each parallelogram on two sides of a triangle becomes a square, and in addition if the triangle becomes a right angled tringle, Pappus theorem gets converted into Pythagoras theorem as shown in Fig. 4. So



Fig. 4

Pythagoras theorem is a particular case of Pappus' theorem.

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Answers to science quiz
1(b), 2(b), 3(a), 4(d), 5(a), 6(b), 7(c).

BOOK REVIEWS (*Continued from page 479*)

Perhaps, a better collection from the traditional texts of yesteryears, namely Tej Ram & Pitambar Lal, Hall & Stevens or Pierpoint, should be incorporated in the forthcoming editions. The final chapter on statistical data presentation could be improved by including the formula for computing mean and drawing of bar and pie-charts.

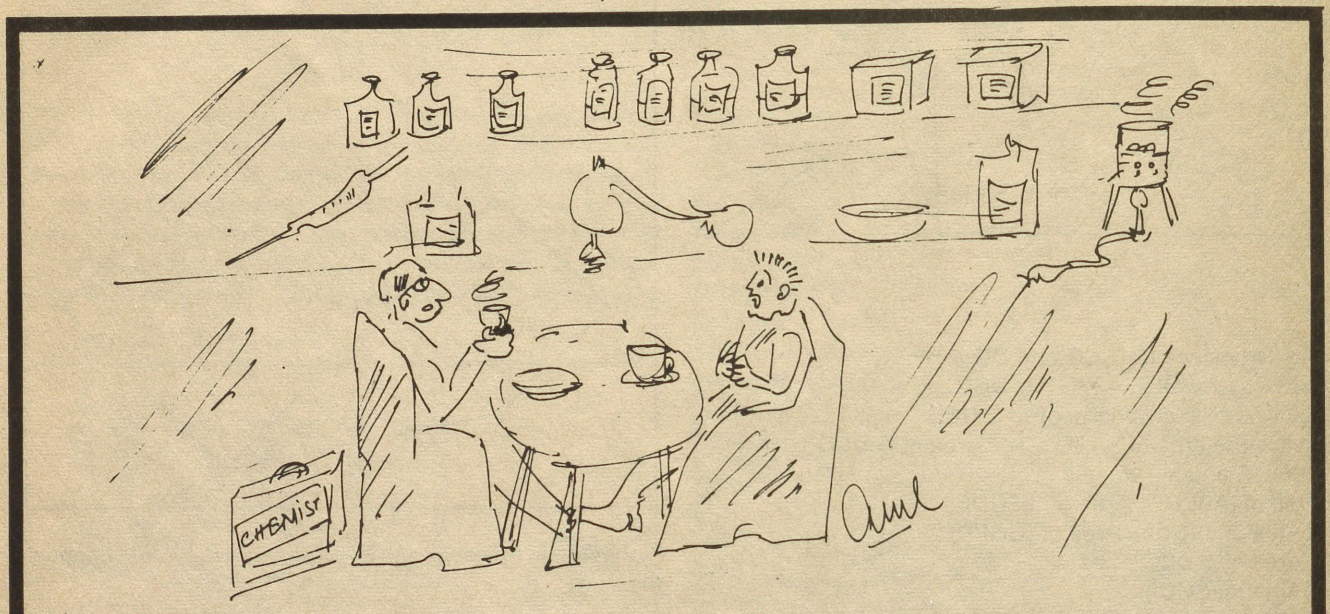
R. Sambasivan

Books Received

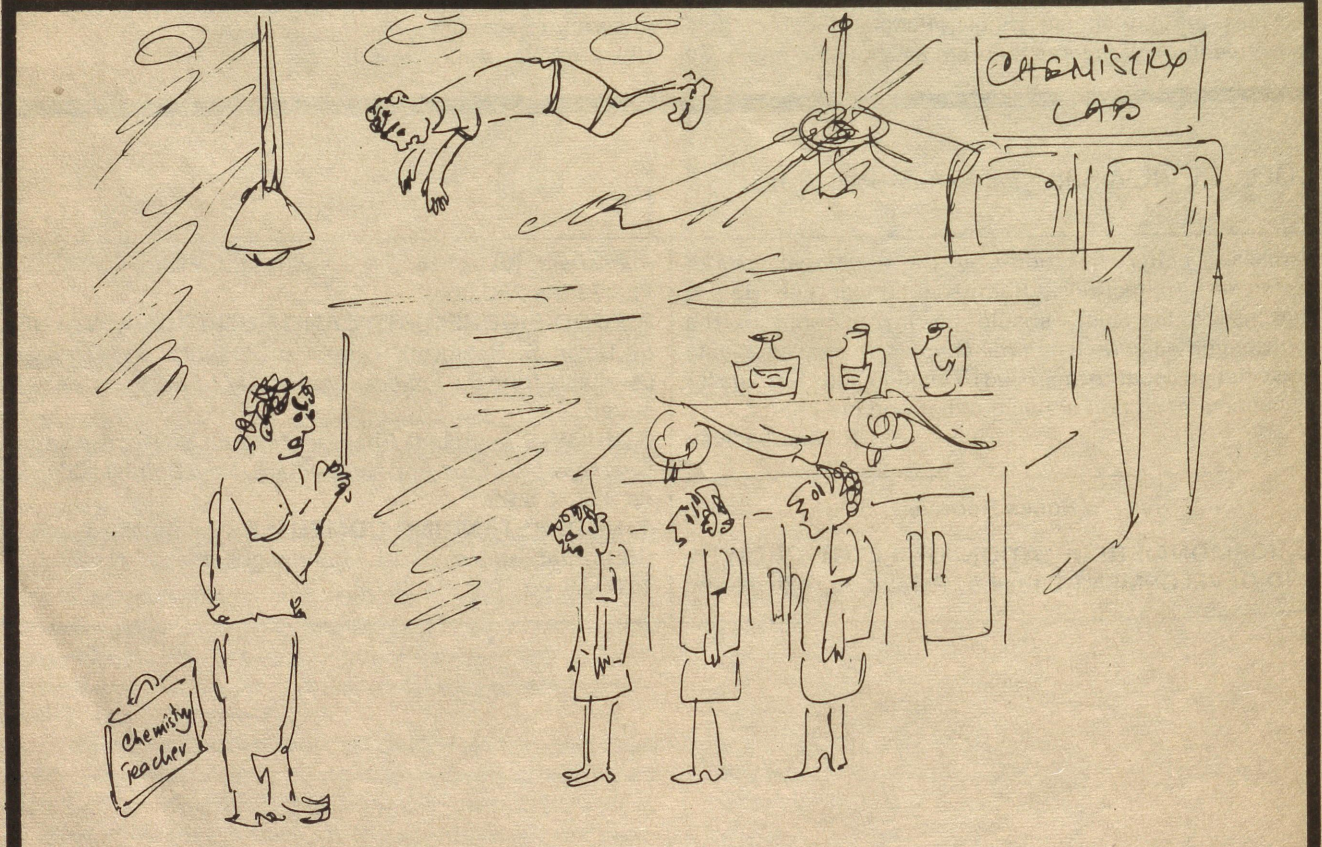
1. **HORMONAL REGULATION OF PLANT GROWTH AND DEVELOPMENT Edited** *by* Purohit, *Agro Botanical Publishers*, IVE /176, J.N. Vyas Nagar, Bikaner-334001, Pp.273, Rs 280.00
2. **FOOD-BIOCHEMISTRY AND NUTRITIONAL VALUE** *by* David S. Robinson, *Longman Scientific & Technical* (Available from *B.I. Publications Pvt. Ltd.)*, Pp. 554, price not stated.
3. **ORIGINS** *by* Robert Shapiro, *Penguin Books*, (*Penguin Overseas Ltd.*, Eros Apt, Nehru Place, New Delhi-110019), Pp 332, £ 5.95
4. **UNDERSTANDING COMPUTERS** *by* Dinesh Kumar, *BPB Publications*, B-14, Connaught Place, N. Delhi-110001, Pp. 386, Rs 36.00

