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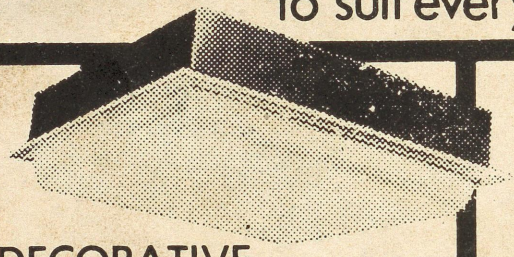

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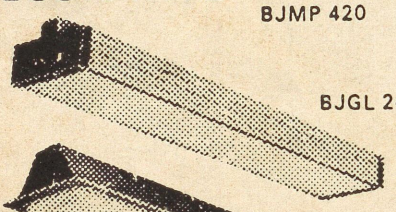

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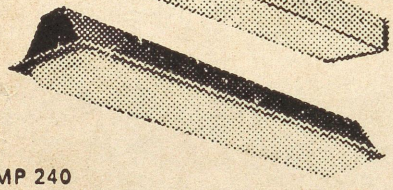

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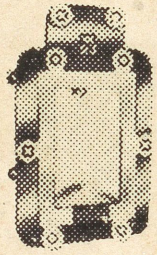

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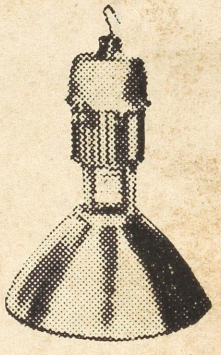

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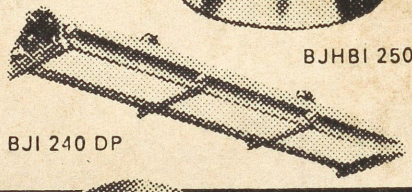

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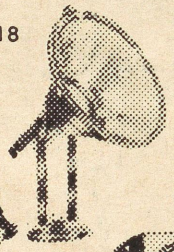

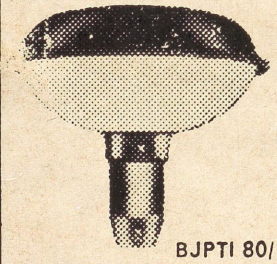

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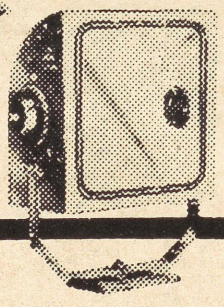

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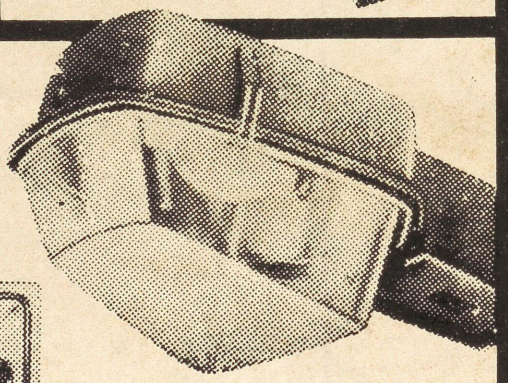

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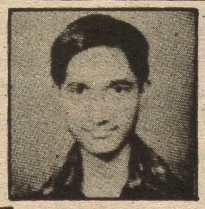

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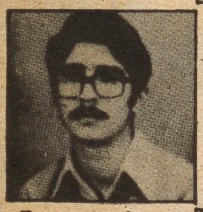

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SCIENCE REPORTER

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COVER: Exhaust from supersonic transport aircraft (SST) is one of the principal destroyers of ozone in the stratosphere.

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LETTERS

Maternal pheromone

Sir, 'The excreta of a mother rat contains a pheromone which attracts the young' (**Chemical communication in tiger**, *S.R.*, Feb. 1979, p. 93). Michael Leon and Howard Moltz of the McMaster University, Canada, have called it 'maternal pheromone' (*Physiol. Behav.*, **8**, 683, 1972), the existence of which has also been recognized in the crayfish (*Nature*, **255**, 400, 1975), fishes (*Biosci. Commun.*, **3**, 331, 1977; *J. Chem. Ecol.*, **3**, 463, 1977; *Z. Tierpsychol.* in Press) and most of the mammalian species (*J. Invest. Dermatol.*, **62**, 124, 1974; *Physiol. Behav.*, **16**, 15, 1976; *Physiol. Rev.*, **59**, 224, 1979) including human (*The Human Neonates in Parent-Infant Interaction*, Ciba Foundation Symposium 33, Amsterdam, 103, 1975; *Nature*, **260**, 520, 1976). Colin Bernett of the University of California, U.S.A, after exhaustive studies on the problem, remarked that the innate bias of neonates for the mother is due to this pheromone (*Anim. Behav.*, in Press).

Richard Porter and Helen Doane of the John F. Kennedy Center for Research on Education and Human Development, Tennessee, have demonstrated that, in the spiny mouse, the maternal pheromone maintains cohesiveness of infants to the mother (*Physiol. Behav.*, **21**, 563, 1978; *ibid*, **23**, 75, 1979). In the earlier studies they showed that, owing to this pheromone, a pup finds a 'foster mother' when its biological mother dies, and claimed that the pheromone aids in communal mothering (*Physiol. Behav.*, **16**, 75, 1976; *Behav. Biol.* **20**, 244, 1977).

Studies by Michael Leon on the rat have proved that the females have an inherited character to produce the pheromone. It is synthesized in the caecum and is not a product of anal gland secretions; and its production is not dependent on the sex hormones; rather it is under the control of prolactin (*Physiol. Behav.*, **13**, 441, 1974). Recently, Howard Multz and colleagues of the University of Chicago, U.S.A, have tried to learn the origin and chemistry of this pheromone. They demonstrated that bile acids are involved in the matter (*Science*, **196**, 81, 1977; *ibid.* **201**, 939, 1978). In a subsequent experiment they fed cholic, chenodeoxycholic and deoxycholic acids to the nulliparous and virgin rats and found that only those who were on the dietary cholic acid supplement evidenced the emission of the pheromone (*Physiol. Behav.*, **25**, 31 , 1980). This led them to hypothesize cholic acid/or its unknown derivative (s) to be the maternal pheromone of the rat (*Pharmacol. Biochem Behav.*, **12**, 555, 1980). However, our knowledge regarding its actual chemistry is still scant (*Physiol. Behav.*, **26**, 301, 1981).

AJAY KUMAR PANDEY
Department of Zoology
University of Gorakhpur
Gorakhpur-273001

Windmills in India

Sir, I intend to write a book on 'Prospects for Wind Energy Utilisation in India'.

In the past, National Aeronautical Laboratory, Bangalore and some Christian Missioneries installed windmills all over the country. I will deeply appreciate if the readers of *S.R.* send me details of the windmills they have ever come across. Due acknowledgement will be given for the information provided.

A. JAGDEESH
Deptt. of Physics
University of Roorkee
Roorkee-247672

Hubble's law in its right sense

Sir, Many thanks for the complements recorded by K. Suresh (*S.R.*, July 1981) on my article **On the arrow of time** (*S.R.*, Feb. 1981). He has expressed his doubt that there is a mistake in explaining cosmological arrow of time. I wish to clarify the Hubble's law of recession of galaxies which has not been understood in its right sense.

It is well-known that P. Hubble selected the brightest galaxies in each cluster of galaxies and discovered that they are receding from one another with a speed proportional to their distances. The cosmological arrow of time is fixed with respect to outward radial motion of these galaxies which are not gravitationally bound. There is yet no evidence that these galaxies are approaching one another.

Individual galaxies in each cluster are not moving randomly under mutual gravitational field, as understood by K. Suresh, but are in some form of orbital motion around the centre of cluster of galaxies. Also they are subjected to the general recessional motion. Thus their motion must be understood in terms of 'proper motion'.

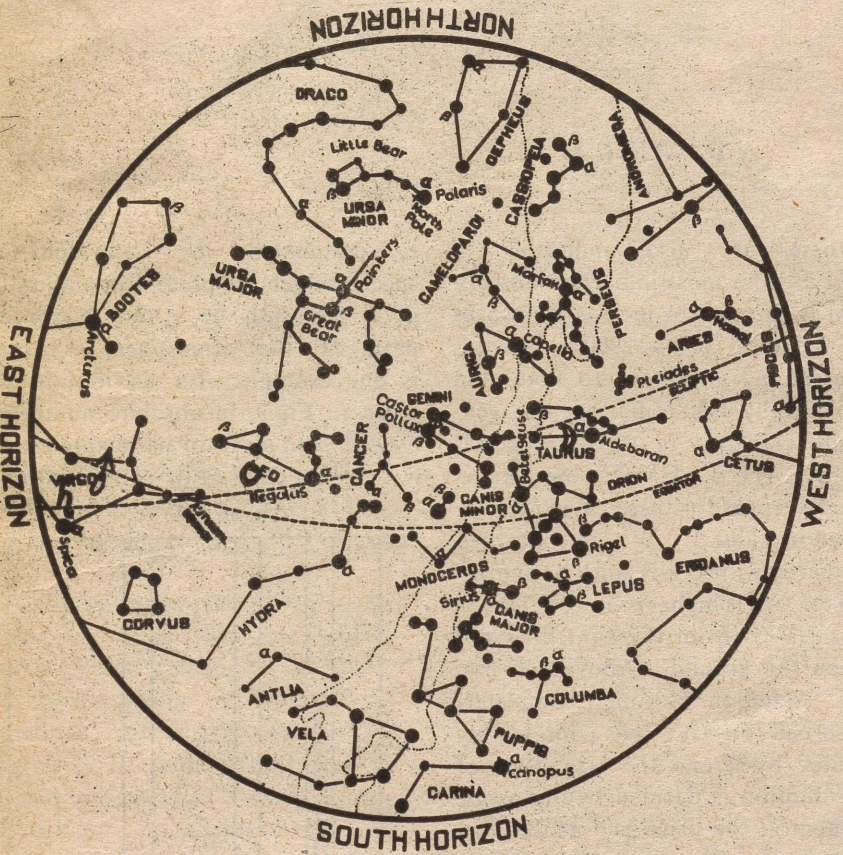
S.C.P. HALAKATTI
Research Scholar, Deptt. of Mathematics, Karnataka University
Dharwad-580003 (Karnataka)

Leafy vegetables

Sir, **Leafy vegetables** (*S.R.*, December 1981) by R.L.N. Sastry was very informative. Here we would like to give some additional information about them (see our article, *S.R.*, November 1981, 402-406).

(*Continued on page 110*)

STARS AND PLANETS



Planetary positions for March, 1982

Date	*1ST*		*10TH*		*20TH*	
Planets	*R.A.*	*DECL*	*R.A.*	*DECL*	*R.A.*	*DECL*
Mercury	21h 04m	17.3°S	21h 50m	14.9°S	22h 48m	10.1°S
Venus	20h 01m	15.1°S	20h 26m	15.0°S	21h 00m	14.1°S
Mars	13h 14m	4.4°S	13h 09m	3.8°S	12h 58m	2.8°S
Jupiter	14h 33m	13.6°S	14h 32m	13.5°S	14h 30m	13.3°S
Saturn	13h 24m	5.9°S	13h 22m	5.7°S	13h 20m	5.4°S

*Adapted from figures supplied by Positional Astronomy Centre, Calcutta.

The moon

Full moon occurs on 10th at 2-15 A.M. and new moon on 25th at 3-47 P.M. I.S.T. The moon passes about two degrees north of Mars in the early hours of 12th and two and a half degrees north of Saturn on 12th, about three and a half degrees north of Jupiter around midnight of 13th and five degrees south of Venus on 21st. The lunar crescent becomes first visible after the new moon day in the evening of 26th. The moon is at perigee or nearest to the earth on 4th, and again on 29th and at apogee or farthest from it on 17th.

The sun is at the vernal equinox on 21st.

The planets

Mercury (*Budha*), visible in the morning sky, rises about an hour before sunrise during the first three quarters of the month. Thereafter it is too near the sun to be visible. It moves from Capricorn (*Makara*) to Pisces (*Mina*) through Aquarius (*Kumbha*). Its visual magnitude varies from +0.3 to —0.4

Venus (*Sukra*), a morning star, rises about two and a half hours before sunrise during the month. It is in Capricorn (*Makara*). Its visual magnitude is about —4.2

Mars (*Mangala*) rises about two and a half hours after sunset during the first half of the month and sets at about sunrise during the second half being at opposition with the sun on 31st. It is in Virgo (*Kanya*). Its visual magnitude varies from —0.5 to —1.2

Jupiter (*Brihaspati*), visible in the morning sky, rises about two and a half hours before local midnight during the first half of the month and about three and a half hours before it during the second half. It is in Libra (*Tula*). Its visual magnitude is about —1.9

Saturn (*Sani*), rises about two and a half hours after sunset during the first half of the month and about an hour before it during the second half. It is in Virgo (*Kanya*). Its visual magnitude is about +0.6 (*Source:* The Director, Positional Astronomy Centre, P-546, Block 'N' New Alipore, Calcutta-700 053)

THE OZONE PROBLEM

Man-made sources such as nitrogen oxides and fluorocarbons are not the only ones that affect the earth's ozone shield; natural phenomena like volcanic eruption and solar flares also destroy ozone in the stratosphere

A.P. MITRA

FOR ages and all over the world people have thought highly of ozone. They have been inhaling with deep satisfaction the seaside air and the mountain air and air in odd places that they somehow feel is rich in ozone and does them good.

The screening effect of ozone

They have been right, but for the wrong reasons. Ozone does all of us good wherever we are, but not through inhalation and its consequent physiological effect, but essentially through a 'negative' act. By a quirk of fate, ozone is a molecule that absorbs radiation in the ultraviolet in those wavelengths which are biologically harmful. Working some 25 kilometres above the earth it absorbs radiation below about 2900Å and thus keeps it from reaching the surface of the earth. The sun emits radiations at all wavelengths, the lower the wavelengths the more its photon energy $\left(E = h\nu = h\frac{c}{\lambda}\right)$ and as the photon energy increases, its efficiency in damaging biological systems increases. But much of it is absorbed in the atmosphere at various levels (Fig.2). This absorption takes place from oxygen, from water vapour and a number of other constituents —these are also indicated in Fig. 2. The most important absorption is through ozone for it absorbs all radiation below 2900Å. In this context, it is relevant to note that biologically UV radiations are generally classified in three categories UV-A, UV-B, UV-C; the wavelength ranges for these categories are given in Table 1. We are concerned primarily with UV-B since its damaging efficacy is higher than with UV-A, and UV-C (from the sun) does not reach the ground. Above 290 nm, the radiation is not completely absorbed by O_3, but considerably diluted by it and the magnitude of the dilution is decided by the ozone content at the place and at the time concerned. This dilution factor decreases sharply (essentially exponentially) as O_3 content decreases, since the term controlling dilution is given by $e^{-A(O_3)}$, where (O_3) is the ozone content.

Ozone is a minor constituent of the atmosphere, i.e., it exists only in very small quantities, less than a part per million of air at ground; even more scarce than CO_2 or H_2O vapour. While this point is not entirely relevant in this discussion, a very amazing feature of nature is that much of the earth's phenomena is dominated by atmospheric species which are present in amounts of a millionth to a few billionth parts of the atmosphere. Ozone is one example. Its distribution is given in Fig.3, in absolute numbers as well as in terms of its mixing ratio (i.e., as the ratio of its concentration

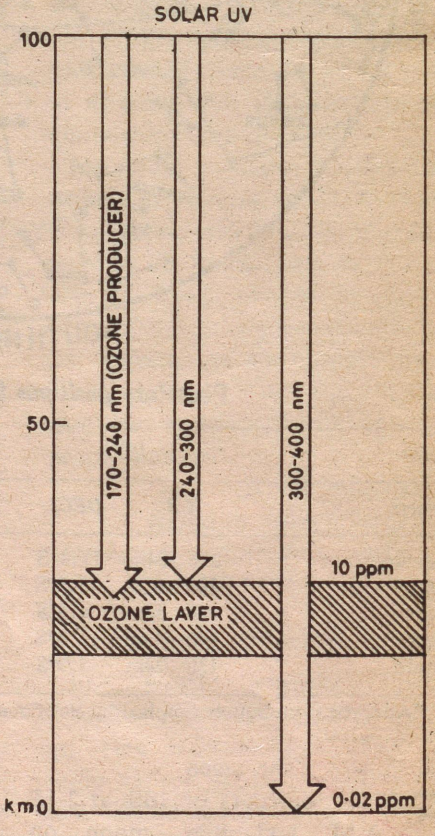


Fig 1

Dr. Mitra heads the Radio Science Division at National Physical Laboratory, New Delhi-110012

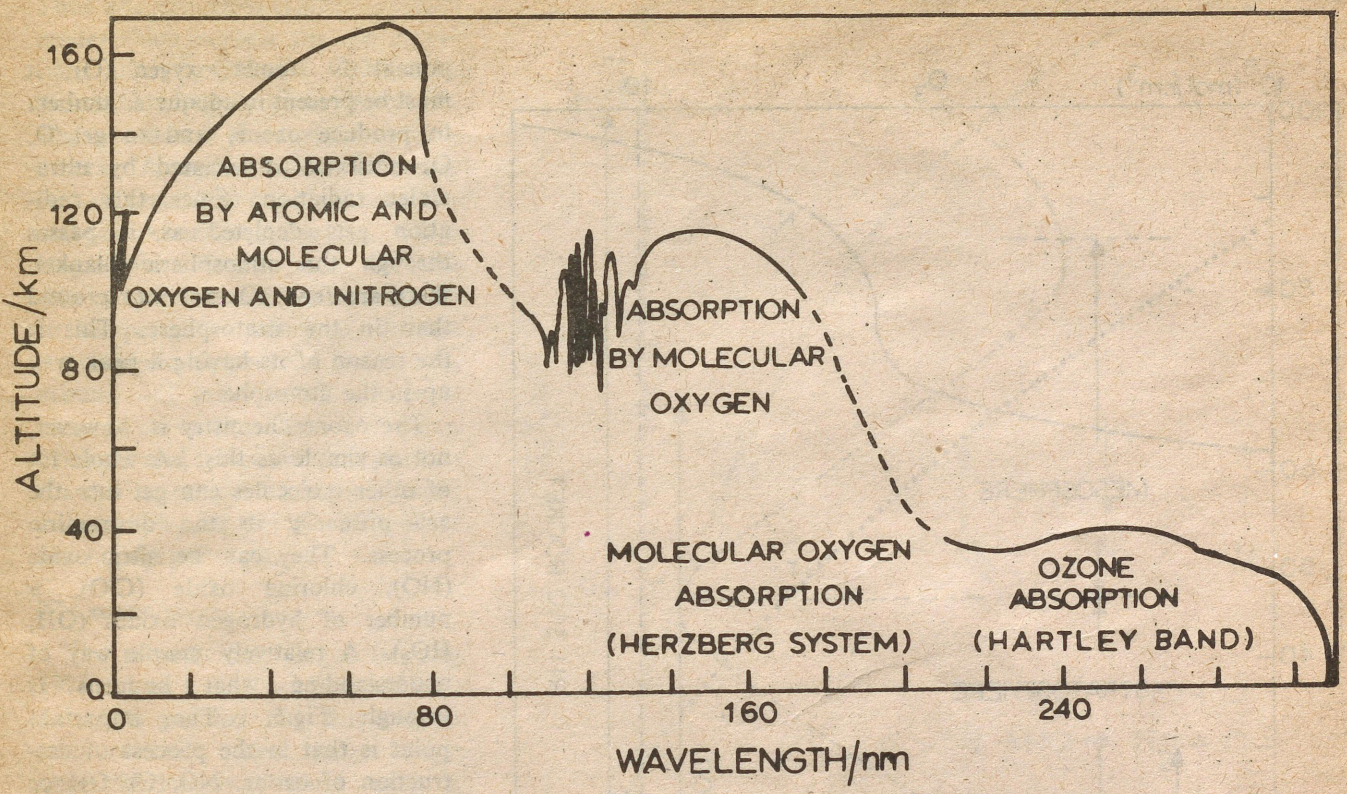


Fig. 2. All radiations emitted by the sun do not reach the surface of the earth. Some are absorbed in the atmosphere. What is shown here is the height at which radiations below 290 nm (i.e., 2900 Angstroms is reduced to $\frac{1}{e}$th of its original value. Note that the region immediately just below 290 nm is controlled almost entirely by ozone.

with concentration of all air molecules). In this the atmospheric structure from surface to 100 km is also shown, along with the regions known as troposphere and stratosphere. It is worth noting that 90 per cent of ozone is located in the stratosphere at altitudes between 50 km and 10 km-17 km (depending on latitude). It is partly responsible for the rise in temperature in the stratosphere (Fig.3). This positive temperature gradient in the stratosphere restricts transfer of material between the stratosphere and the troposphere below.