CARTOONS

By Anil Aggarwal



"Thanks for having coffee with me. Since nothing happened to you, it means the new chemical synthesized is not poisonous."



"So he accidentally consumed sulphuric acid. But tell me who gave him zinc?"

New wheel hand hoe for better weeding

WEED control is one of the foremost aspects in crop management. Since weeds compete for water, light and nutrients with other plants, they can considerably reduce the quality and yield of the farmer's crop. Removal of weeds is, therefore, necessary for a better yield.

A simple wheel hand hoe costing **Rs. 125/-** has been developed at the Punjab Agricultural University, Ludhiana for better weeding operations. Apart from being cheap, the wheel hand hoe is simple to operate and can cover a larger area in a short time. Labour and financial savings in comparison to conventional means have been found to be 97.8 man h /ha and Rs. 242.46 /ha, respectively.

At present the 'khurpa' is the most popular tool available to control weeds. But to remove weeds with a khurpa, the farmer has to sit down, consequently his progress is slow. In general, 100-120 man hours are required per hectare with a 'khurpa'. Weedicides are expensive and wheel hoes already available are difficult to operate because of their heavy weight.

The new wheel hand hoe developed at P.A.U., Ludhiana is light in weight, it weighs only 7 kg. Moreover, the provision of a cycle axle in the wheel helps in the smooth movement of the weeder.