Ozone is a photochemical product, i.e., it is a result of chemical reactions in which the starting molecule is oxygen. Some of the peculiar features of ozone are that its maximum concentration is not at the ground but at a height of about 50 km where its concentration is about 5×10^{12} molecule per cm^3. Although production of ozone is the maximum near the equator, its concentration is minimum at these latitudes. The protective umbrella is thinner at equator than at the poles and higher latitudes.

Table 1. UV classifications

UV-A	315 nm	to	400 nm
UV-B	280 nm	to	315 nm
UV-C	200 nm	to	280 nm

There is no doubt that life became possible on the earth only when the ozone layer was atleast partially formed and allowed life to evolve and protected living systems to emerge from out of the oceans. The time scale of this evolution in the 4.5 billion years that has passed since the earth was born is shown in Fig.4. This is based on several assumptions. An important assumption is that the abundances of nitrogen, carbon dioxide and water vapour in the atmosphere were controlled at their present levels by abiotic processes and that the temperature structure of primitive atmosphere was similar to that of today excepting that the temperature maximum at stratopause was absent. Since the crucial parameter for life was the increasing efficiency of the ozone layer in screening the earth's atmosphere from UV radiation, the evolution of the screening effect is shown. The important point to note is that the ozone content reached its maximum sometime in the past when the oxygen content was $\frac{1}{10}$th its present value. If for some reason this protective layer is withdrawn or even partially depleted, biological consequences must be severe, although we are not quite clear about all aspects of this hazard.

Ozone, as mentioned, is a photochemical product. The possibility

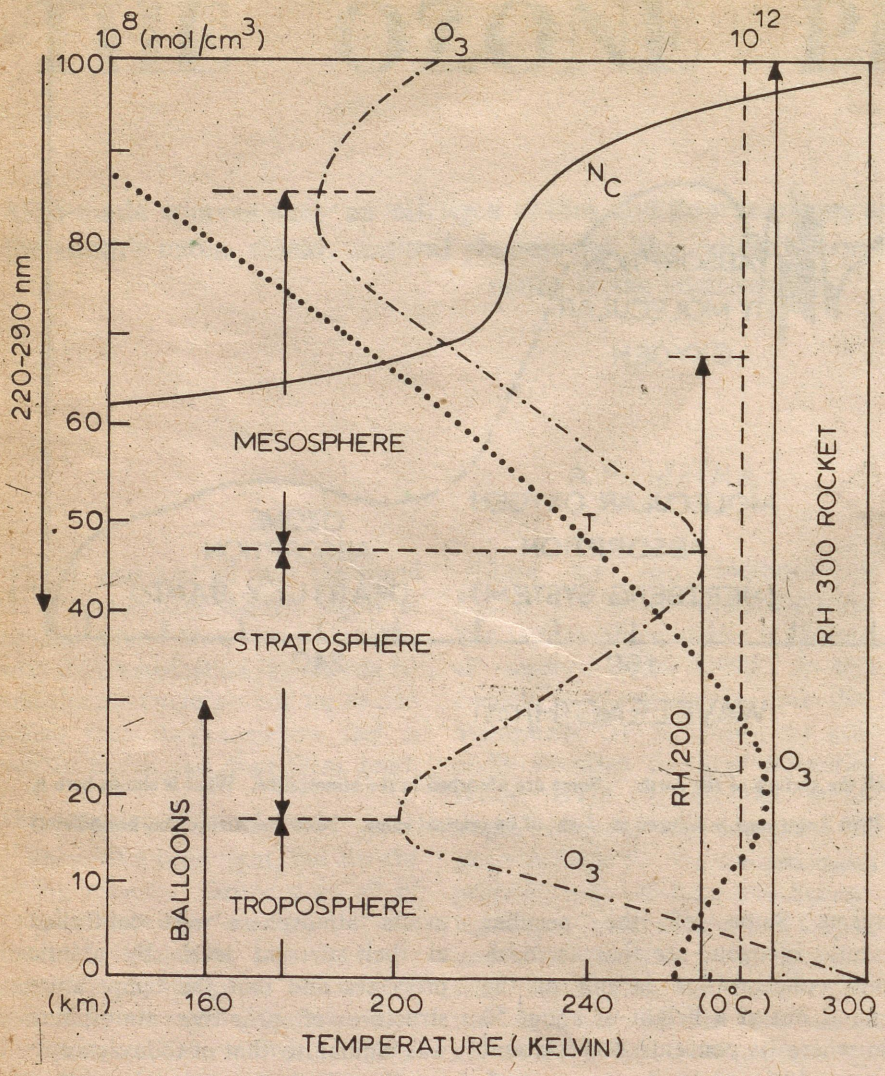


Fig. 3. A simplified representation of the atmosphere from surface to 100 km and the distribution of ozone. The atmosphere is divided in this height region into three broad regions on the basis of temperature; the Troposphere, the Stratosphere and the Mesosphere. The Ionosphere begins at about 60 km. The sharp increase of electron density between 60 to 100 km is also indicated (Ne curve). The heights reached by the balloons and by the Indian rockets Rohini 200 and Rohini 300 are also indicated

that it may have climatic consequences has been realized over a long period of time. Like water vapour it is a 'greenhouse' molecule, i.e., it absorbs infrared radiation emitted by the earth and then radiates it back to the earth thus producing a warming effect.

Ozone chemistry

The simplest description of the ozone life cycle is given by the so-called Chapman cycle (Table 2). According to this simple chemistry, ozone is produced by 3-body association of atomic oxygen and molecular oxygen and subsequently destroyed by: (a) dissociation through solar ultraviolet, and (b) reaction with atomic oxygen. The key component is atomic oxygen (O); it must be present in adequate numbers to produce ozone, and to get O, O_2 must be dissociated by ultraviolet radiation. Since this radiation gets depleted as it passes through the atmospheric blanket, there are fewer O atoms at ground than in the stratosphere. This is the reason of its having a peak way up in the atmosphere.

The ozone chemistry is, however, not as simple as this. A whole lot of other molecules can get into the act—primarily in the destruction process. They can be nitric oxide (NO), chlorine oxide (ClO), a number of hydrogen oxides (OH, HO_2). A relatively simple way of understanding what happens is through Fig.5. The important point is that in the process of destruction of ozone, NO, Cl, OH or HO_2 plays only a catalytic role, without itself getting destroyed. This can be seen through the following sets of reaction:

NO
$$NO + O_3 \rightarrow NO_2 + O_2$$
$$NO_2 + O \rightarrow NO + O_2$$
$$O_3 + O \rightarrow 2O_2$$

OH
$$OH + O_3 \rightarrow HO_2 + O_2$$
$$HO_2 + O_3 \rightarrow OH + 2O_2$$
$$2O_3 \rightarrow 3O_2$$

Cl
$$Cl + O_3 \rightarrow ClO + O_2$$
$$ClO + O \rightarrow Cl + O_2$$
$$O + O_3 \rightarrow 2O_2$$

Table 2. Chapman mechanism for ozone

Production:	
$O_2 + \nu \rightarrow O + O$	Oxygen dissociation
$O + O_2 + M \rightarrow O_3 + M$	Ozone formation
Destruction:	
$O_3 + \nu \rightarrow O_2 + O$	Ozone photo dissociation
$O_3 + O \rightarrow O_2 + O_2$	2-body recombination

Thus any processes (natural or man made) which increase the concentrations of NO, OH and ClO in the atmosphere help in destroying ozone. The question is their relative importances. A model calculation may include some 150 chemical reactions and photochemical processes. These may have different rates, different time constants and different response to temperature variations. In the stratosphere temperature is very low, around —60°C to —40°C and pressure is around 30torr - 200torr. Pressure and temperature dependences can be crucial for some species; for example, for OH and HO_2 these are highly pertinent.

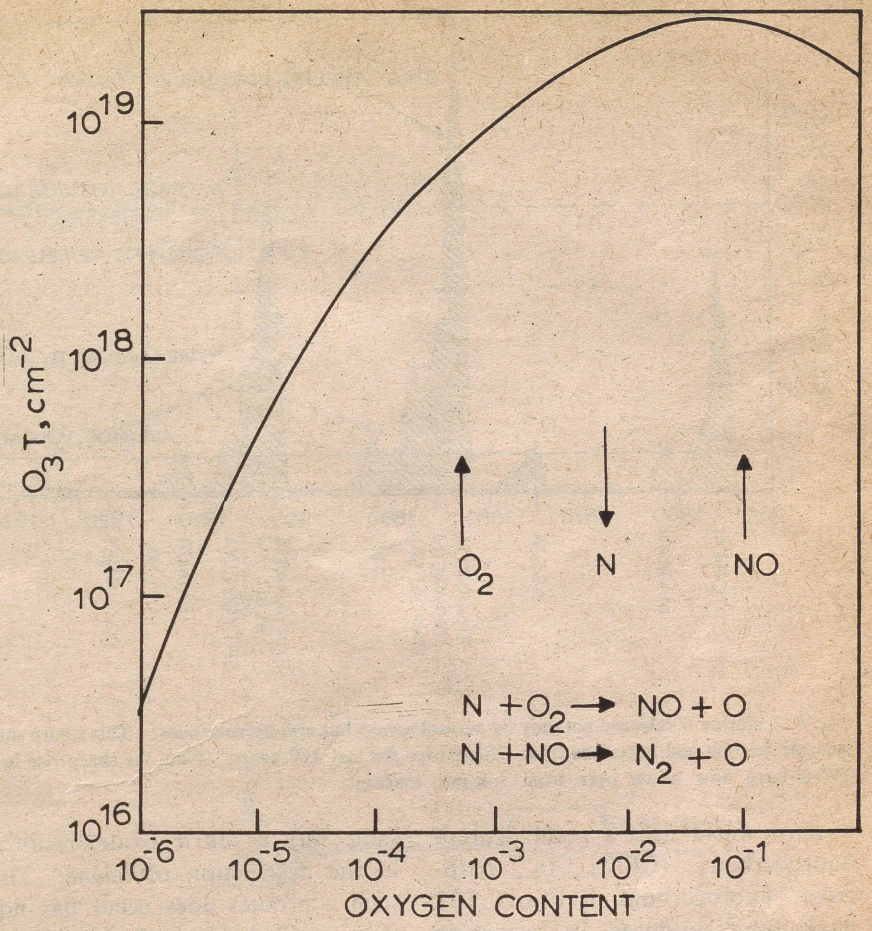


Fig. 4. Evolution of ozone in the atmosphere of the earth

The ozone scare

The present story began in early 1971 when a U.S. chemist Harold Johnston pointed out that supersonic aircraft, then under design and fabrication, would emit a large quantity of nitric oxide at exactly those heights where ozone has peak abundance. Nitric oxide, he said, would catalytically attack ozone converting it into molecules of oxygen in the way outlined above. Thus, Johnston argued, large-scale use of supersonic aircraft will appreciably deplete ozone over the entire globe. This reduction would mean an increase in ultraviolet-B radiation. This, it was argued, could result in a variety of environmental consequences including possible increase in skin cancer, stoppage of tissue growth, albumin coagulation, change in photosynthesis rate in plants, change in global rainfall and temperature conditions and introduction of ecological disturbances.

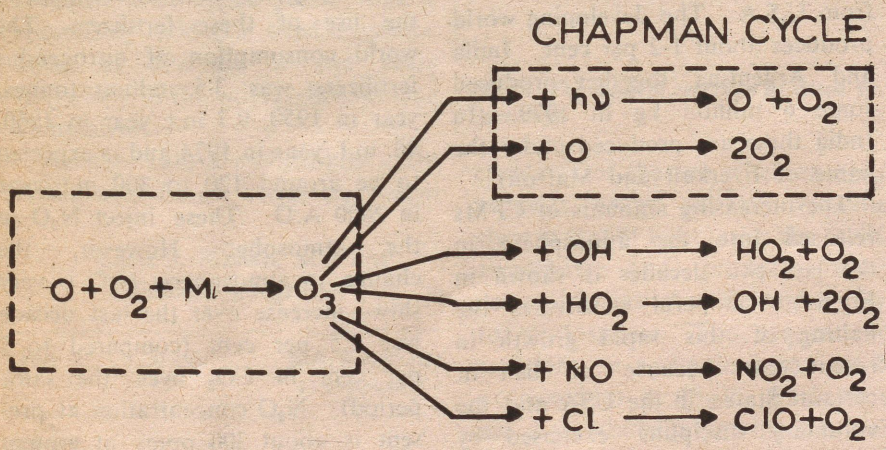


Fig. 5. Reactions that produce ozone and those that destroy ozone. The box indicates the simple Chapman chemistry. Other reactions are the ones that were later incorporated; much of the human influences really operate through those reactions later added

This warning caused a lot of scientific excitement. Soon scientists fell in two camps: one group considered that the effect was negligible and the publicity misguided and unnecessarily dramatic. The other group considered the possible effect to be sufficiently important to require immediate action. The U.S. Government stopped Boeing developmental activities in SST, and ordered the study of the stratosphere through a programme called Climatic Impact Assessment Programme (CIAP).

Fluorocarbons

It soon became apparent that another, and perhaps potentially more catastrophic, hazard exists. The

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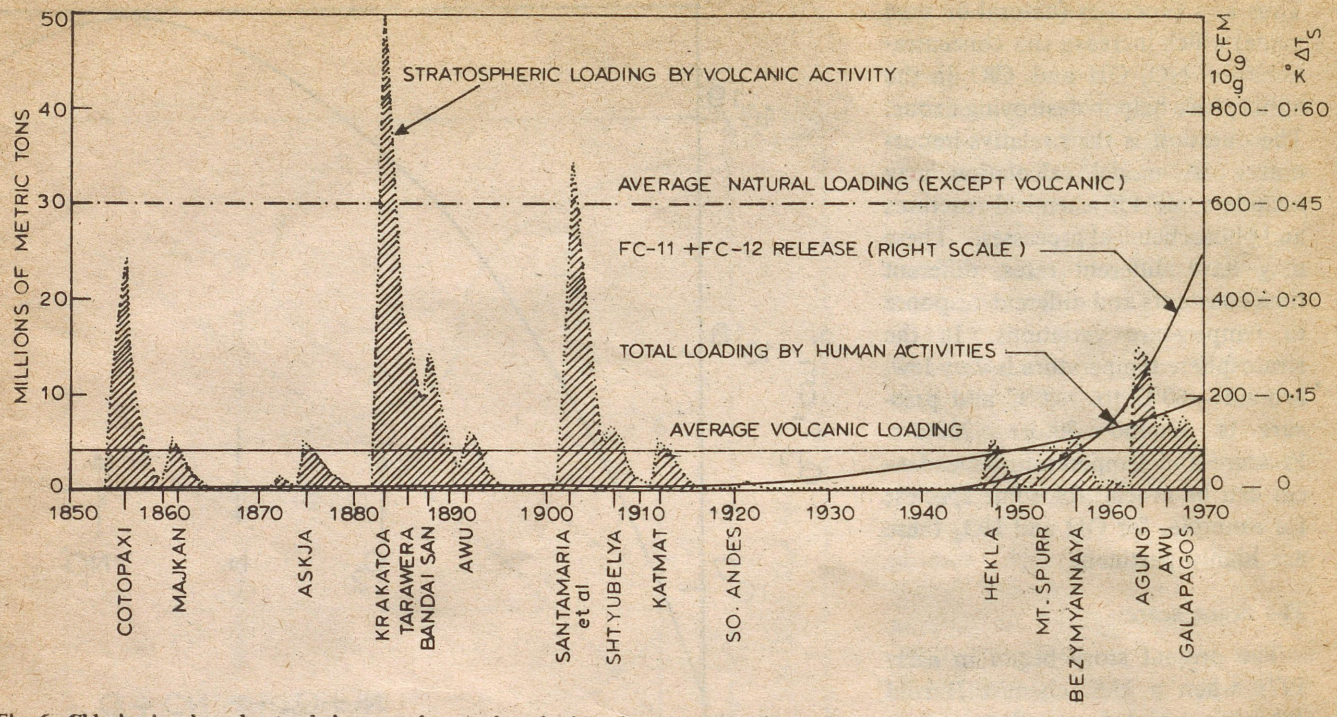

Fig. 6. Chlorine is released not only by aerosol sprays but also by volcanoes. This figure shows nature of injections from volcanoes, the average volcanic loading and injections from CFMs over the last 100 years. Note the sharp rise in CFM injections in recent years and the fact that CFMs have now taken over from volcanic loading

western world uses a good deal of fluorocarbons (CFM). In particular, fluorocarbons F11 and F12 have been produced in increasing amount after World War II for a diversity of purposes: aerosol sprays, working fluids for refrigerators and airconditioners and agents for producing certain solid plastic foams. F11 is the trade name for $CFCl_3$ and F12 for CF_2Cl_2. Fluorocarbons find use in instant foam shaving creams, hair sprays insecticides sprays and in a variety of other ways. What happens is that when these gases are released in the atmosphere (note that there is no danger in closed recycled system as in refrigeration and airconditioning equipments), the molecules $CFCl_3$ and CF_2Cl_2 get dissociated, as they rise to stratospheric height. This dissociation occurs because of the increasing intensity of solar ultraviolet radiation at the higher levels. The result is the production of free chlorine. This free chlorine then attacks ozone catalytically in the same way as nitric oxide, resulting in the destruction of ozone. That such a process does occur has now been verified from observations of $CFCl_3$ and CF_2Cl_2 from balloons which show a definite decrease in their concentrations as we go to stratospheric heights. The total world production of these hydrocarbons have increased from 41 million kg in 1950 to 700 million kg in 1980. 50 per cent of this comes from U.S.A. The developing world produces about 1-2 per cent. India and Argentina together produced some 6 million kg in 1979. (In India these are produced under the name of Everkalt and Mafron).