Fig. 2. Wheel hand hoe in operation for weeding in wheat

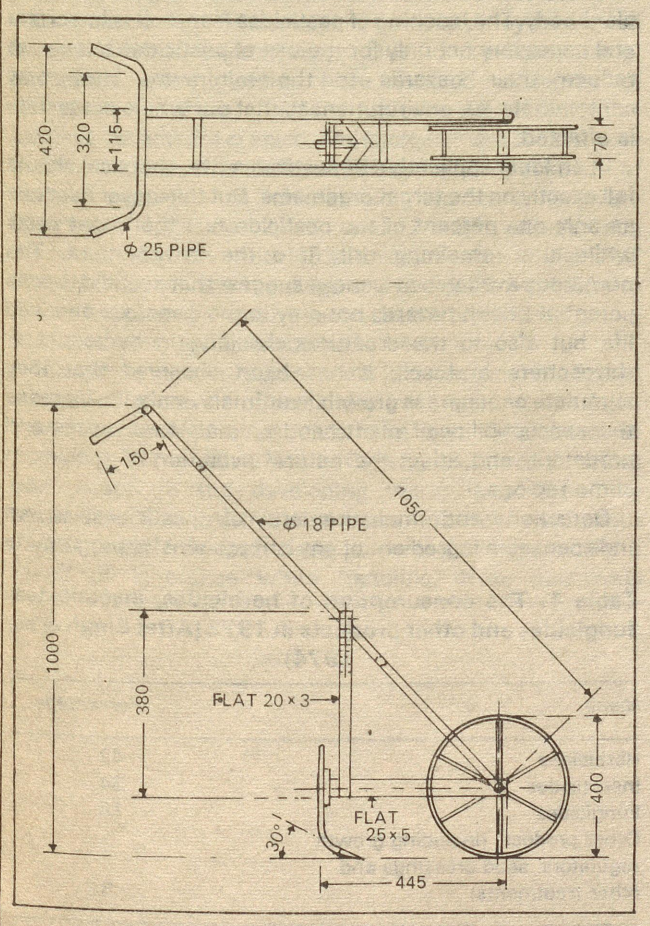


Fig. 1. Blueprint of wheel hand hoe

It can be easily operated by a single person who simply walks along pushing the weeder ahead of himself. This posture is more convenient than the sitting posture with a 'khurpa'. What's more, the height of the handle of the weeder can be adjusted to suit the height of the operator.

The performance of the wheel hand hoe has already been evaluated under different field conditions. It has been found suitable for all row crops, except paddy, and can be operated without fear of damaging any plant in the rows. The shovel of the weeder penetrates at an angle of 30 degrees working the soil up to a depth of 5 cm as compared to only 1.0 to 1.5 cm with the 'khurpa'. Thus, apart from providing better aeration to the plants, the soil thrown by the equipment at the base of the plants lends them better support. The average capacity of the wheel hand hoe is 0.36 ha /day, that is, 4-6 times faster than that with a 'khurpa', without any additional load on the operator.

The crop yield obtained by farmers using the new wheel hand hoe has been found to be the same as or better than (up to 5%) the yield by other weeding methods.

Hasan Jawaid Khan

Pesticides and environment

"PESTICIDE" is a term used in broader sense for products, synthetic or natural, utilised for the control of insect pests, fungi, bacteria, weeds, nematodes, rodents, etc. Growth regulators and defoliants are sometimes also considered as pesticides. The use of chemical pesticides is the most convenient, effective and economic method of pest control in agriculture, horticulture and forestry.They have gained importance due to the increasing demand of food grains and other agriculture products all over the globe.

The total losses attributable to all forms of pests are difficult to assess and estimate. It is impossible to quantify with certainty what the yield of crop might have been under some hypothetical and disease-free circumstances. Fig. 1

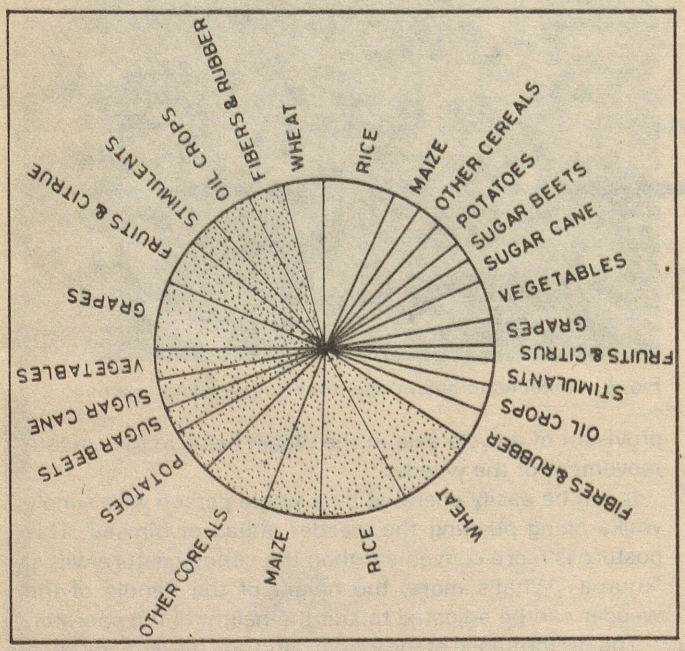


Fig. 1. Actual production (dotted) and losses (white) for different groups of crops (after Cramer, 1967)

gives the world production of crops and estimated losses. Food losses due to pests and plant diseases are about one third of the total production. There is a 10%-20% loss of useful crops in the U.S.A. and Britain. In West Germany about 25% of the total agricultural production is lost as a result of destruction caused by pests, weeds and diseases despite the relatively sophisticated state of the country's agricultural industry. The loss would have been close to 50% without the use of agrochemicals.

In some underdeveloped countries, the losses due to pests are quite high, about 40% in Latin America. In India, the loss of crop in traditional farming due to pests, diseases and weeds was earlier reckoned at 15%-20%. It is now reported to have increased, more than 50% particularly in rice, pulses, cotton and oil seeds under intensive cultivation. Further investigations have indicated that rodents alone are responsible for a loss of about 25% of the remaining crop during storage. Both in quantitative and financial terms, the losses are so heavy that any method of control would be desirable. The studies reveal that 1.5 billion tonnes of crops valued at US $ 75 billion are lost annually in the world due to insect pests, diseases, weeds and polyphagous pests like locusts, termites, rodents, etc.

More than 900 pesticides falling under a wide variety of acaricides, fungicides, herbicides, insecticides, molluscides, nematicides and rodenticides have been developed and produced. The consumption of herbicides is more than the insecticides and fungicides. Table 1 gives the total consumption of different pesticides on percentage basis. It is necessary to have a better knowledge and understanding of pollution due to pesticides and procure detailed information on the dynamics of uptake of pesticides into a plant body. The leaching of pesticides from soil is important and necessary not only for the use of pesticides but also to reduce their hazards to the minimum. They may contaminate our environment so that our whole ecosystem is affected.

In an ideal application of pesticides, the chemical should fall exactly on the target organisms. But this never happens as only one percent of the pesticide hits the target pests while the remaining drift into the environment. The numerous available evidences suggest that pesticides pose potential health hazards not only to the livestock and wild life but also to the creatures dwelling in hydrosphere, rhizosphere and soil. It has been observed that they stimulate or suppress growth in animals or plants, increase the susceptibility of plants and animals to diseases and predators, and affect the natural evolution of species in some regions.

Detection and measurement of pesticides is an indispensable ingredient of any comprehensive programme

Table 1. The consumption of herbicides, insecticides, fungicides and other products in 1973 (After Singh *et al.*, 1974)

Name	*Percentage*
Herbicides	42
Insecticides	34
Fungicides	18
Other products (including growth regulators, seed dressings and other treatments)	6
Total	100

taken up to lessen or abate their deleterious effects on biota of various ecosystems. Unlike other general pollutants, pesticides are not amenable to accepted means of treatment. Some of the pesticides especially organochlorines are quite persistent and consequently accumulate in tissues. They can also contaminate all the systems, i.e., air, water, soil, etc., by transporting from one system to another. From these various sources, pesticides can be transported to the diet of wild animals, feed stuff and finally human beings. They have an impact on biotic and abiotic systems.

Pesticides cause air pollution by volatilisation. Filling, loading, mixing and spraying operations lead to their dispersal into air. Drift and wind erosion of soil particles laden with absorbed residues also cause air pollution. Soil is contaminated by "fallout" after a crop spray. Water gets polluted when pesticides are directly used to kill water-inhabiting pests. Industrial effluents or emptying or washing of spraying equipment and pesticide containers also lead to pesticidal pollution in water.

Impact on biotic system

The predators and prey populations generally evolve a balanced supply-demand economy. This balanced economy is in dynamic equilibrium which, however, may be altered by pesticides in several ways. Due to repeated use of pesticides, many species have evolved a degree of tolerance to them. Certain chlorinated insecticides increase the amount of macro and microelement constituents in corns and beans. In the late 1960's, the harmful effects of human exposure to chlorinated hydrocarbons were observed. Herbicide 2,4-D and 2,4-5T reduce egg production to 8% and 18% respectively, while DDT exposure causes egg breakage and complete reproductive failure in brown pelican.Reduced seed production in plants is also noticed due to exposure to herbicides.

Human beings consume pesticidal contaminated food stuffs. The presence of pesticides in concentrations more than the threshold levels leads to various health hazards. According to the World Health Organisation, every minute one person in the developing world is poisoned by pesticides. Conservative estimates indicate that about 75000 suffer from pesticides poisoning every year. As a result of ignorance while handling these poisonous substances, two-thirds of the pesticides-related deaths occur in the developing countries, though they use only one sixth of the total pesticides manufactured all over the globe.