The increasing amounts of CFMs released into the atmosphere in the last two decades is shown in Fig.6. A hopeful feature is the halting of this rapid growth in recent years because of ban in certain States in the USA and the voluntary discipline exercised by the industries in recent years. The CFM production in 1980 as compared to 1950 are shown in Table 3.

Another manmade source which might prove a hazard to the ozone environment is nitrogenous fertilizer. Whether such a hazard really exists is not clear. This is an area of particular concern to India where use of chemical fertilizers is a necessity for increasing food production, and, therefore, only a very compelling reason can be accepted for any alteration or stoppage in the use of these fertilizers. The world consumption of nitrogenous fertilizers was 3.5 million tonnes/year in 1950, 9.7 m.t./year in 1960, 40. m.t./year in 1974 and is expected to be around 120 to 300 m.t./year in 2000 A.D. These inject N_2O in the atmosphere. However, the change in atmospheric N_2O is very slow—increase over the last decade was 1.5 per cent (compared to 2 per cent in CO_2 over the same period). N_2O concentration at present is about 300 ppmv at ground level. The tropospheric burden is 1.7×10^{15} gm and stratospheric

burden is 8×10^{15} gm; the estimated global flux is 210×10^{12} gm N_2O/year.

But manmade sources are not the only ones that affect ozone concentration. Afterall ozone is produced by solar radiation and at wavelengths which are not constant and therefore variations of ozone from purely solar point of view exist. In addition, nature can be violent. One example is the volcanic eruption. For large eruptions, the volcanic cloud may penetrate well into the stratosphere sometimes right upto 50 km. Such eruptions affect the atmosphere in two ways: by providind an aerosol layer in the troposphere which decreases transmittance of the solar radiation and therefore cools the atmosphere, and (ii) by introducing chlorine into stratosphere which destroys ozone through reactions indicated earlier.

Volcanic eruptions are not infrequent. A detailed list of eruptions from 1500 A.D. is available. One of the largest eruptions in recent history was the Krakatoa in 1882 and amongst the recent ones was the Mt. Agung eruption in 1963. An event of the size of the Mt. Agung or of Krakatoa is rare. The waiting time for one per cent probability for an Agung type eruption to occur is about 50 years. But if reasonably moderate sized eruptions occur at intervals of two years (anywhere in the world) they become cumulative.

Another natural catastrophic event is the solar flare. These are violent eruptions of the sun when energetic particles thrown out with velocities close to that of light, enter the earth's atmosphere and produce ozone-destroying nitric oxide right down to stratosphere. The sequence of reactions, in a simple form, can be expressed as in Fig.7. Such flares are more abundant during the years when solar activity is maximum. Nitric oxide injected into the stratosphere by some of the flares can be catastrophically large. For example, the solar flares of August 1972 (the largest in recorded history) injected 3×10^{33} NO_x molecules in the earth's stratosphere in a short period of a few days—ten times larger than the total annual injection from galactic cosmic rays.

Thus we have manmade sources as well as natural sources affecting ozone. The former must be comparable to or exceed the latter to pose danger. The different sources and the nature of injections are

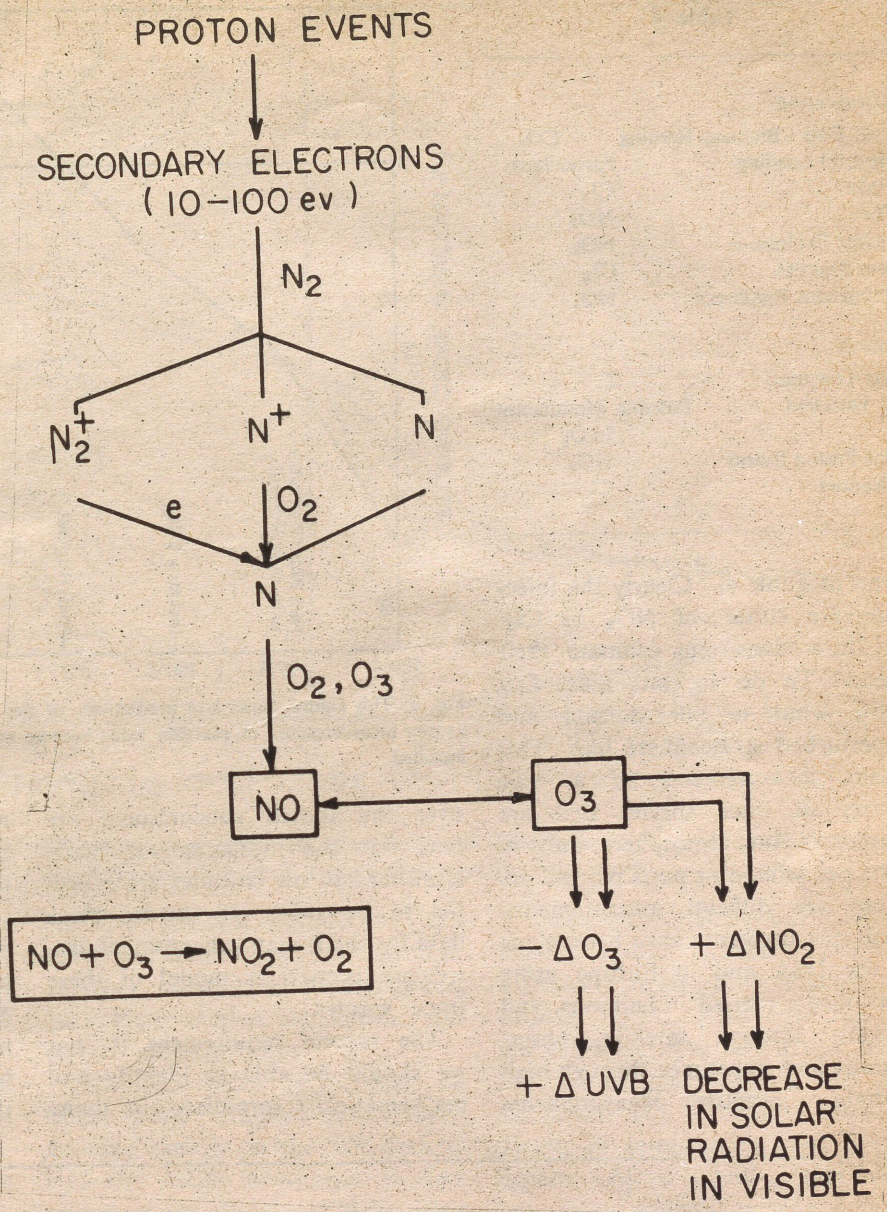

Fig. 7. The chain of reactions produced by the entry of solar energetic particles after a solar flare event

Table 3. Release of CFM (million kilogram)*

Year	*World*	*India+Argentina (4 companies)*
1950	32	0
1975	725	36
1980	590	7

*Taken as about 80 per cent of production

Table 4

Anthropogenic	
Fossil Fuel + Biomass Burning	CO_2
Industrial Loading	Particulates
CFMs	Cl_x
SSTs	NO_x
Nuclear Explosions	NO_x
Space Shuttles	Cl_x
Nitrogenous Fertilizers	NO_x
Natural	
Solar Constant	?
UV Variation	Possible Modulation In O_3
Solar Proton Events	NO_x
Volcanoes	Cl

given in Table 4. Clearly the injections are either of NO_x or Cl_x. But how does one estimate their effects? To do so, one must first know what is our normal and unperturbed stratosphere like. This means measurements of a wide variety of trace species that are present in the atmosphere only in parts per million or parts per billion. These are difficult measurements. Such measurements have been made in the USA and in Europe using instruments carried in balloons, and rockets, through satellite, observations and sometimes through high altitude aircrafts. Measurements over the Indian subcontinent are few, but the measurements made elsewhere at low latitudes are expected to be valid. If we use these data for the Indian subcontinent also we can prepare a model of these trace species.

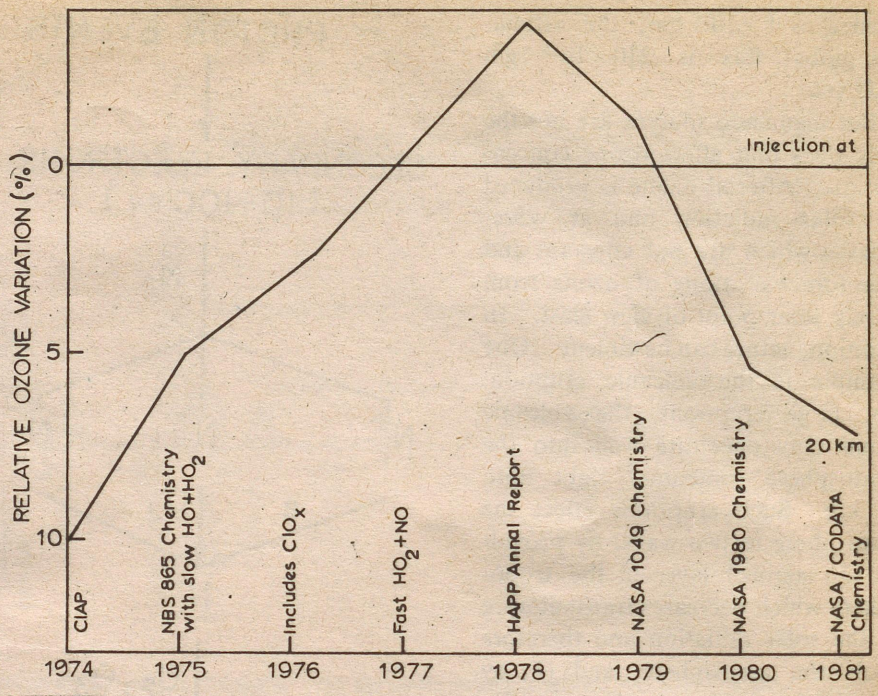

Fig. 8. This figure shows how predictions of the effect of supersonic aircrafts have changed as new measurements of reaction rates became available and as new types of chemistry were included

The second requirement is that we should be able to identify and mathematically formulate the many reactions that occur. Some have been observed and measured under laboratory conditions — some are still hypothetical. Calculations need large computers—there are about ten groups making such calculations. And calculations over the years have not given the same results. There have been some drastic changes in the estimates as new measurements of

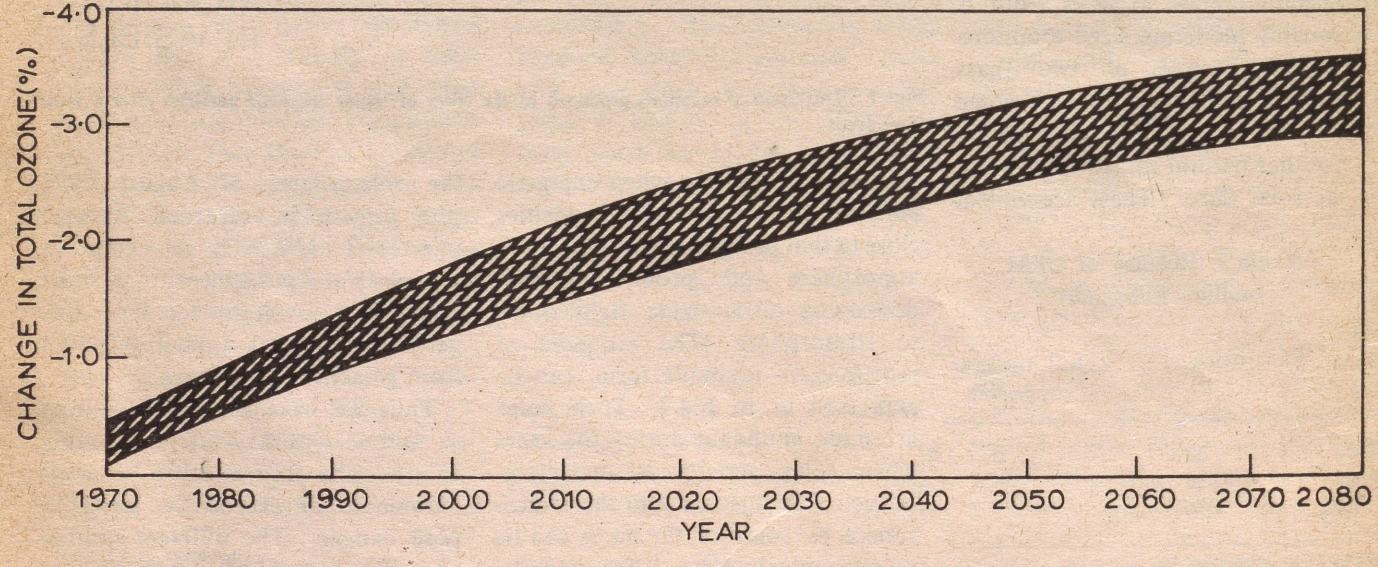

Fig. 9. Estimated ozone depletion with time from CFM alone

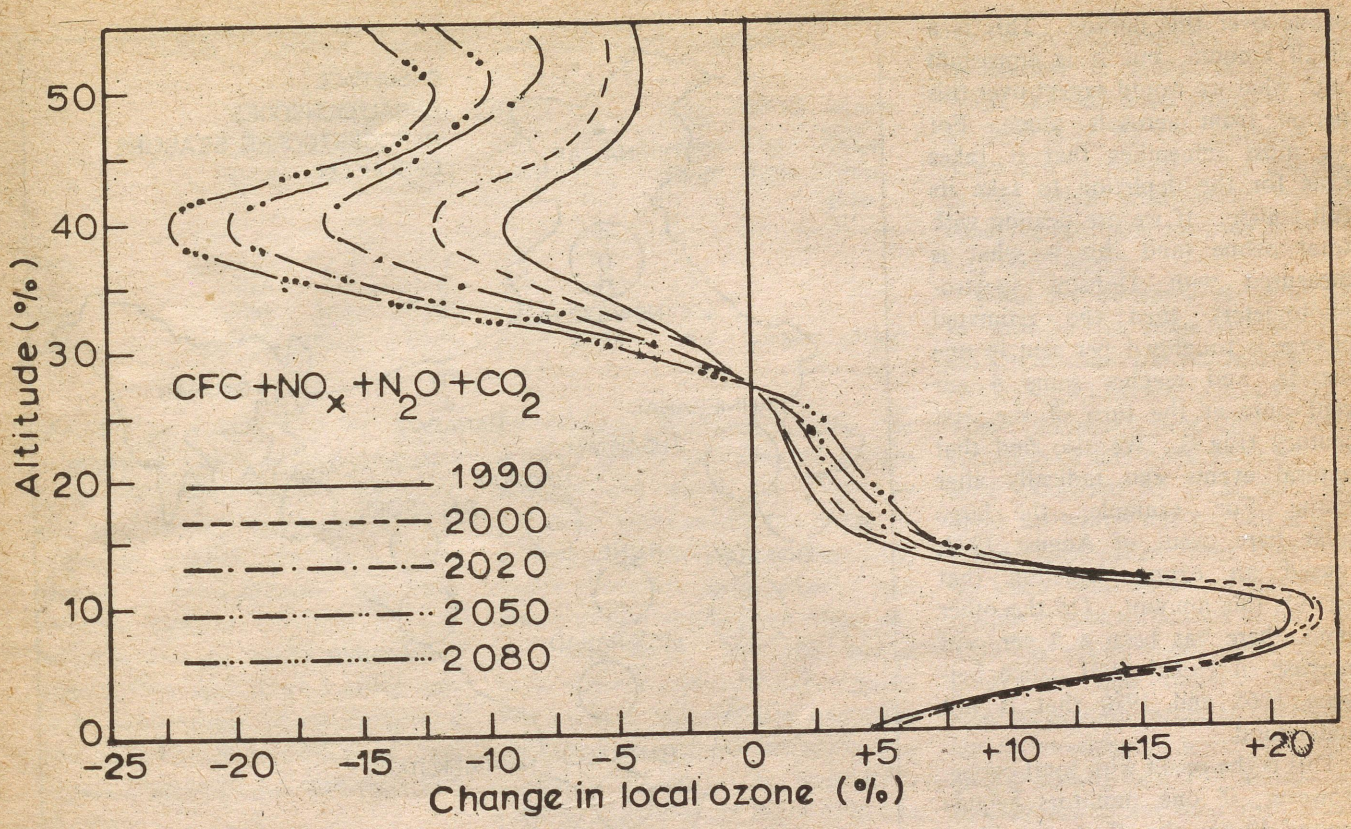

Fig. 10. While the total ozone variation is not expected to be very large from human influences, changes at specific levels can be substantial. This is shown in this diagram. Note that the changes are quite different in the troposphere and the stratosphere

some of the critical reactions became available. An example is shown in Fig.8. This figure shows how initial predictions of large-scale depletion in ozone from supersonic aircrafts changes to a prediction of enhancement and again in recent years to depletion. These are pitfalls that we must contend with for some time.

It seems, from these calculations, that the real danger comes from CFM release from aerosol sprays. Supersonic aircrafts do not pose much danger nor do nitrogenous fertilizers, at least in foreseeable future. Fluorocarbons from aerosol sprays, at their present rate of production, on the other hand, will eventually cause a reduction of 10 per cent in ozone. (Table 5 gives current estimates of different effects). This will not occur immediately—it will take decades. Use in aerosols have decreased in recent years. World production of F11 and F12 fell by 17 per cent between 1975 and 1979, but there is increase of other chlorine containing compounds, particularly methyl chloroform and carbon tetrachloride.

But the final test must be ozone itself. Aerosol use has been growing rapidly in the last decade. Has the ozone concentration decreased in the decade 1970-80? This it should be possible to determine. There are about 40 Dobson ozone spectrophotometers operating in different parts of the world, five of these in India. All these have been calibrated with the standard in Boulder, USA. Also over the last ten years we have had a new series of measurements carried out with satellites. The Indian measurements, in some cases, exist over a decade. More recently, experiments have been undertaken with rockets.