The threat to human life and health posed by pesticides is not limited to farmers and agricultural workers alone. Pesticides pose a direct threat to any one who consumes agricultural products. Independent studies carried out in India by institutions such as Indian Agriculture Research Institute New Delhi, Central Food Technological Research Institute, Mysore, and Central Plant Protection and Training Institute and Punjab Agriculture Research Institute have shown that almost everything that is consumed by people is contaminated with pesticides beyond tolerance limits stipulated by the World Health Organisation (WHO). Fifty-five per cent of the milk samples showed DDT present at levels higher than the tolerance limit. Vegetables and fruits were even more highly contaminated. Nearly 50% of the samples collected from markets all over the country showed a DDT content as high as 4.2 ppm and Dieldrin as high as 1.4 ppm.

A more disconcerting problem due to the indiscriminate use of synthetic pesticides is the increase in the number of pests that are becoming immune to them. Recent studies indicate a sixteen fold increase in the number of pests that are resistant to one or more of the common pesticides used during 1955-1980. According to the Food and Agriculture Organisation (FAO), the number of pesticide-resistant insect species doubled just in twelve years from 182 in 1965 to 364 in 1977.

With the dramatic increase in the production of chemical pesticides and their reckless use, a chemical time-bomb is ticking away. While the chemical industry has spent huge sums to promote the myth of "Safe pesticides", the truth is that there is no such thing. By design and purpose, pesticides are intended to kill. They are poison like all other poisons, their manufacture, handling, distribution and use should be strictly controlled. The urgent need is for pesticides which are selective and non-toxic to the organisms other than the target organisms.

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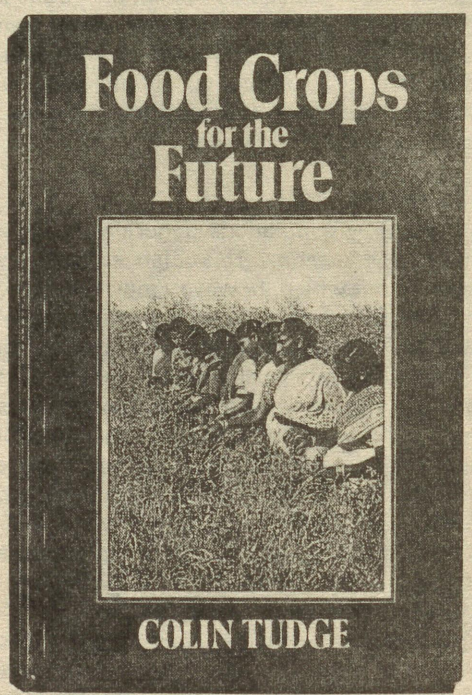
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FOOD CROPS FOR THE FUTURE *by* Colin Tudge, *Basil Blackwell Ltd.*, U.K. (Available at *Affiliated East West Press Private Limited*, G-1 /16, Ansari Road, New Delhi-110002) pp. 225, £ 9.95

DESPITE strenuous efforts made to contain the world population, relationship between population growth and food production is today, indeed, perplexing. The population growth has out-stripped the demand for food. The integrated application of science and the advances of farming technologies in the last 15 years or so have undoubtedly revolutionized the agricultural production. Yet, huge global food deficits are anticipated before the close of this century if the current trend of population growth versus food production is allowed to continue. Besides, shortages of energy, fertilizer, irrigation water, together with menace of diseases and pests to crop plants are prompting agricultural scientists to seek, identify and develop new crop varieties that are energy and water efficient, resistant to disease, suitable for intensive culture and productive of marketable food. Against this background, Colin Tudge, a prolific science writer and a presenter with BBC Science Unit, reviews the current trends in plant breeding programmes and their future implications, some of which are presently the focus of research in many advanced laboratories.

The book begins with the chapter, "The meaning of improvement", wherein the author has candidly debated the tactical versus strategic conflicts of improvement and stressed the need for multidirectional crop improvement programmes to suit the local needs and divergent environmental conditions. The following chapter is an introduction on the world's principal food and feed crops. Although man has exploited about 3000 plant species for food, only 20 species are the major source of supply of food to humans. The stories behind the origin and distribution of these principal economic food plants, many of which are presently cultivated on continents far from where they originated, have been very briefly reviewed in this chapter. The discovery that had the greatest influence on plant breeding, however, was Gregor Mendel's laws of inheritance. The author has rightly devoted the next two chapters to the reasons why plant breeding in practice is so difficult with the innumerable complications in technical operation including various kinds of reproductive barriers, both between plants of different species and between plants of same species. The advantages of asexual and sexual reproduction, the concept of polyploidy, male sterility, etc., have also been outlined. The next chapter deals with the principles, of plant domestication, breeding, mutation and their overall implication in the evolution of new cultivars. The sequence of developments in subjects of plant breeding after Mendel's work has been well enumerated drawing adequate examples from much studied crops. Furthermore, the author has taken extreme care to use minimum technical terms to make the general reader understand the text without any previous knowledge of the subject.