What do these measurements show? We do find a global trend of decrease of roughly 1 per cent in

Table 5. Present status

Source		*Change in ozone*	
SSTs		— 5.3%	New Nasa Chemistry
61-62 N. Tests		Negligible	
CFMS		— 8%	1981 Estimate
Rocket Exhausts		— 0.3%	Space Shuttle Missions
SPE (Solar Proton Events)		— 20%	45 km
Aug. 4,1972		— 13%	30 km
Volcanoes	Krakatoa	— 7%	
	Agung	— 0.7%	
UV		5%	

ozone over this decade. This is a small amount, but it is consistant with what we would expect over this period from aerosols alone. For we must remember that it takes time for the depletion to take its full course. If we are dealing with total ozone (and this is what is measured with Dobson spectrophotometer), then the estimated change is roughly 1 per cent in one decade, and reaches some 4 per cent only at the turn of the 21st century (Fig.9). We also find that natural events can radically alter ozone. For example, the large solar flare event of August 1972, caused an ozone depletion that exceeds this amount. On the other hand, there has been a 5 per cent increase in global total ozone between 1965 and 1970 that is not understood.

This is the result with total ozone. However, if one monitors heights around 40 km, the effects should be much larger. This seems to be the case. Thus it looks as if the calculations are at least grossly correct.

The question that the magnitude and nature of the effect is radically different at different heights is important. We can understand this by looking at Fig.10. Below 25 km, the net result of all anthropogenic changes (CFC from aerosol sprays, NOx from SSTs, N_2O from fertilizers and CO_2 from fossil fuel) is an increase in ozone, peaking to about 20 per cent at 10 km. Above 25 km, the effect is one of depletion by about 20 per cent at 40 km.

Assuming we are indeed having a decrease in the ozone content due

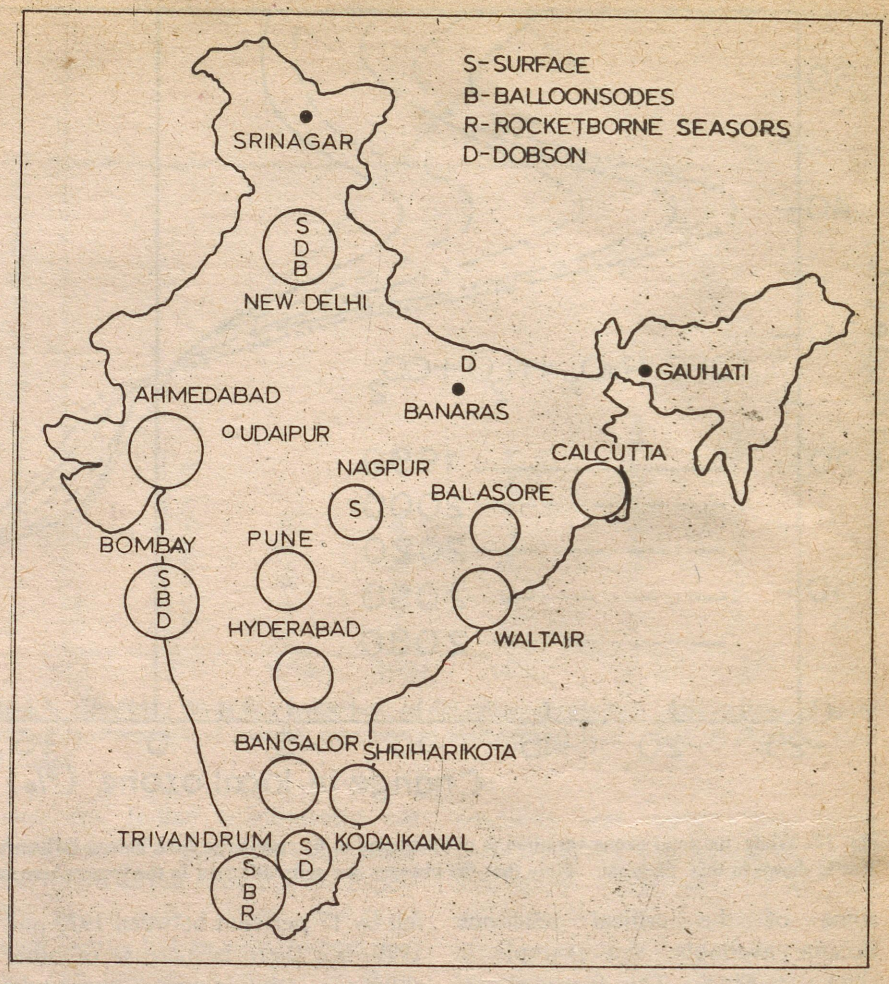

Fig. 12. The distribution of Indian ozone stations are shown. There are four kinds of measurements; measurements of surface ozone, use of Dobson spectrophotometer, sensors flown in balloons and those flown with rockets. These are indicated

to aerosols, what are really the consequences. Firstly, this means exposure to increased UV-B radiation. The increase is nonlinear and highly dependent on wavelengths. The shorter the wavelength, the more severe is the biological effect. For a 10 per cent change in ozone the increase in UV-B radiation is from 16 to 30 per cent depending upon season and latitude. One must remember, however, that at any location the UV-dosage depends normally on the ozone content, but on a number of other factors. One formula for this dosage is given in Fig. 11.

There are two types of skin cancer. The first type, non-melanoma, is not fatal. It is found principally in older people and probably indicates the effect of cumulative exposure over a number of years. The other type (melanoma) has fatal consequences. Statistical studies in the West have shown that the incidence of skin cancer is a strong function of latitude and for every 8° decrease in latitude there is doubling of the incidence of non-melanoma skin cancer. It is clear now that erythema (the reddening of

Relative Annual Damaging UV Radiation

$$= D$$

$$= D_r \times D_L \times D_h \times D_c \times D_A \times D_B$$

OZONE CONTENT	LATITUDE	HEIGHT	AVERAGE CLOUD	ALBEDO	AMOUNT OF AEROSOLS

Fig. 11

Table 6. Changes in trace species and climatic consequences

Year	Mixing ratio by volume					Ozone content change	Global warming	
	CO_2 (ppm)	CH_4 (ppm)	N_2O (ppm)	F11 (ppb)	F12 (ppb)		CO_2 Alone	CO_2+ Other gases
1940	300	1.4	0.3	0	0			
1975	330	1.5	0.3	0.1	0.17	+ 1		
2025	(500)	(2.1)	(0.45)	(0.5)	(0.8)	— 6.4		
2050	(600)	(3.3)	(0.7)	(0.7)	(1.5)	— 6.5	+2.0°C	+3.6°C

the skin by sunburn) is the visible evidence of skin burn that ultimately leads to skin cancer. However, the response of the human skin to radiation depends on many other factors : pigmentation, age, sex, location, clothing, life style, etc., and perhaps also to genetic characteristics. Nevertheless, as a crude estimate, there would be an increase of 100 per cent in incidence of skin cancer from a 25 per cent reduction in ozone.

The increased UV radiation also affects plant life. Animals can reduce exposure of their living cells to sunlight through protective body covering and behavioural responses. Most plants, on the other hand, have specially evolved to expose their tissues to sunlight. Thus for plants, increased UV radiation can be particularly damaging. Damaging effects have been observed in growth, composition and function including photosynthesis in a large variety of plants, including important crops such as soyabean. Of about 100 species monitored, approximately 20 per cent showed sensitivity to increased UV-B doses.

Perhaps the most important consequence of large-scale global depletion is possible climatic change. I must point out here that we are talking about climate, not of weather. There are several ways climatic changes may occur. Firstly, the fluorocarbons themselves are greenhouse molecules—this was first pointed out by an Indian scientist, V. Ramanathan of National Centre of Atmospheric Research, USA. He showed that a doubling of fluorocarbons will warm the globe by ½°C. This looks small, but in fact is a very important change, Secondly, ozone in the stratosphere and ozone in the troposphere affect climate differently. And this brings us to another aspect of ozone pollution—that of deforestation and other ecological changes in changing tropospheric ozones. The impression I have given you so far is that the only source of production of ozone is the sun. This is not entirely true. Methane is also a big producer, and methane is produced copiously by water-logged paddy fields and one may not believe it, by termites. Each molecule of methane can produce 2-3 molecules of ozone. However, this is so only if there are enough nitrogen oxides present. Forested regions abundantly produce nitrogen oxides. Thus deforestation has the extra affect of changing tropospheric ozone. And tropospheric ozone can substantially change radiation balance.

Reverting back to the climatic effect of ozone, we should remember that in the atmosphere there are several constituents of climatic interest—the one generally and most frequently referred to is CO_2, but others are CH_4, N_2O, and CFCs as well as ozone. Gradual global warming with time is the combined effect of all these constituents and not of CO_2 alone. Trends of changes of these constituents during the last decade as well as predictions for the future are available. One such calculation is given in Table 6. While the estimated global warming by 2050 A.D. by CO_2 alone is 2°C, if we are to consider the increases in the other constituents by that time, the resultant warming is 3.6°C, i.e., 80% larger.

What are we doing about all this in India? The India Meteorological Department has for years measured ozone at several places (Fig.12). There has been a good deal of intensification of this work recently. We have examined all these and have come up with what we call a Reference Ozonosphere over India. So we know what an unperturbed ozonosphere looks like over India. We have also set up about a year ago an equipment that directly monitors solar ultraviolet radiation continuously at wavelengths which are biologically damaging. This should give us evidence of any long-term change in this radiation. We plan to put such equipment at different locations. We should put one at a very low latitude—perhaps at Trivandrum. The erythemal dosage is two times larger at Trivandrum than at Delhi. There is some work on changes in skin pigmentation and on desert plants, and work on changes in photosynthesis rate is beginning. Whether or not large-scale changes of tropospheric ozone due to deforestation affect monsoon systems has not been examined. It is not unlikely. All this will be examined in great detail in a forthcoming international programme called MAP (short for Middle Atmospheric Programme) in which India is a major participant. One point we must remember is that near the equator the protective ozone thickness has a relatively stable minimum value and the noontime elevation angle of the sun is high and thus erythemal dose at UV-B is high. We in India are thus particularly vulnerable to large-scale ozone changes.

ELECTRICITY FROM THE WIND

Today's wind energy conversion systems can generate upto 5 megawatts of pollution-free, clean power, and the resource is almost limitless

S. G. VOMBATKERE

THE energy that is in the wind has been recognised by Man since time immemorial by its effects upon his environment. It was only relatively recently that he has taken steps to harness some of that energy for his benefit. The earliest known use of wind energy was for the propulsion of boats and ships using sails.

Another common use of wind energy was the windmill used to grind corn and lift water. In these machines, the energy of the wind was converted into a rotary motion which provided a stationary source of power.

Sources of energy and some comparisons

Wind energy is actually an offshoot of solar energy—it is indirect solar energy since the differential heating of earth's surface by the sun causes convection currents and winds on a global scale. Likewise fossil fuels are solar energy locked in over the millennia in sub-surface geochemical substances. Geothermal and ocean-wave energies are also basically solar in origin. Tides are caused by the gravitational effects of the sun and the moon and result in the periodical movement of large masses of water. Nuclear energy has its origin in the radioactive behaviour of certain elements. Presently, techniques are available for the generation of power only by nuclear fission; the process of nuclear fusion has vastly greater potential but requires containment at very high temperatures and pressures to initiate and maintain the fusion process, and is beyond the capabilities of today's technology.

A comparison of the various sources of energy is presented in Table 1. An important factor to be considered in the choice among various sources is their effect upon the global ecosystem. It is well-known that fossil fuels are the greatest polluters of the atmosphere.

In recent years, the increasing use of motor-cars and diesel-driven vehicles and power stations using coal or oil has discharged millions of tonnes of carbon dioxide and other noxious gases into the atmosphere. The simultaneous widespread deforestation has reduced earth's capacity to convert CO_2 into oxygen by photosynthesis and a net increase in atmospheric CO_2 is suspected, with attendant global effects upon the polar ice-caps and wind and weather patterns. It is therefore important to consider the development of energy sources that cause the least damage to the ecosystem; and wind energy is one such source.

Nuclear energy is a virtually inexhaustible source but causes severe environmental problems by the thermal pollution of large bodies of water and the disposal of nuclear wastes. Typically, 68% of the reactor heat is rejected as waste heat into the cooling waters while low-level radioactive materials with half-lifes of around 10 years are discharged into the atmosphere and the cooling waters. The effect of this upon the ecosystem has not been assessed nor has the disposal of 'high-level' radioactive wastes or the demolition of 'dead' reactors been considered even in the advanced countries.

The sun pours an unbelievable quantity of energy upon the earth—the absorbed power is of the order of 10^{18} kWh per year. Of this, approximately 2×10^{17} kWh/year is converted into wind power. But like the other 'low-grade' energies such as solar, tidal and ocean-thermal energies, it is difficult to store wind energy or to convert it into an easily transmissible form.

The uses of wind power being tried out at present include propulsion, lifting of water as an energy-storage scheme or for irrigation. and small-scale generation of electrical power. The possibility of saving conventional fuels in the propulsion of large ocean-liners by using sails is being explored.

Lt. Col. Vombatkere is in Indian Army Corps of Engineers, at Chief Engineer's Office, South Zone, Island Grounds, Madras 600 009

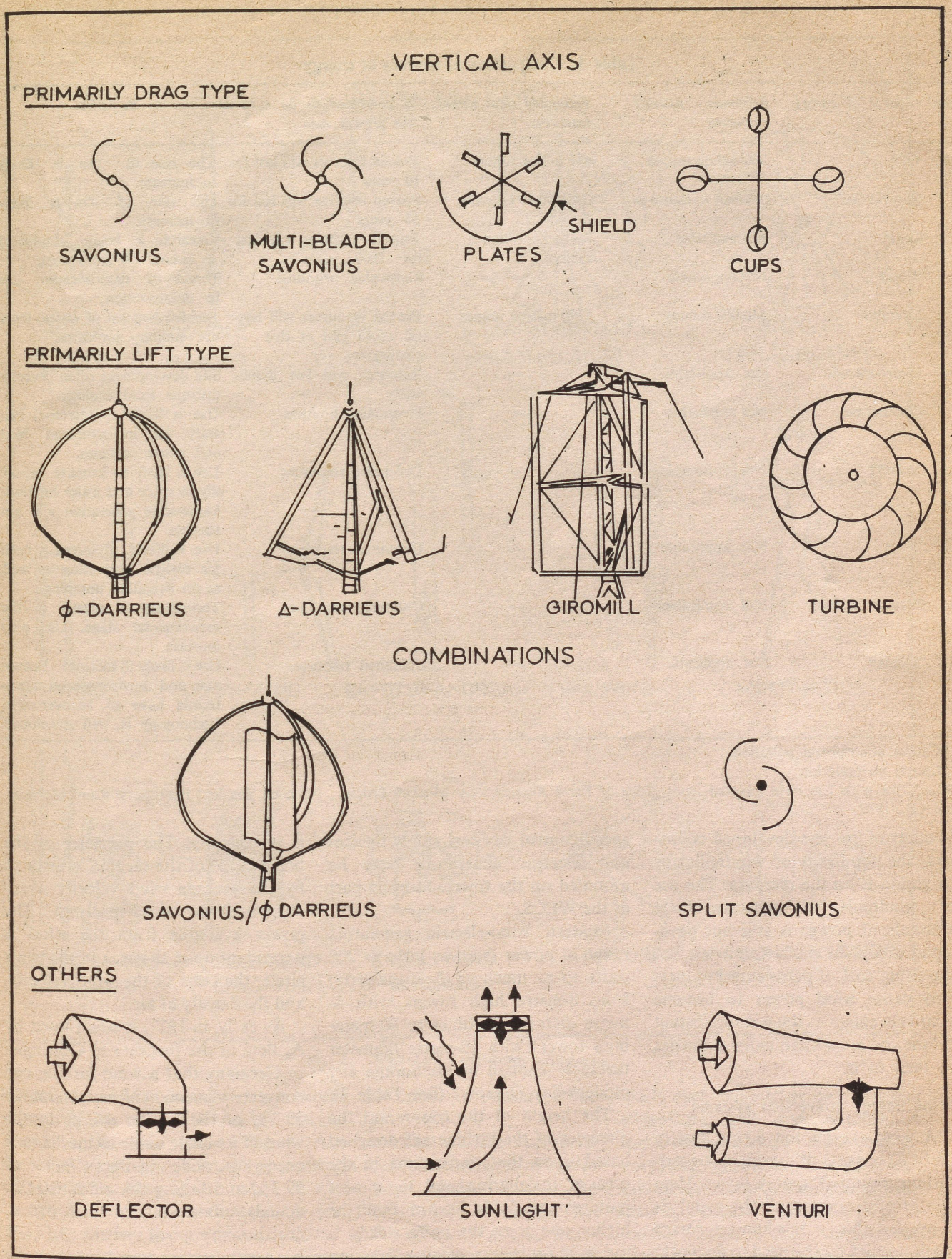

Fig. 1. Wind energy conversion systems

Table 1. Comparison of sources of energy

No.	Source of energy	Reasonably assured resources	Estimated total global resources	If continued to be used at the present rate	Remarks
1.	Oil*	360 billion tonnes	448 billion tonnes	Proved reserves will last for 30 years	The rate of use is likely to increase.
2	Natural Gas	Difficult to estimate	Difficult to estimate	Proved reserves will last for 53 years	The rate of use is likely to increase.
3	Coal*	Not available	7.6 to 12 trillion tonnes	Proved reserves will last for 1800 years	Research is being conducted to extract oil from coal.
4	Wood	Not applicable	—	Renewable resource	Threat of desertification due to deforestation.
5	Uranium	540,000 tonnes	4290 million tonnes	Proved resources will last till about end of this century	Besides disposal of waste, there are military problems.
6	Hydro-electric	Not applicable	—	Resource will last indefinitely	Site development often severely disrupts local ecology.
7	Geothermal	Not applicable	—	Potentially limitless	Use is likely to increase. Primary use in combined heat and power schemes.
8	Solar**	Not applicable	—	Unlimited resources	Use is likely to increase especially in space and water heating. Large-scale generation not yet feasible.
9	Wind	Not applicable	—	Unlimited resources	Use is likely to increase both for electric generation as well as for irrigation pumping.
10	Waves**	Not applicable	—	Unlimited resources	Technology is mostly in the experimental stage. Use may increase
11.	Tidal**	Not applicable	—	Unlimited resources	Use is likely to increase. Economic and Environmental constraints have to be overcome. Technology is well developed.

*Causes atmospheric pollution.
**Causes no pollution.
Note: This table has been adapted from *Atlas of Earth Resources* by Mitchell Beazley; Mitchell Beazley; Publishers: Rand McNally and Co., 1979.

In many of the less-developed countries, the popularity of windmills for irrigation is on the increase. The use of windmills to generate large amounts of power is still not developed except in a few countries, but the rising cost of petroleum products may cause wind power to become relatively cheap in the not too distant future and encourage more countries to turn to it.

Wind energy conversion systems

A wind energy conversion system (WECS) consists primarily of a wind-turbine mounted upon a tower. Here the kinetic energy of the wind is converted into a mechanical rotary motion which can be used to do work. Equipments such as gear-boxes, speed-control devices, safety devices and electric generators may be mounted on the tower, forming part of the WECS.

Modern wind-electric generators range in power from as little as 200 watts to as much as 5 megawatts; from 8-metre high towers with 5-metre diameter turbines to 60-metre high towers with 60-metre diameter turbines—enough to discourage any modern-day Quixote! (See Table 2).

The height of the tower and the diameter of the turbine are designed based upon the wind-regime in the area of installation and the power requirement. It is known that the higher one goes, the more steady is the wind (gustiness being a function of surface-roughness) and the greater is its velocity. The diameter of the blade circle of the turbine is dictated by the average wind velocity available and the wind-spectrum. The power available from the wind is dependant upon the area of the blade circle, the cube of the wind velocity, and the density of air.

As early as 1927, it was shown by A. Betz of the Institute of Gottingen in Germany that a wind-turbine can convert a *theoretical* maximum of 59.3% of the kinetic energy in the wind in its blade circle to mechanical energy. Considering Betz's factor of 59.3% and taking the efficiencies of actual wind-turbines, their drives, gear-boxes, control systems and electric generators, an overall efficiency of about 40% is practical.

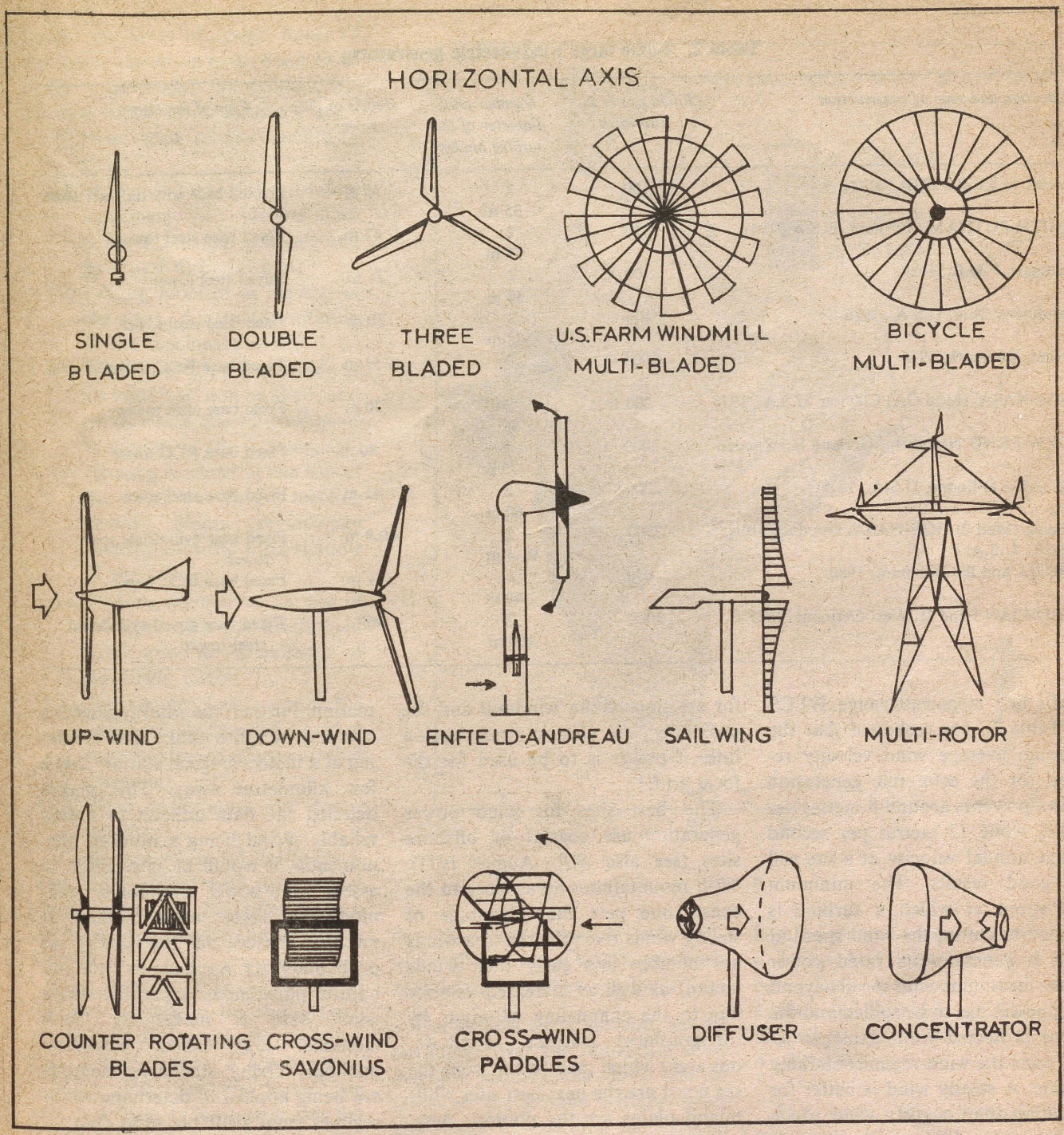

Fig. 2. Wind energy conversion systems

In practice, wind-turbine efficiency is measured by the ratio of the blade-tip speed to the wind speed. The aerodynamic behaviour of the turbine is very similar to that of the rotar blades of a helicopter. As in the case of helicopter blades, the product of the r.p.m. and the diameter in metres of the blade circle is kept below 6300 so that the blade-tip speed does not exceed the speed of sound in air (about 330 m/sec.).

Another effect of the 'tip-speed ratio' is seen in the number of blades used in large wind-turbines. The larger the number of blades, the lower is the efficiency due to interference of the rotating blades with the windstream. One-, two-, and three-bladed turbines are usually used; each have their own peculiar advantages and disadvantages. A single-bladed turbine causes counter-weighting problems; a two-bladed turbine eases counter-weighting problems but causes forces due to gyroscopic action; the three-bladed machine overcomes these problems but suffers from a lower efficiency.

P.C. Putnam, the designer of the

Table 2. Some large wind-electric generators

No. Location and year of construction	*Rated power in kilowatts*	*Number and diameter of the turbine blades*	*Height of the tower*	*Type of the tower*
1. Yalta, U.S.S.R., 1931	100	3 35 m	30 m	Pivoted base with inclined strut
2 SMITH-PUTNAM, Vermont, U.S.A., 1941	1250	2 53 m	42 m	Fixed base steel tower
3 Stuttgart, F.D.R., 1959	100	2 34 m	21 m	Guyed steel tower
4 Sandusky, Ohio, U.S.A., 1976	100	2 38 m	30 m	Fixed base steel tower
5 Tvind, Denmark, 1977	2000	3 54 m	53 m	Fixed base RCC tower
6 DOE-NASA, (Mod OA) Clayton, U.S.A., 1978	200	2 38 m	30 m	Fixed base steel tower
7 KMW-ERNO Näsudden, Gotland Is,. Sweden	2000	2 75 m	80 m	Fixed base RCC tower
8 GE (Mod 1) Boone, U.S.A., 1978	2000	2 60 m	41 m	Fixed base steel tower
9 Boeing (Mod 2) DOE-NASA, Goodnoe Hills, Wash., U.S.A.	2500	2 91.4 m	60.9 m	Fixed base cylindrical steel tower
10 Nibe (A and B), Denmark, 1980	630	3 40 m	41 m	Fixed base RCC tower
11 GROWIAN I and II, West Germany, 1981	3000	2 100 m	96	Fixed base guyed cylindrical steel tower

world's first megawatt range WECS (see Table 2), has reckoned that the minimum average wind velocity required for the economic generation of wind power is around 8 metres per second, while 12 metres per second average annual velocity at a site will give good results. The minimum wind speed at which a turbine is designed to cut-in, the wind speed at which it generates its rated power and the maximum wind speed beyond which power has to be spilled and the turbine protected from damage, depend upon the wind-regime obtaining at a site. A steady wind is better for generation than a gusty wind which may produce high but unusable peaks of wind power. The selection of a suitable site and the exact location of the turbine has to be carefully made based upon observations of wind velocity and duration (preferably continuously recorded) over a period of years. The selection of the site has to take into account local topographical features, vegetation density and type, ease of approach for erection of the windmill and the proximity of electric transmission lines if power is to be used for the local grid.

The best sites for wind power generation are coastal or offshore sites (see also *S.R.*, August 1971). With mountainous areas close to the coast, one gets the advantage of steady winds from the sea (sea-winds are notably less gusty then winds inland) as well as increased velocity due to the channeling of winds by topographical features. Mountainous areas which may be far from the sea coast are the next-best sites while inland plains are the poorest. Also, typically, temperate zones are better than the tropics for the purpose of usable and advantageous wind-regimes. Fig. 3 shows a wind map of India.

Unfortunately, the use of wind energy on a large-scale being still in its infancy, wind-observations for power generation are few and far-between and are either unreliable or unsuited to power-generation estimation. Further, the wind-regime of a site may be quite unlike that obtaining at a meteorological station only a few kilometres away. This makes detailed site data difficult to obtain reliably. Wind being a random phenomenon, it would be impossible to assess wind-power availability definitely and resort must be had to methods based on the theory of probability as applied to random natural phenomena, especially where wind data is inadequate. Such methods are called stochastic methods. Today, stochastic methods are being applied to determine wind-regimes from available wind data.

Design problems

WECSs today involve large loads aloft a tall tower. As a rough guide, the weight of the machinery aloft is about 110 kg per rated kilowatt. For a WECS of 2000 kW rated capacity, the weight of the machinery aloft will be of the order of 200 tonnes. Such a load of rotating machinery on the top of a high tower presents

special problems of design. Some of the loads which are to be assessed in order to determine the dynamic behaviour of the tower structure are:

(i) Dead load of the machinery aloft;

(ii) Dynamic load of the rotating machinery, i.e., turbine shaft at low r.p.m. and gear-box and generator at high r.p.m;

(iii) Rolling moment at the top of the tower due to the rotation of the machinery aloft;

(iv) Wind load upon the turbine as an axial load uon its shaft, and its variation due to wind gusts or change in the yaw-angle;

(v) Pitching moment at the top of the tower due to the rotating turbine blades periodically entering into the wind-shadow of the tower;

(vi) Pitching moment at the top of the tower due to variation of wind speed at the extremes of the blade circle;

(vii) Gyroscopic force upon the tower (in the case of 2-bladed turbines) due to change in wind direction;

(viii) Wind load upon the tower structure.

In the assessment of the loads it must be noted that wind is a random phenomenon and the rules of stochastic analysis have to be applied in each case.

Wind-turbines may be classified into two main types, viz., the vertical-axis and the horizontal-axis machines. Figs. 1 and 2 show a few types of WECSs. The Savonius rotor can have a vertical or horizontal axis but it suffers from a low efficiency. The Darrieus rotor is a vertical-axis machine which has good performance at high wind speeds but is not self-starting. The blades for a Darrieus rotor are curved aerofoil sections and their cost is therefore high. A combination of Savonius and Darrieus rotors has been proposed to overcome the starting problem of the latter. The propeller-type rotor is today the most common and well-tried, all the large WECS are horizontal-axis propeller machines.

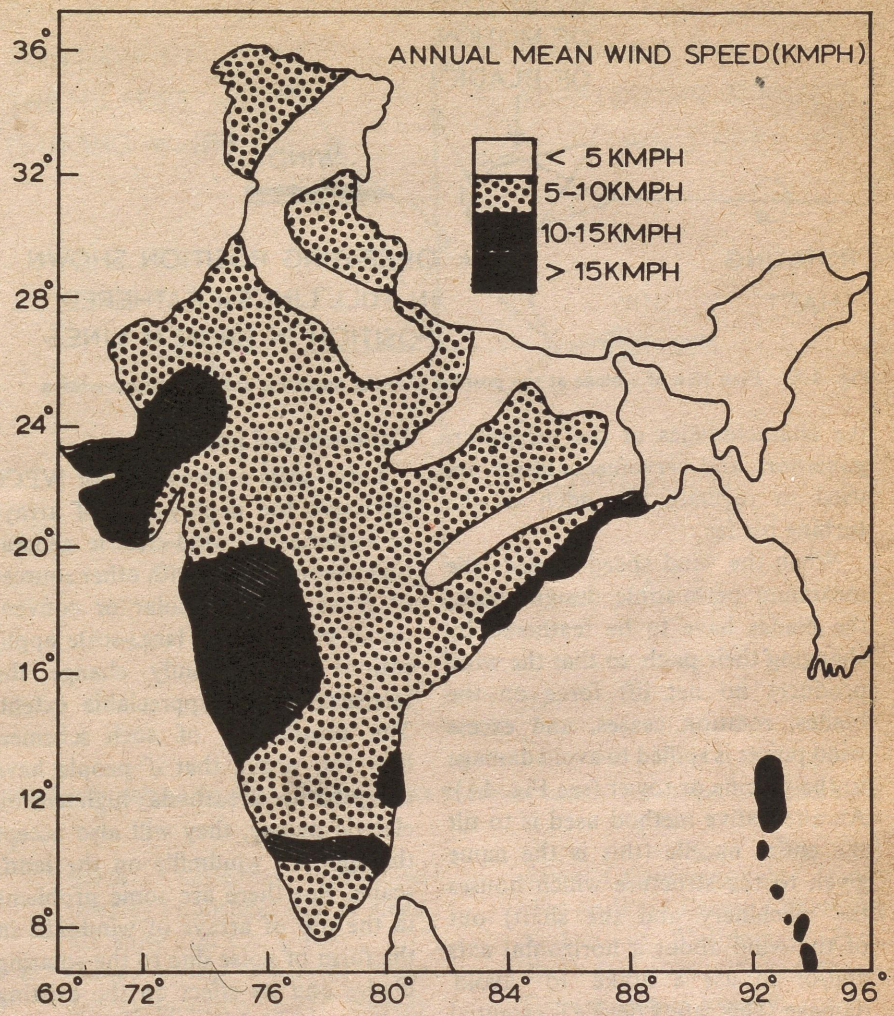

Fig. 3

The vertical shaft machine has an advantage over the horizontal shaft machine because the drive can be taken to the ground without gear-box losses encountered in changing the direction of rotation of a horizontal-axis machine. In order to overcome this problem, modern WECS carry the generator with the other machinery aloft and take electrical power to the ground using slip-rings.

The world's largest WECS is at Tvind in Denmark. This is a horizontal-axis machine on a 52.5 metre high reinforced concrete tower with a 3-bladed, 54-metre diameter turbine. Each blade weighs about 5 tonnes and is made of fibre-glass. Started in May 1978, it is rated at 4×10^6 kWh year.

The r.p.m. of a large-diameter wind-turbine is, of necessity, low. At the same time, efficient electric generators require a relatively high r.p.m. of the order of 1000 or so. A gear-box to raise the r.p.m. of the turbine shaft (which is typically about 40 r.p.m.) to match the generator requirements is interposed between the turbine and the generator. Since the turbine speed has to be maintained constant within certain limits due to

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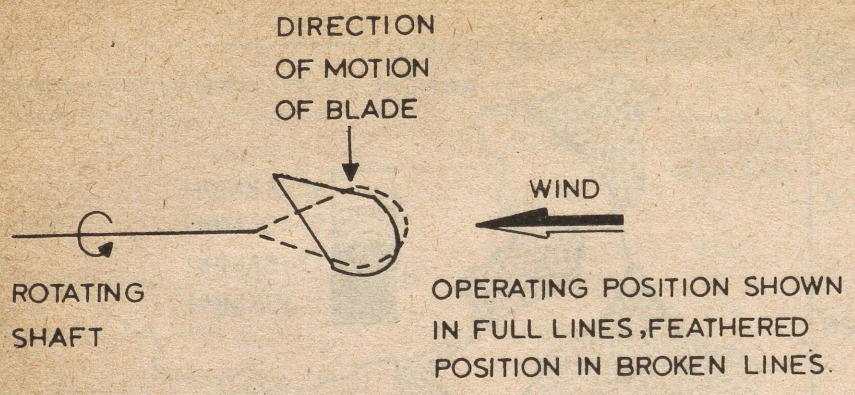

Fig. 4-A. Plan view of a blade at top position showing operating and feathered condition

the characteristics of the generator, governors and servomechanisms are used to regulate the pitch of the turbine blades.

When the wind speed exceeds the maximum permissible design speed, the blades have to be feathered by changing their pitch so that the wind produces no net lift force on the blades, rotation ceases, and excess wind power is spilled to avoid damage to the turbine or tower (see Fig. 4A). An alternative method used is to tilt the entire nacelle (this is the name given to the structure which houses the machinery and the shaft) out of the wind about a horizontal axis and/or to use a brake to avoid damage. This safety device is essential for protection against storms and cyclones.

Gusts of wind can have speeds which are several times the steady wind speed. These gusts can cause an increase of 10-20 times of the load upon the blade at its root. In order to reduce the stresses the blades may be allowed to 'cone', i.e., the blades are free to rotate to form a plane circle and with increases in wind velocity, from the curved surface of a cone (see Fig. 4B). Many WECS have the rotor mounted downwind of the tower so that coning can be allowed without an unduly long cantilevered shaft. The angle of coning which may be automatically adjusted to suit the wind velocity, also introduces a degree of stability in yaw to the windmill.

Environmental impact

Large-scale employment of WECS envisages the deployment of arrays or batteries of wind-electric generators in conjunction with other sources of power such as solar or conventional power. Such large-scale applications will certainly change the landscale to an appreciable extent. The proponents of such schemes, however, argue that if people have accepted the present day high tension electric pylons, they will also accept the sight of windmills on the landscape. But there are some problems in the use of arrays of windmills in the form of noise due to the rotating blades and its effect on the existing pattern of bird-life.

Man has always strived to obtain energy in various forms. Today, life for the majority of mankind has become heavily energy-dependent in one way or another and scientists and engineers are applying their knowledge and resources in their quest for the dream of cheap and plentiful power. But between the dream and the reality lie a myriad of complex technical, social, economic and environmental problems which put the inventiveness of the human mind to test. This is not a task solely for the scientist or the engineer but as much for the administrator, the economist and, most of all, for the common man.

Indian work

Some work has been done in India on the harnessing of wind energy. Considerable research work has been carried out at the National Aeronautical Laboratory (NAL), Bangalore. However, the accent has been on small machines meant primarily for direct use in pumping of ground water for agriculture. These are low-speed windmills of power less than 1 kW. The NP-2 windmill was developed by NAL during the early 1960's, with a 12-vane rotor 4.8 metres in diameter. A multipurpose machine (called MP-1) is being developed, using a 7.5 metres diameter rotor. Recently, some private firms have entered this field with foreign collaboration and are manufacturing small windmills for use as power source for isolated installations such as wireless repeaters, DF aids, etc. To date, work on large WECSs has been negligible.