In the following two chapters the spectrum of modern biotechnological application of tissue culture and genetic engineering in various crop improvement programmes have been covered. The practical application of genetic engineering to crop agriculture by successful use of DNA transfer vectors and also the advances in several other fields of research, namely, the isolation of particularly interesting genes, an understanding of their regulation and the improvements of techniques of cell culture to make it



feasible to study more agronomically useful species, micro-propagation, cellular fusion, etc., have been briefly discussed. In the next chapter, while outlining the global concern over the fast depletion of genetic resources, the author has mentioned about the utility of modern methods of cryopreservation and seed banks for conservation of germplasm. The chapter on biological nitrogen fixation legumes and *Rhizobium*, transfer of *nif*-genes, etc., provide at-a-glance information on the current trends of research in this fascinating area of biology. In the last four-page thought-provoking concluding chapter, he advocates the need to make available the benefits of scientific research equally between the 'haves' and 'have-nots' to build a stable and attractive world, capable of indefinite survival. An addendum of chapter-wise selected references for further perusal of literature, a glossary of technical terms and an 11-page subject index have been appended at the end of the text.

The other remarkable features of this well written book which deserve special mention are that not only the entire history of utilitizaon of intensive scientific research in plant improvement programmes has been very lucidly enumerated in only 225 pages but also priorities and thrust areas have been identified supplemented with Tudge's own views, of which some are debatable. The examples cited in the text are fragmentary and scattered; nevertheless, they explicitly illustrate the new converging trends in future agricultural research. Above all, the book contains a nice blend of scientific enthusiasm and economic realism.

Written in an extremely easy-to-follow style, the book is eminently suited to a wide range of readers from students of biosciences and agriculture to policy makers in academia and government, and to all those who want to be enlightened about the indisputable role science and technology will continue to play in future crop improvement programmes.

P.K. Panda

TO SAIL BEYOND THE SUN SET *by* Robert A. Heinlein *Sphere Book Ltd.* (Available from: *Penguin Oversease Ltd.* Eros Apt., Nehru Place, N. Delhi-110019) Rs. £ 3.50

MANY science fiction (and general fiction, too) authors place their stories in the framework of a functional universe or history that they have created. Isaac Asimov's Foundation series and sequels, Larry Niven's "Known Space" series, E.E. Smith's "Lensman" series, etc., are as well known as Robert Heinlein's "Howard Families" series. There are advantages to authors, readers and publishers: the authors can develop a coherent story line and add convincing details over a much wider scope than a single story or novel allows (and later on save mental effort in thinking up new stories, events and plotlines), the readers can take up something they are somewhat familiar with, and like initially; the publishers have less risk in advertising and selling a well known product. But even with greatest effort, originality suffers and the series finally die out in dullness.

Heinlein's "Howard Family" series follow the pattern. The Howards are a group of individuals who have the genetic potential for longevity. Brought together by a Foundation which has as its goal the extension of human life (and youth) they practice selective breeding among themselves to further improve the breed. The foundation was initially set up in the 1860's by one Ira Howard, who found himself dying of old age at the age of forty and who wanted others to avoid this fate. In time, the foundation becomes extremely rich and powerful and its members begin to view themselves as a breed apart from the "Short lifers". In order not to excite the jealousy of the short lifers they function as a secret society, and escape from Earth (in the 21st century) as human society on earth begins to fall apart under the pressure of population growth and resource depletion. They set up interstellar colonies, develop technologies for regeneration, prolonging and preservation of life and youth, and finally time travel in order to go back in time and correct tendencies which might harm their idyllic existence.

The initial stories in the series were very interesting, but they all in general suffer from excessive moralising. The individual is all, the society exists only as a convenience to him. The powerful and hence "good" individuals (such as the Howards) have a right to whatever they can take, any talk of the rights of the weak are mere verbiage and the fit place for those who fall behind in the struggle for life is the grave. This is evolution in action. The morality of Heinlein is "Capitalism, red in tooth and claws". The Howards themselves in particular are free from any of the customs and manners of the short lifers. For instance, incest between close family members (father/daughter, mother/son, brother /sister) is practiced on the theory that since the genes of the Howards are so good, any offspring from them will be fine, and that for people with life span of centuries (and fertile throughout this period) such distinctions are impossible to maintain.

The initial stories in the series concerned the origin and development of the Howards. They are mostly the adventures of one Lazarus Long, born in 1912 and continuing his existence for more than 2000 years. In accordance with the rules of the Foundation, where the senior most member is automatically the Chairman, Lazarus has ample opportunities to take over the Chairmanship and indulge his whims and fancies such as going back in time to his childhood and youth and impregnate his mother. There are many stories in the group, initially interesting but finally deteriorating into moralising, namely —*The Man who sold the moon, Revolt in 2100, The Moon is a Harsh Mistress, Metluselahs children, Time Enough for love, The Rolling Stones, The Number of the Beast, The Cat that could walk through Walls,* and so on.