Government has recently formed a high-level technical commission (Commission for Additional Sources of Energy or 'CASE') with the best of the country's men from the field of energy management in order to investigate and exploit the various sources of energy for the benefit of the community. Even though wind-regimes in India are not very favourable for large-scale electric power generation except in certain coastal and mountainous areas, the use of wind energy for direct pumping of water for irrigation is quite feasible. More research needs to be undertaken in this field to suit the available technology to Indian needs so that this valuable source of energy is not lost. Liberally misquoting the old saying, "It is a good wind that does no ill".

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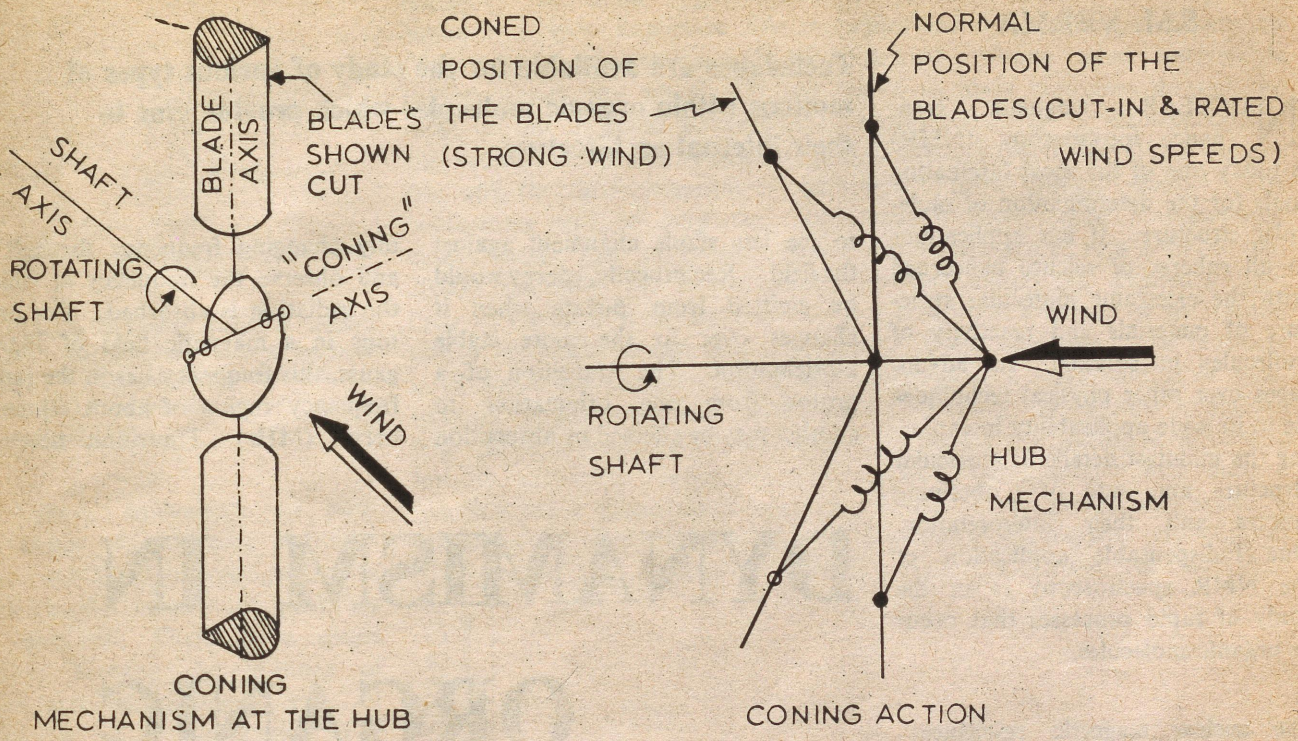

Fig. 4-B. To prevent the blades in the coned position from striking the tower, the shaft needs to project more for an upwind rotor than for a down wind rotor

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DYNAMISM IN ORGANIC MOLECULES

S.M. VERMA

Techniques are available for the study of various types of motions within organic molecules which provide clue to their internal architecture

NUCLEAR magnetic resonance spectroscopy (NMR) is today one of the most fascinating tools for the determination of molecular structure. It has applications in all spheres of science concerned with the electronic molecular structure of materials and reactivity of molecules in solution. Its advantages over other physical techniques lie in its wide applicability in exploring the minutest details of molecular structure and ease of obtaining spectra and their interpretation. One indispensable application of the NMR spectroscopy is in the study of rapid processes that occur in organic molecules.

The nuclear magnetic resonance spectrum

Nuclei of certain atoms are known to possess a mechanical spin or angular momentum. A spinning nucleus may be considered as a tiny bar magnet. When placed in a uniform magnetic field, it would assume (2I+1) discrete orientations where I represents the spin quantum number. Some of the nuclei which have been employed for resonance studies are ^{1}H, ^{13}C, ^{19}F and ^{31}P; all of them possess a spin value of $\frac{1}{2}$ resulting in two orientations in a magnetic field. One of these nuclei with which organic chemists are mostly concerned, is the proton (^{1}H), the nucleus of ordinary hydrogen.

In a strong magnetic field, these nuclei can be aligned in either of the two ways—with or against the external magnetic field (α and β orientations, Fig. 1). Alignment with the magnetic field (α-state) is more stable, i.e., it is a lower energy state and energy must be supplied to flip the tiny proton magnet over to the less stable alignment against the field. Reciprocally, energy would be emitted from β-state when it changes over to the more stable α-orientation. The transition of a proton from one orientation to another may be effected by absorption or emission of a discrete amount of energy and this flipping process is known as resonance.

The difference in the energy ($\triangle E$) between the two states is proportional to the applied magnetic field (H_0) and is given by the expression,

$$E = \frac{\nu h H_0}{2}$$, where h is Planck's constant and ν is the gyromagnetic ratio, a constant characteristic of a partcular nucleus. $\triangle E$ is related to the frequency ν at which a particular proton resonates by the equation

$$\Delta E = h\upsilon. \quad \text{Hence, } \upsilon = \frac{\gamma H_0}{2\pi}.$$

In principle we could place a substance in a magnetic field of constant strength and pass radiation of steadily changing frequency through it and observe the frequency at which the radiation is absorbed. For protons in a magnetic field of 14,000 gauss, this frequency lies in the radio frequency region of about 60 mega hertz (MHz). Transition between the energy levels is also possible by keeping the frequency constant and varying the magnetic field over a small range.

In an organic molecule, some hydrogen nuclei happen to be in regions of greater electron density than others. As a result these protons absorb at slightly different frequencies (or at different magnetic field strengths). The exact frequency or the field strength at which a proton resonates depends upon the magnetic environment of that proton. In NMR spectrometer the resonance frequencies are amplified and displayed as a signal (a peak or a series of peaks) on a strip of calibrated chart paper (Fig. 2). The position of the signal is characteristic of the type of hydrogen atom in the molecule.

Dr. Verma is Prof of Organic Chemistry at Banaras Hindu University, Varanasi-221005.

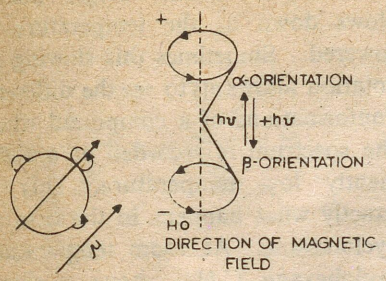

Fig 1. (*Left*) **Sponsoring charge in nucleus generates a magnetic field with a magnetic moment, μ, directed along the axis of spin;** (*Right*) **Two orientations of a nucleus in a magnetic field**

Magnetic equivalence or non-equivalence of hydrogens is fundamental in NMR spectroscopy because it affects the number of peaks in the spectrum. There is a direct relation between the number of peaks and the different types of hydrogens in a compound. For example, acetone (CH_3COCH_3) has all the six protons equivalent and only one signal is observed. p-xylene (CH_3-C_6H_4-CH_3) has two types of hydrogen and the compound displays two peaks in its NMR spectrum (Fig. 3).

Rate processes in organic molecules and NMR spectra

The total energy of a molecule is directly related to its geometry. For example, in ethane, C_2H_6, the molecule will adopt the minimum energy geometry available to it by rotation about the single C-C bond. The various geometries a given molecule can attain by bond rotation are called 'Conformations'. Rotational processes are best interpreted in terms of energy, and usually a molecule has more than one minimum energy geometry which are stable and interconvertible (for example, the staggered conformations *anti* and *gauche* of *n*-butane are shown in Fig. 4). The excess energy of the transition over that of one of stable conformers is known as energy of activation ($\triangle E$) which assumes a very important role in the rotational phenomena. If $\triangle E$ is very small, say about 400 cal/mole or less at room temperature, the rotation is said to be absolutely free and the interconversion of the conformers will be very fast. In cases where $\triangle E$ is greater than 20,000 cal/mole (20 K cal/mole), then at room temperature the rotation is practically frozen out; if $\triangle E$ is of some intermediate values, the rotation would be neither completely free nor completely frozen out but is restricted. Some of the common rapid processes in organic molecules are shown in Fig. 5.

Professor J.D. Roberts of California Institute of Technology has described the NMR spectrometer as unusual among other instruments used to study molecules through the absorption of electromagnetic radiation in that it acts like a camera with a slow shutter speed. The 'shutter speed' here is commonly about the same as in a conventional camera having an exposure time of a 100th of a second or so. When the NMR spectrum of a molecule undergoing a rapid motion or reaction is taken, the result is something like taking the picture of a turning spoked wheel with a box camera. If the wheel turns only once a minute, a photograph at 100th of a second will show the individual

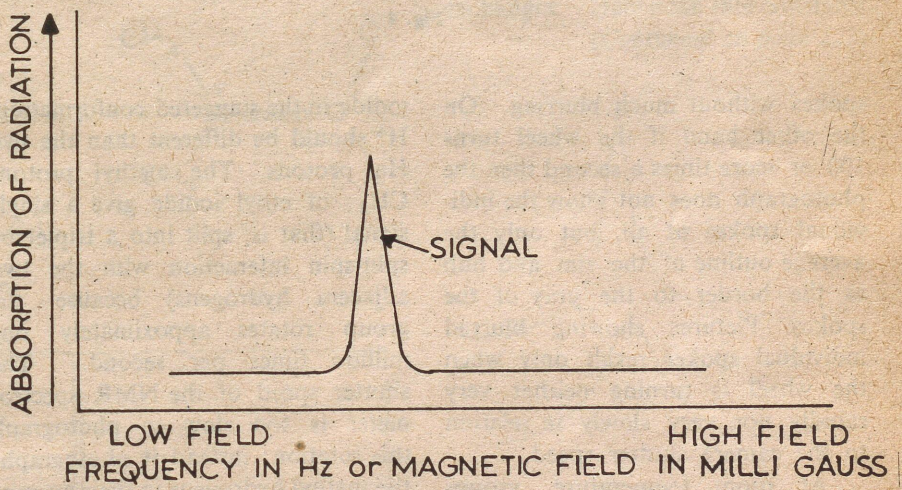

Fig. 2

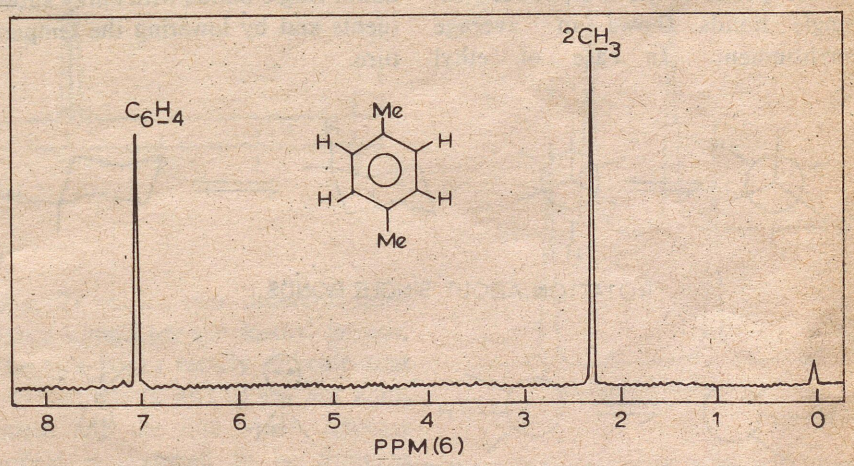

Fig. 3

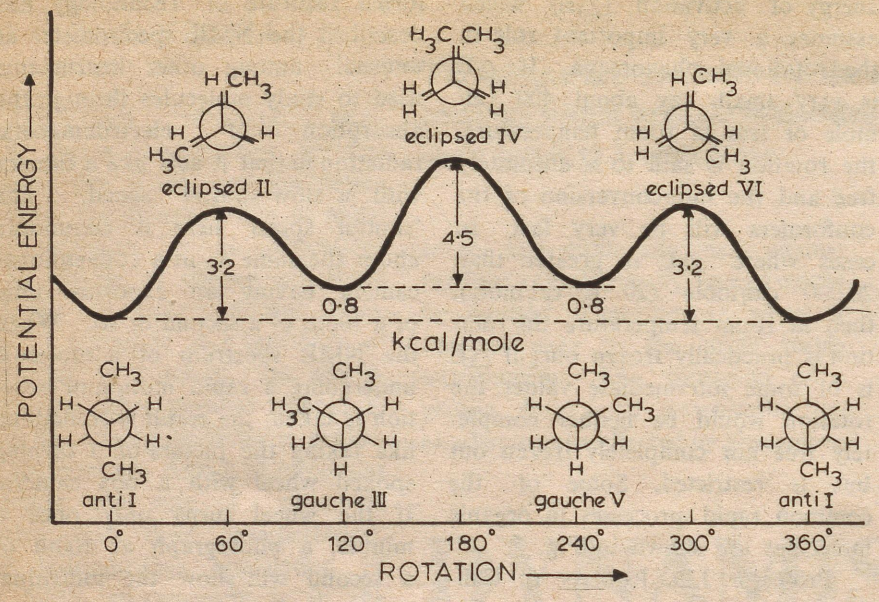

Fig. 4

spokes without much blurring. On the other hand if the wheel turns 100 or more times a second then the photograph does not show the individual spokes at all, but only the average outline of the rim and hub as the border to the gray of the spokes. Pictures showing blurred individual spokes result only when the wheel is turning neither very rapidly nor very slowly in relation to the camera shutter speed.

At room temperature groups connected by carbon-carbon single bonds rotate very rapidly and the NMR spectra of the compounds with single bonds shows an average environment. In case of ethyl iodide in the staggered conformation, H* should be different than the two Ha protons. The methyl protons CH_3, of ethyl iodide give a single signal (that is, split into a triplet by spin-spin interaction with the two adjacent hydrogens) because the group rotates appoximately one million times per second. The shutter speed of the NMR spectrometer is too slow to photograph this rotation; instead it photographs the methyl hydrogens in their average environments. However, it is possible to slow down the rotation about single bonds with bulky substituents and by lowering the temperature.

Rotation about single bonds slows down as the temperature is lowered. Sometimes this slowing of rotation allows us to see the different conformations of a compound when the spectrum is recorded at a sufficiently low temperature. This is exactly what happens in the case of cyclohexane. At room temperature cyclohexane C_6H_{12} shows a single signal indicating that all the twelve protons are equivalent, but below $-67°C$ two sets of absorption bands are observed, one for axial and the other for equatorial protons. In this way it has been possible to estimate that for cyclohexane, the rate of chair-chair interconversion is about 130 times per second at $-67°C$ and about 160,000 times per second at 25°C.

When the barrier hindering rotation is a formal covalent double bond as in case of methyl styrene, the isomers can be isolated as *cis* and *trans* isomers of olefins. The two hydrogen atoms Ha and Hb show two resonance signals in both the isomers of $C_6H_5CH=CHCH_3$ which are characteristic of the *cis* and *trans* configuration.

When the rate of rotation about a single bond is intermediate between that of rotation about a single bond and of severely hindred rotation about formal double bonds, the NMR spectrum usually consists of a superposition of spectra resulting from two or more rotational isomers that are present in equilibrium.

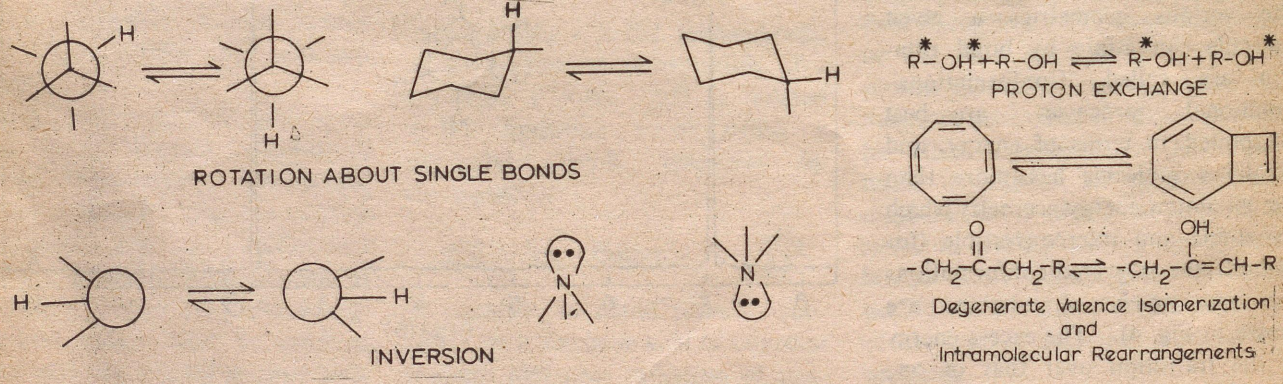

Fig. 5

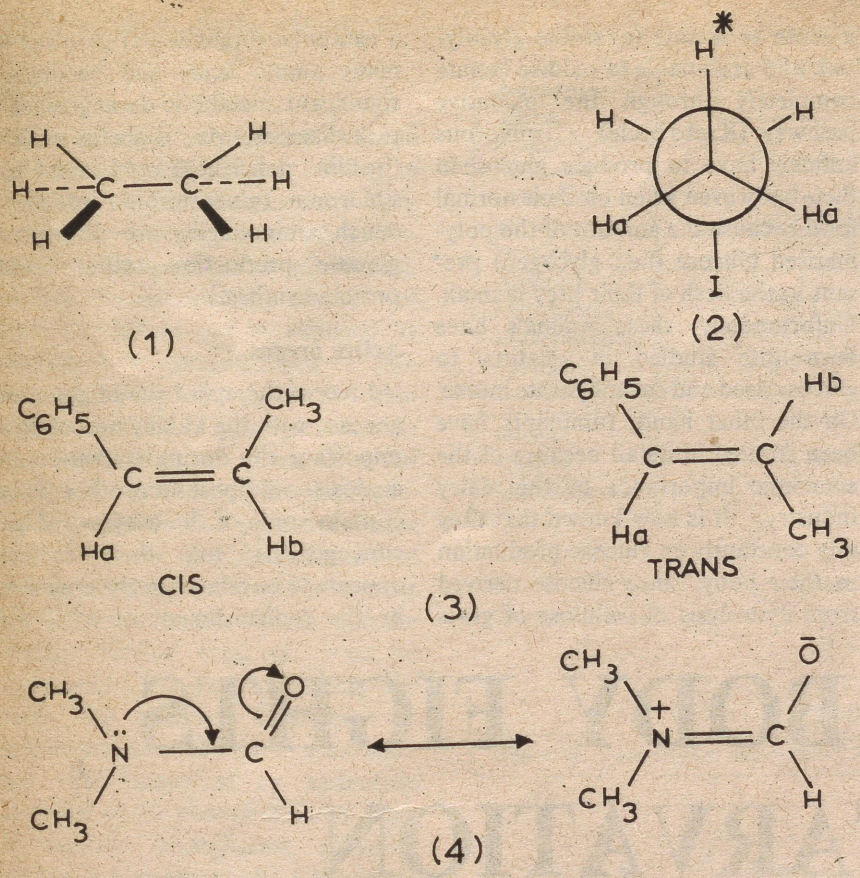

Fig. 6

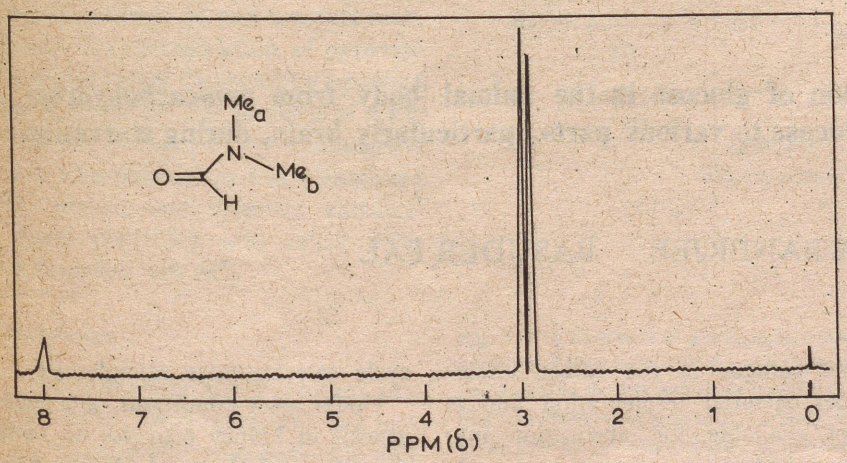

Fig. 7

One of the most thoroughly investigated examples of this phenomenon is the hindered rotation about C-N bond in simple amides. Resonance theory predicts that this bond has considerable double bond character.

The spectrum of N, N-dimethyl formamide at room temperature (Fig. 7) shows two different resonance signals for the methyl groups. The two peaks clearly indicate that two methyls (a and b) are not equivalent and the one which appears upfield is assumed to be *trans* to the formyl proton. When the temperature is raised, the rotation about C-N bond increases and the two signals start approaching each other. The variable temperature NMR spectrum (Fig. 8) shows that the two N-methyl signals are separated by 10Hz at 30°C, 6Hz at 92°C and 4Hz at 109°C and coalesce at 111°C to a single absorption signal. At elevated temperatures, the methyl groups become magnetically equivalent because of rapid rotation about the C-N bond. The energy barrier determined about this bond at room temperature is about 21 Kcal/mole.

The rate of collapse of the signals of chemically equivalent protons in different conformations with temperature is a measure of the involved energy barriers to conformational exchanges. Hence the rate constants

(*Continued on page 122*)

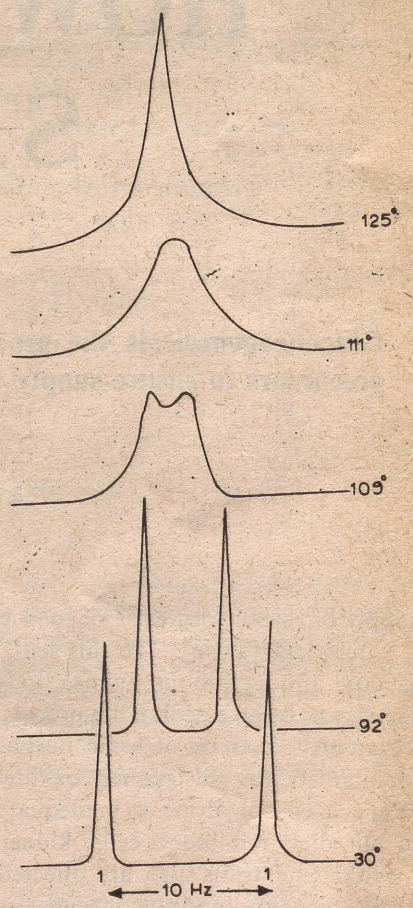

Fig. 8. Behaviour of N, N-dimethyl signals of N, N-dimethyl formamide at different temperatures

HOW BODY FIGHTS STARVATION

Gluconeogenesis is the production of glucose in the animal body from non-carbohydrate precursors to ensure supply of glucose to various parts, particularly brain, during starvation

SANTA BANERJEE BASUDEB PAL

IT is well-known that animals depend upon plants for their supply of carbohydrates in food. Plants make carbohydrates from carbon dioxide and water through a process known as photosynthesis. Surprisingly enough, there are situations in which animals too can make carbohydrates in their body. The production of glucose in the animal body from non-carbohydrate precursors is called gluconeogenesis. Depending upon the situation, it represents an important metabolic adaptation or a metabolic aberration.

The principal metabolic fuel of the brain is glucose. Gluconeogenesis ensures glucose supply to this vital organ during a short dietary supply of carbohydrates or of food as a whole (starvation). In this sense, glucose production in animal body appears to be an essential life process, because the activity of brain must be maintained for sustenance of life. When a carbohydrate is inadequate in our diet, red blood cells, kidney medulla and testis also are affected as they depend upon gluconeogenesis for their energy. These tissues derive their energy from conversion of glucose to lactate (anerobic glycolysis), and are unable to oxidise lactate completely through the oxidative pathway (Krebs cycle). Carnivorous animals have to produce glucose in their body even when on their normal food because the amount of the polymerised glucose (i.e., glycogen) present in the flesh of their prey is small. Unfortunately, these animals have been little studied in relation to glucose need and carbohydrate intake. On the other hand, ruminants have been studied in detail because of the economic importance of the dairy industry. It is now known that they rely constantly on glucose production in their body, since glucose derived from hydrolysis of cellulose of grass and forages in the rumen undergoes bacterial fermentation and is not available for absorption into the blood.

Gluconeogenesis is involved in a major way in the disposal of (i) lactate produced by muscle during exercise, (ii) glycerol during fat mobilisation as occurs in starvation and slimming, and (iii) 2-oxoglutarate produced by the kidney in metabolic acidosis. It also represents a catabolic (breakdown) pathway for many amino acids and becomes a significant metabolic derangement in two diseases, viz., diabetes mellitus (insulin deficiency) and Cushing's syndrome (glucosteroid excess), in which amino acids are diverted to glucose production rather than protein synthesis.

Active organs

Liver is the major site of gluconeogenesis, with the kidney becoming an important site during starvation and acidosis. Adipose and other tissues contain some of the enzymes of gluconeogenesis, but their function appears to be related to glycerogenesis or the replenishment of citric acid cycle intermediates (anaplerosis).

Under most conditions, gluconeogenesis in kidney provides no more than 20% of the total glucose produced. During prolonged starvation, however, renal gluconeogenesis increases and liver gluconeogenesis decreases with the result that the kidney and the liver contribute almost equally to glucose production. Metabolic acidosis is probably the major factor in increasing renal

Smt. Banerjee is Research Fellow in the Deptt. of Biochemistry, School of Tropical Medicine, Calcutta 700073, Dr. Pal is Prof. and Head, Deptt. of Biochemistry at the same School.

gluconeogenesis during starvation.

Pathway

The pathway for glucose formation in liver is shown in Fig. 1. Many of the gluconeogenic reactions are identical to those of glycolysis; such reactions are always close to equilibrium so that the rate and the direction of flow of residues can be changed by variations in concentrations of substrates and/or products. On the other hand, reactions of glycolysis that are non-equilibrium, i.e., those catalysed by hexokinase (HK), phosphofructotokinase (PFK) and pyruvate kinase (PK) release a considerable amount of energy as heat and therefore cannot be easily reversed. These specific 'energy barrier' reactions must be bypassed in the gluconeogenic pathway. The reactions catalysed by hexokinase and phosphofructokinase are both bypassed by hydrolytic cleavage of the phosphate ester bond by specific phosphatase enzymes, glucose-6-phosphatase (G-6-Pase) and fructose diaphosphatase (FDPase), respectively. The pyruvate kinase bypass consists of two separate reactions—(a) carboxylation of pyruvate to oxaloacetate catalysed by pyruvate carboxylase (PC) in presence of ATP, and (b) conversion of oxaloacetate into phosphoenol-pyruvate catalysed by phosphoenol-pyruvate carboxykinase (PEPCK), also called PEP-carboxylase (PEPC).

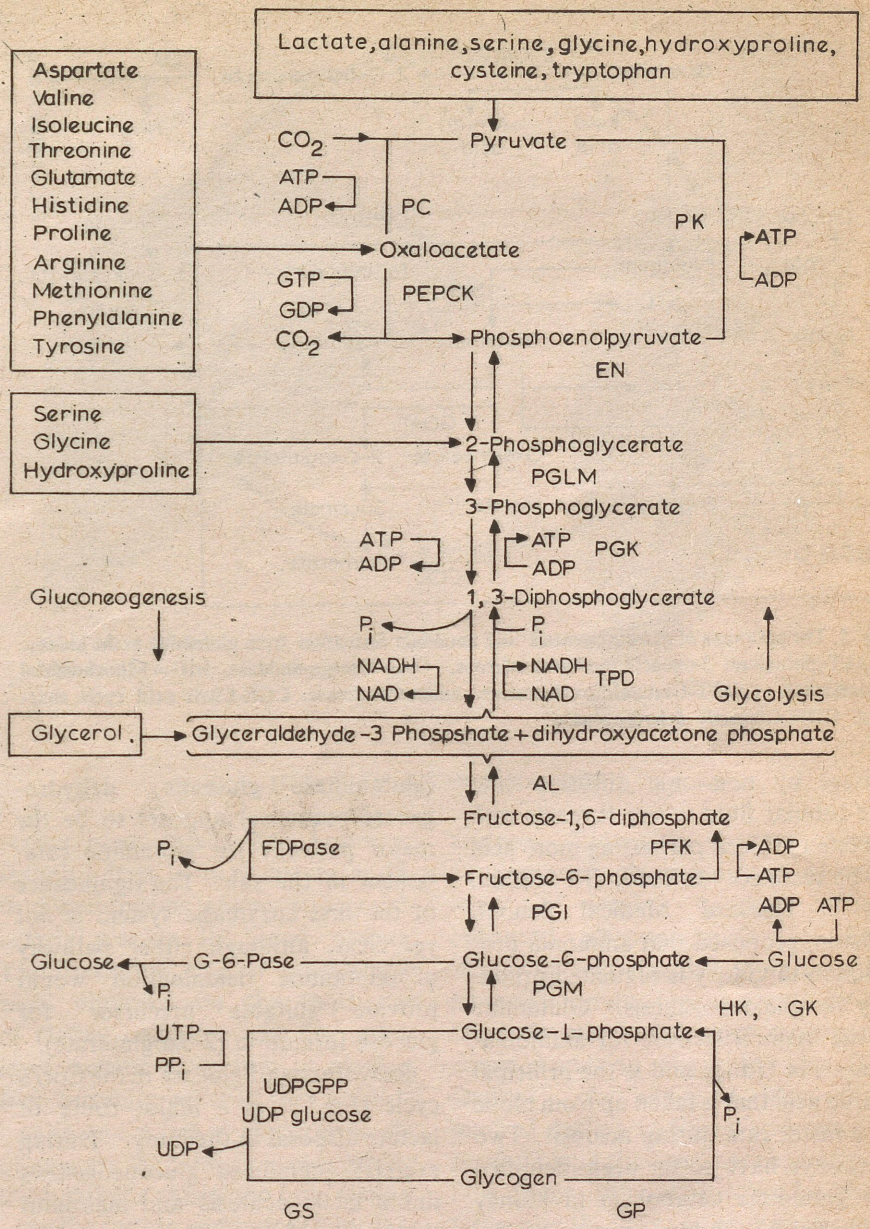

Fig. 1. The pathways of gluconeogenesis and glycolysis. The reactions common to gluconeogenesis and glycolysis are shown by arrows in the centre; reactions specific to gluconeogenesis are shown on the left and those specific to glycolysis on the right. PC-Pyruvate carboxylase, PEPCK-Phosphoenolpyruvate carboxykinase, EN-Enolase, PGLM-Phosphoglyceromutase, PGK- Phosphoglycerate kinase, TPD-triosephosphate dehydrogenase, AL-Aldolase, FSPase-Fructose diphosphatase, PGI-Phosphoglucoisomerase, G-6-Pase- Gluocose 6-phosphatase, PGM-Phosphoglucomutase, UDPGPP-Uridine diphosphoglucose pyrophosphorylase, GS-Glycogen synthetase, GP-Glycogen phosphatase, HK-Hexokinase, GK-Glucokinase, PFK-Phosphofructokinase, PK-Pyruvate kinase

Precursors

Quantitatively, the important precursors to gluconeogenesis are lactate, glycerol and gluconeogenic amino acids. Lactate is converted into pyruvate by lactic dehydrogenase and enters the gluconeogenic pathway at pyruvate carboxylase. Glycerol enters the pathway by phosphorylation to glycerol phosphate and oxidation to dihydroxyacetone phosphate, catalysed by glycerol kinase and glycerol phosphate dehydrogenase respectively. In 1964, H.A. Krebs reviewed the available evidence and concluded that all amino acids except leucine can give rise to gluconeogenic precursors. The entry points of the amino acids in the gluconeogenic pathway are shown in Fig. 1.

It has long been known that the amount of ammonia in urine increases when urine is more acidic. Ammonia produced by the renal tubular cells

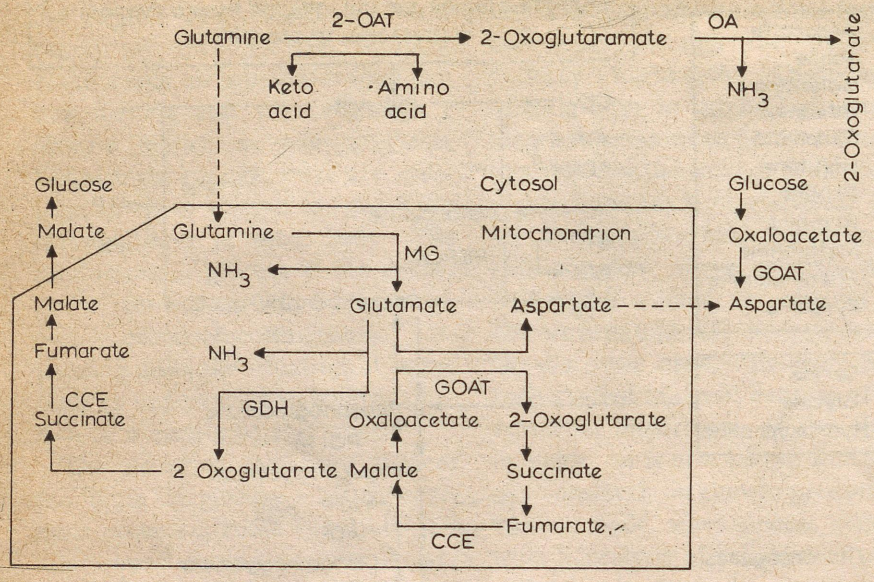

Fig. 2. The pathways of gluconeogenesis and ammonia formation from glutamine in the kidney. 2-OAT-glutamine: 2-oxoacid aminotransferase, OA=Omega-amidase, MG=Mitochondrial glutaminase, GOAT-Glutamic oxaloacetate aminotransferase, CGE-Citric acid cycle enzymes, GDH-Glutamic dehydrogenase

passes by non-ionic diffusion into the tubular fluid where it reacts with secreted H^+ ions permitting more acid to be secreted. In 1966, G.F. Cahill, Jr. of Harvard Medical School, Boston, proposed that ammonia production in kidney is regulated primarily by gluconeogenesis. Glutamine is the major substrate for ammoniagenesis in kidney and is the principal amino acid that is taken up from blood at a faster rate during acidosis. Two pathways have so far been identified for glutamine catabolism in kidney (Fig. 2): (a) Glutamine may be deaminated via a cytoplasmic system involving transamination, catalysed by glutamine: 2-oxoacid aminotransferase (2-OAT) to give 2-oxoglutaramic acid which is rapidly hydrolysed to 2-oxoglutarate and ammonia by omega-amidase (OA), also called 'glutaminase II system'; (b) the alternative route for glutamine deamination is via the mitochondrial glutaminase (MG), also called 'glutaminase I system' to give glutamate and ammonia, followed by oxidation of glutamate by glutamate dehydrogenase (GDH). The second pathway (glutaminase I-glutamic dehydrogenase sequence) appears to be the major pathway for glutamine catabolism in the rat. The significance of the first enzymatic system is not yet clear, although either pathway of glutamine deamination would provide suitable precursor for glucose formation (2-oxoglutarate).

Resynthesis of glucose in the Cori's cycle (Fig. 3) is a major route of lactate disposal in the body. During exercise, enhanced gluconeogenesis limits lactic acidosis and maintains the supply of fuel which can rapidly yield energy under the partly anaerobic conditions of a contracting muscle. Following exercise, ATP consumption in the liver for lactate gluconeogenesis is a major factor in the "oxygen debt" phenomenon, part of which may also be due to the reesterification of free fatty acids released during exercise. It is important to note that Cori's cycle does not result in a net increase in glucose formation in the body. Lactate formed by glycolysis in blood cells, brain and other tissues also contributes to glucose recycling which may represent 10%-33% of glucose turnover in a normal man.

Although under normal circumstances, glycerol is a minor contributer to gluconeogenesis in man and other non-ruminants, its contribution towards glucose production becomes important during starvation, because triglycerides stores are large.

Special role of alanine

Although almost all amino acids are potentially gluconeogenic, only alanine, serine, threonine and glycine give rise to significant amounts of glucose in a perfused liver. These amino acids are well utilised by the liver *in vitro* and *in vivo*. It is probable that gluconeogenesis is their principal route of metabolism. Studies *in vivo* have shown that the liver takes up the extra amino acids entering via the portal vein during assimilation of a protein meal and that glycogen is deposited in this condition. Gluconeogenesis increases when plasma amino acid levels rise due to breakdown of body protein as in early starvation, insulin deficiency or cortisol excess. There is much evidence that alanine is the principal amino acid involved in hepatic gluconeogenesis.