The stories contain all the ingredients of exciting SF—moon colonies, space ships, starships, exotic planets, time travel, eternal youth, sentinent computers, space ships which are also computer persons and so on. But as the series wears on, there is a curious element of flatness; the advanced technologies are never described in concept or operation; they coexist with covered wagons and mules (for displaying the virtues of rugged individualism), the Howards do not seem to use their long lives for anything other than fornication; both heroes and villains seem no thicker than cardboard as far as their depicted personalities are concerned.

The book under review is the latest (and, possibly the last—Heinlein died in May 88) of the Howard stories. They concern the life and times of Maureen Smith, Lazarus

Long's mother. Born in 1882, she leads a conventional (for a Howard) existence for many years, gives birth to a lot of children, meets Lazarus Long (in the name of Ted Bronson), falls in love with him, gets a lot of predictions from him about the stock market crash of 1929 and new inventions such as Xerox, laser, nuclear power, etc., which allow her (and the Howard Foundation) to make a lot of money, and is finally rescued from a traffic accident in 1982 (as she is going to meet her lover—the Howards are very long lived and youthful) by Lazarus Long's associates, both for sentimental reasons and as her talents are needed in the future. Rescued, repaired and rejuvenated, she joins the Time Corps devoted to correcting "errors" in the past which could affect the Howards. In one of her trips, she lands up naked with a naked corpse in her bed in a theocratic world. She is "rescued" from jail by a gang of assassins—the Committee for Aesthetic Deletions who have as their aim the extermination of certain socially harmful individuals. She is rescued from them again by Lazarus and his group, and finally goes on an expedition to defeat the Germans in the Second World War, in the air battles of 1942 in Britain. Her father is also rescued and brought into the future. The rest of the story is her recollections of her life.

This story is more shabbily written than the rest of the series. Nothing emerges, except that Maureen is one lusty lady. The moralising goes on interminably. The plot is thin. Almost everything in Heinlein's past stories is brought in without much purpose, even the "rolling roads" from a 1938 story. The time paradoxes are not handled at all. Altogether, very unsatisfying for Heinleins fans; Heinlein should have known when to stop.

S. Mohan

GUIDE TO CAREERS FOR SCIENCE STUDENTS *by* S.L. Kakani and N.C. Parakh, *Sultan Chand and Sons*, 23 Daryaganj, New Delhi 110002, Pp. 145, Rs. 15.00.

THERE was a time when students took up science with the aim of becoming either doctors or engineers. But with increasing competition more and more science students are unable to enter into these streams and subsequently find themselves handicapped for lack of choice of other careers. Suddenly they are graduates or post-graduates and still undecided on which career to choose. The problem is further compounded due to a lack of proper guidance and information on the range of career choices for a science student.

The book under review is an attempt at bridging this information gap. It begins with a review of the new pay scales of Central Govt. employees, Armed forces personnel, and College and University teachers. Subsequent chapters deal with courses after higher secondary, courses for science graduates and professional courses, with each chapter giving a list of institutes where the courses are available. Other chapters are devoted to employment opportunities in defence, banking, advertising, forestry, railways, information technology, etc.

Separate chapters have been devoted to self-employment opportunities and opportunities available abroad. But the chapter on self-employment opportunities could have been dealt with in more detail. Also, there is a lack of information on science journalism, a growing field by every means. However, the authors seem to realise fully well that a single book cannot be comprehensive in every respect and have given a list of books for details on specialised courses.

Readers will also find five appendices at the end of the book extremely helpful as they give lists of universities, research institutes and laboratories, Central Govt. enterprises and a list of industries for science and technology personnel. This reasonably priced book can be a great help for students of science in terms of career planning.

Hasan Jawaid Khan

COMPUTER SCIENCE, Vol, II *by* R. Dheendayalu, *Tata McGraw-Hill Publishing Co. Ltd.*, 12 /4, Asaf Ali Road, New Delhi-110002, Pp. 207, Rs. 27.00

THE book under review is the second in the series of two volumes. The review of the first volume appeared in *S.R.*, November 1987. The volume under review is meant to cover the computer science syllabus of class XII prescribed by the C.B.S.E. and the Directorate of School Education, Madras. The topics covered in the book are Boolean algebra, instruction format, machine and assembly languages and instruction types, data structures, coding systems, access mechanism of files, report preparation, systems analysis and various phases in problem solving, computer centre organisation, BASIC programming, and FORTRAN programming. The chapter on computer centre organisation gives a practical knowledge about the qualifications and responsibilities of EDP (Electronic data processing) manager, systems analysts, systems programmers and other staff engaged in the functioning of a computer centre. An attempt has been made to cover broadly various topics in the book. The exposition has been simple and systematic. Worked-out examples and exercises provided at the end will certainly prove to be of immense value to students. The book will benefit not only those students who have opted for a computer science course but also those who want to learn the subject for general awareness. Certainly, a book worth possessing for personal use as well as for library.

P.K. Mukherjee

CYTOLOGY GENETICS AND EVOLUTION *by* P.K. Gupta, *Rastogi Publications,* Shivaji Road, Meerut 250002, Pp 631, Rs.45

CYTOLOGY, genetics and evolution are facinating topics of biology and have a direct bearing on human welfare. Many breakthroughs in plant, animal and medical sciences have been achieved through research in cytology and genetics. The book under review deals with the fundamentals of these topics. It comprises four parts. Part I deals with the cell theory and cell structure. Part II deals with the principles of Mendelian and Morganian genetics, including some of the most recent advances. Part III gives details, on molecular biology, including the structure and synthesis of nucleic acids and proteins, genetic code and synthesis of genes. Part IV includes evolution and covers origin of life, evidences and theories of organic evolution and speciation.

The book is well-written. At the end of every chapter many problems are given. The book is supplemented with many clear line illustrations. All the topics are explained in a simple manner. There are some spelling mistakes, which the author assures would be taken care of in the next edition.

This moderately priced book would be useful to graduate students in understanding the fundamentals of cytology, genetics and evolution.

N.R. Mankad

BLUESONG *by* Sydney J. Van Scyoc, *Penguin Books* (Available from Penguin Overseas, 706, Eros Apartment, Nehru Place, New Delhi-110019), Pp. 261, £1.95.

THE Science Fiction under review deals with the thrilling adventure of a young woman Keva who had been abandoned by her father due to some strange reasons. As fate would have it, all of a sudden Keva discovered a narrow strip of blue fabric and a dark blue stone embedded in a metal casing. On touching the fabric some elusive memories at once came to Keva's mind and she was reminded of a bearded man her father who wore a blue fabric round his waist. The fabric sang a strange song which was described as the "Bluesong". Keva decided to leave her home to search for her father Jhaviir. It was on her way that she met Danior and they together went in search of Jhaviir.

After thrilling adventures in alien lands, Keva and Danior could ultimately complete their search. They discovered Jhaviir in a desert land. Jhaviir had united the people of this land into a social unit and had become their leader. The desert people were called Greater Clan, a name which Jhaviir had himself given to them. Through her father Keva came to know that she was the daughter of a woman who could harness the sun's power with her mystic fire-cuffs and sunstone. Keva also used her powers in her fight with other clansmen who were alien to the Greater Clan. This has been described in horrifying and blood-curdling details. Certainly, an action-packed and thoroughly gripping Science Fiction.

P.K. Mukherjee

THEORY AND PROBLEMS OF MATHEMATICS FOR CLASS IX (with solved problems) *by* G.S. Baderia, *Tata McGraw-Hill Publishing Company,* 12 /4, Asaf Ali Road, New Delhi 110002. Pp viii+251; price Rs 22.00.

THE present book is one in the 'Self Study Series' published by the Tata McGraw-Hill Company. It is intended as a home study supplement to the work done in school. Written by a former Reader in mathematics at NCERT, the book strictly conforms to the 1985 syllabus of the Central Board of Secondary Education, New Delhi. Every chapter of the book is appended with a good collection of both simple and hard problems. It is therefore useful to students appearing in competitive examinations like the National Talent Search, National Defence Academy and even IIT Joint Entrance. To facilitate self-study there are a large number of solved problems, and hints for harder ones are included wherever necessary. A uniform pattern or presentation of the text material is resorted to. Every chapter begins with a clear statement of definitions, laws and principal formulae (proofs for theorems are given briefly). An analysis of solved problems is given wherever it is desirable. The text material is broadly divided into three parts: mathematical analysis, plane geometry and commercial mathematics, with a concluding chapter on graphical presentation of statistical data.

Keeping in view its specific purpose, the book is well written. However, there is ample scope for improvement in subsequent editions. Firstly, an appendix listing the principal algebraic formulae, mensuration, some trigonometric (though not needed for IX class students, but might be of help to those appearing in competitive examinations) and logarithmic tables is desirable. In the chapter on indices /logarithms, it is necessary to explain how $a^0 = 1$ and $a^{-m} = 1_a{}^m$ follow from the index laws. There is no mention of the important base changing formula of logarithms:

$$\log_b m = \log_a m \ / \log_a b$$

Again, keeping in view certain topics that regularly appear in competitive examinations, problems concerning Pythogoras theorem, loci, concurrency theorems and constructions based on them could be included. Also, problems of geometry included in the book are quite simple.

(*Continued on page 471*)

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