On the basis of the evidences available, P. Felig of Harvard Medical School, Boston and L.E. Mallette of Vanderbilt University School of Medicine, Nashville, U.S.A. proposed

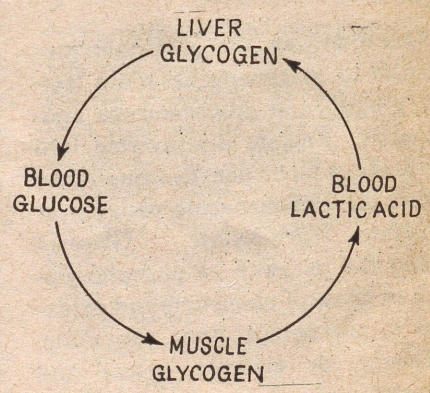

Fig. 3. Cori's cycle

almost simultaneously (1969-70) that alanine functions in a metabolic cycle analogous to the Cori's cycle. This new cycle is known as "alanine cycle", or is more aptly described as "Glucose-alanine cycle". As outlined in Fig. 4, alanine is formed in the muscle by transfer of amino groups from amino acids to pyruvate. Pyruvate is derived from blood glucose or muscle glycogen and amino acids from the breakdown of muscle protein. Alanine is released by muscle into the blood stream and is carried to the liver where its nitrogen part is converted into urea and carbon part into glucose. Urea is excreted in urine and glucose returns to the peripheral tissues. From the intimate relation between the oxidation of branched chain amino acids and alanine synthesis in muscle, A. L. Goldberg of Harvard Medical School, Boston proposed in 1975 a "branched chain amino acid-alanine cycle" involving transfer of the amino groups of the branched chain amino acids to pyruvate in muscle (Fig. 5), which complements the glucose-alanine cycle.

Although glucose-alanine cycle (or branched chain amino acid-alanine cycle) does not yield new carbon skeletons for *de novo* glucose synthesis, its importance relates to a non-toxic alternative (alanine) to toxic ammonia in the transfer of amino groups from the periphery to liver.

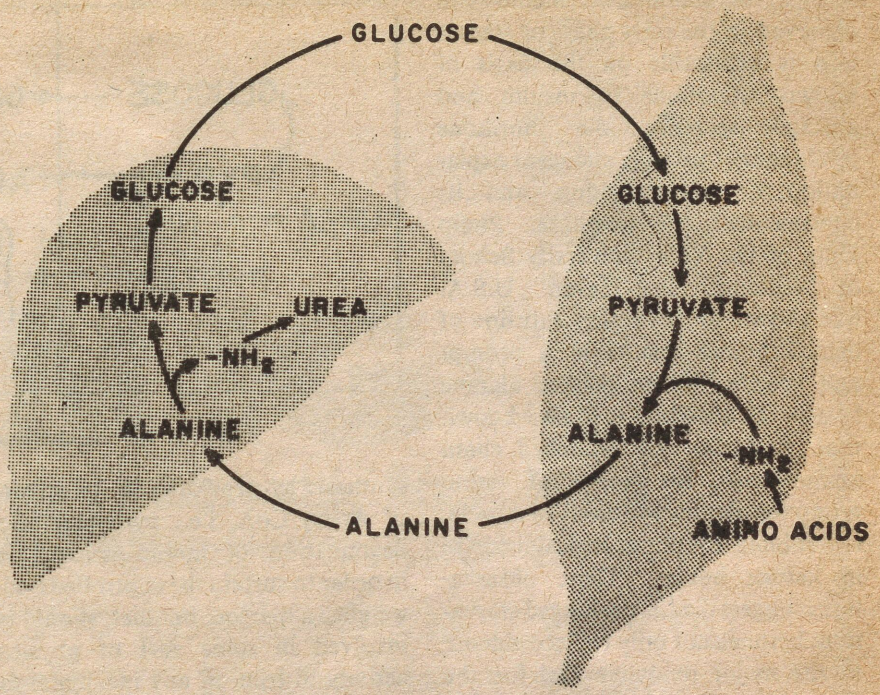

Fig. 4. The glucose-alanine cycle

Gluconeogenesis in physiological and pathological conditions

If we consider brief fasting, viz., fasting for 24 hr or so, the liver store of glycogen (75 g in a normal 70 kg man) is insufficient to provide the glucose needs of the nervous system (144 g) and other glycolytic tissues (36 g). The additional glucose requirement is met mainly through formation of glucose from amino acids mobilised from muscle protein (75 g).

An increase in gluconeognesis occurs after only a few hours of fasting. It is in part due to a rise in gluconeogenic amino acids particularly alanine in blood plasma. The maximum rate of gluconeogenesis observed on the third day of fasting coincides with the maximum hepatic extraction of alanine. It is currently believed that a fall in insulin and a rise in glucagon in the plasma are the primary events behind the metabolic changes in brief fasting.

As the fasting continues from days to weeks, the release of amino acids from muscle and hepatic gluconeogenesis are reduced and consequently brain's dependance on glucose has to be curtailed. In prolonged fasts, ketone bodies meet 75% of the energy demand of the brain (25% is still provided by glucose). The hepatic glucose output of about 180 g/24 hr during the first few days of fasting declines to about 45 g/24 hr as starvation prolongs beyond that period.

Renal glucose production increases to 40 g/24 hr. The stimulus for the change might be the associated acidosis. Kidney is changed from an organ of alanine output to an organ of alanine uptake. The enhanced gluconeogenesis in the kidney is accompanied by increased ammonia production as shown by a large elevation of urinary ammonia commencing on the third day of fasting. As expected from the marked decline in amino acid gluconeogenesis in the liver, urea excretion falls dramatically accounting for the large overall decrease in the urinary nitrogen excretion.

In brief, the metabolic response to starvation is biphasic, the changes in body fuel metabolism differing in the early (upto 3 days) and late (beyong 3 days) stages. The initial response is directed at maintaining hepatic glucose output by augmenting amino acid gluconeogenesis, while the late response is conducive to the maintenance of the body protein reserve by minimising protein catabolism. Conservation of protein is all the more essential, as the loss of one third to one half of body protein

stores results in death. Although the changes in amino acid metabolism observed in the early phase of starvation is explicable on the basis of known alterations in insulin and glucagon secretion, the hormone levels cannot provide sufficient explanation for the transition and its continuance in the late phase. Philip Felig of the Yale University School of Medicine, New Haven, U.S.A. had shown in 1975 that infusion of ketone bodies results in a prompt and specific fall in plasma alanine levels. In addition, it is also known that oxidation of branched chain amino acids, the source of amino group for alanine synthesis in muscle, is inhibited by physiological increase in ketone bodies. These observations suggest that in prolonged starvation, ketones not only replace glucose as the major oxidative fuel for the brain, but also contribute to protein conservation by limiting amino acid (alanine) availability for gluconeogenesis.

Slimming. Slimmers avoid carbohydrate foods as much as possible, since excess acetyl CoA derived from glucose can initiate by its own condensation synthesis of fatty acids in the body. Whether a slimming diet is carbohydrate-deficient or is isocalorically protein rich, a slimmer has to maintain his blood sugar level partly through gluconeogenesis. During weight control by partial fasting, the muscle proteins are depleted to supply amino acids for glucose production. A reducing diet regimen rich in protein is therefore to be preferred, since in that case body proteins will not be called upon to supply amino acids for gluconeogenesis. However, because of the high cost of protein foods, "slimming while eating" is expensive. On the other hand, unrestricted consumption of protein may lead to synthesis of undesirable amounts of body fat through production of glucose over and above the requirement. Proteins may also directly stimulate fat

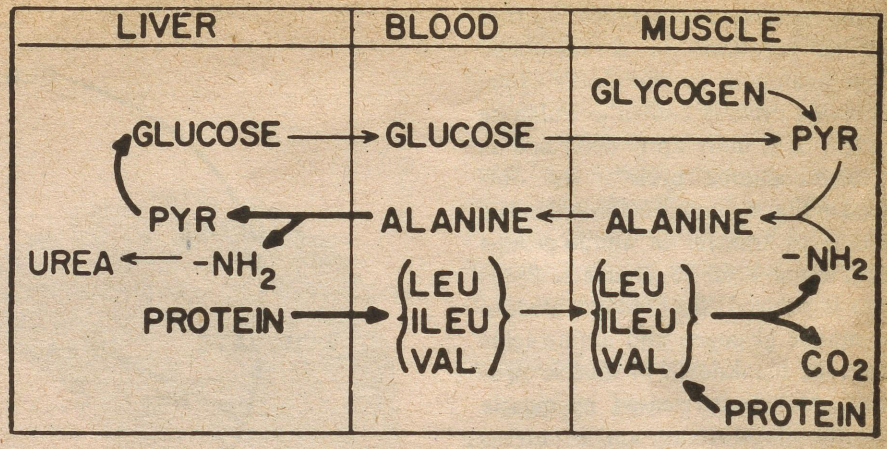

Fig. 5. The branched chain amino acids-alanine cycle

synthesis by providing the precursor of acetyl CoA, i.e., pyruvate (after deamination of amino acids). So, in order to sustain the controlled body weight, a person on diet should be involved in some sort of physical activity to trim off any incidental fat accumulation.

Exercise. During exercise, because of the partial anaerobic condition in which the muscles contract, glucose is incompletely burnt and blood lactate level is considerably elevated. In the recovery phase, lactate is mainly disposed of through the Cori's cycle and is converted back to its original parent molecule, glucose or glycogen. In the lactic gluconeogenesis of exercise, both liver and kidney cortex participate. Apart from the stimulation of gluconeogenesis due to increased availability of lactate as a substrate, administration of lactate to an intact animal has been found to raise the pyruvate content in liver which stimulates pyruvate carboxylase. The administration of lactate also increases the citrate level in liver and this would be expected to inhibit PFK and hence lead to enhanced gluconeogenesis due to stimulation of fructose-diphosphate hydrolysis.

Diabetes. Enhanced gluconeogenesis is probably as important as impaired peripheral glucose utilisation in the development of hyperglycemia characteristic of diabetes. Perfused livers from diabetic rats synthesise glucose from lactate at almost three times the normal rate. Besides, it is long known that some amino acids increase glucose excretion in animals whose pancreas have been removed.

The principal gluconeogenic substrates utilised by diabetic subjects are amino acids derived from muscle protein or dietary protein. The levels of gluconeogenic amino acids are decreased in livers from rats with diabetes, whereas the levels of branched chain amino acids, e.g., valine, isoleucine and leucine are increased. These changes probably reflect both stimulated gluconeogenesis in liver and enhanced proteolysis in liver and peripheral tissues.

In brief, a major part of the hypoglycemic action of insulin is due to inhibition of amino acid gluconeogenesis. The action is exerted both on the liver to slow down glucose synthesis through the gluconeogenic pathway and at the periphery to inhibit amino acid release. The hepatic component is probably more important because insulin does not decrease the peripheral release of alanine, the major gluconeogenic amino acid.

Lactation. Additional burden is placed on gluconeogenesis by lactation, specially in ruminants. Gluconeogenesis is the major means by

(*Continued on page 120*)

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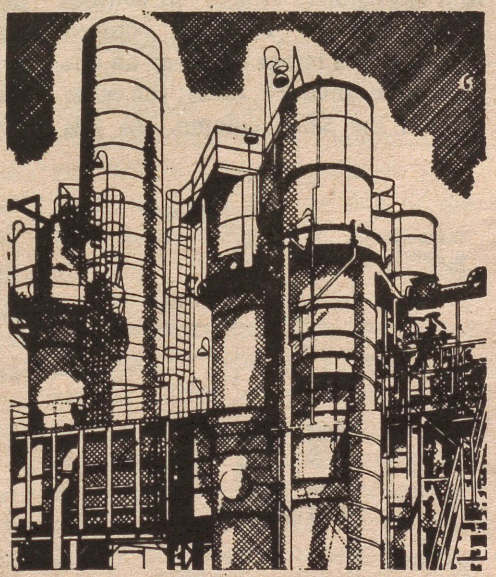

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SCIENCE SPECTRUM

New trends in scanning electron microscope

THE microscope is an instrument with a very wide general applicability in many fields of research and developmental technology. It had been expected that with the further growth of new fields of research needs would arise which would demand special requirements and would lead to a detailed specialisation of microscope design and methods of use which deviate from tradition. Examples of this development are such fields as Interference Microscopy, Polarising Microscopy, X-ray Microscopy, Flying Spot Microscopy, Reflecting, Fluorescence and Phase Contrast Microscopy. However, the latest advancements in scanning electron microscopy (SEM) has superseded all the existing techniques (see also *S.R.*, Dec. 1978).

It has been only fifteen years since the first commercial scanning electron microsope was introduced. Since then the growth of SEM has been so rapid, that access to such a microscope has become virtually essential for scientists and technologists who work with materials in any form—geologists, biologists, engineers or forensic scientists—as well as the more obvious physicists, chemists and materials scientists. SEM has become an extremely versatile tool for topographic, chemical, structural and electronic characterisation of materials on a microscopic scale.

The principle of SEM is simple and is illustrated schematically in Fig. 1. The instrument is similar to a television (TV) set. It consists of two types of TV tubes coupled together. The image is viewed on one or more normal TV tubes; the other tube is the SEM column. In this column a fine spot is formed by an electron gun and two or three electron lenses (the electron lens is similar in principle to an optical lens, except that the focal length and hence the power of the lens can be varied by controlling the electric and magnetic fields and this lens is free from chromatic spherical aberrations). The spot is scanned across the sample using the same scan generator as for the display TV tubes, and the magnification is increased simply by attenuating the current applied to the scan coils in the column. Because the scans are coupled in this way, there is a one-to-one correspondence between the positions of the spots in the column and in the TV display tubes. More specifically, when the radiation (in the form of secondary electrons) from a point on the specimen is high, the intensity of the point on the display TV tube is also high. If the probing beam is then moved to an adjacent spot on the specimen, correspondingly the intensity shifts in the TV tube; thus there

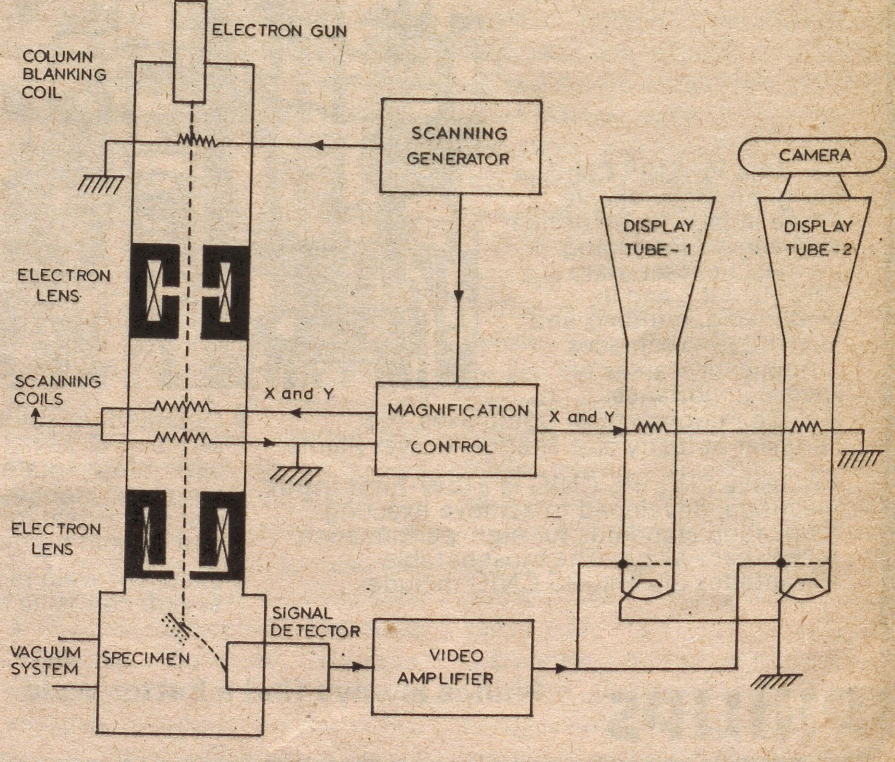


Fig. 1. The principle of scanning electron microscope

is also a one-to-one correspondence between the position of the spot on the specimen to that in the TV display tube. In practise, the points follow one another with great rapidity so that the image of each point becomes an image of a line, and the line in turn can move down the screen so rapidly that the human eye sees a complete image as in a television.

It now remains only to modulate the brightness of the display tubes with a 'signal' derived from the sample. It is normal to use the secondary electron signal, since these electrons are generated fairly close to the point of impact of the incident beam with reasonable efficiency. This signal is amplified (in a video amplifier) and applied to the display tube, which can then be photographed.

Most of the applications of SEM result directly from the ability to produce high resolution, 3 Dimensional-like pictures using the secondary electron signal. The machine compliments and extends the range of the optical microscope. Unlike the transmission electron microscope (TEM) or its scanning equivalent STEM, it can examine bulk samples, requires little specimen preparation (except that the specimen should have surface relaxation) or operating training. These versatile and fool proof features are alone sufficient for accounting rapid acceptance of SEM in many laboratories.

In SEM all features of the interactions of an electron beam with solids can be studied and used to obtain information about the sample. To realise this ambitious goal we have to develop new techniques, but already commercial instruments are able to detect several different signals which can give extra useful information. For example, the secondary electron detector can be used to reveal magnetic domains or surface voltages (these studies are basic for the understanding of energy conversion in magnetic domain flipping, especially in memory devices like ferromagnetic and ferro electric materials). A negative bias of a few hundred volts on this same detector rejects secondaries but allows back-scattered electrons to be collected. The contrast in the back-scattered signal reflects atomic number differences in a general way, because more electrons are back-scattered from high Z materials. The current flowing to the sample can also be measured, and many variants of these techniques can be easily devised.

The technique which is in routine use, however, is more precise than these. In the energy dispersive X-ray dectector (EDX) technique, X-ray photons are detected as pulses in Si (Li) crystal and the height of each pulse is used to assign an energy location for the pulse in a multi-channel analyser. Thus, with suitable electronic circuitry and some knowledge of the characterstic energies of the X-ray, any point in the image can be analysed qualitatively for its chemical constituents (heavier than Na) with a spatial resolution limit to about 1 μm by the side of the cascade in which the X-ray are produced. Further, the characteristic regions of the spectrum can be used to modulate the brightness of the SEM TV tube and so produce a picture of the distribution of the desired element. The combination of a topographic picture using secondary electrons and a 'chemical' picture is extraordinarily informative. X-rays can also be detected using a' crystal spectrometer—also called wavelength dispersive spectrometer (WDX). In this technique, which is used for quantitative chemical analysis in electron probe micro analysis, the energies of the X-ray are scanned sequentially, or serially. Thus WDX is an example of a 'spectroscopy' with 'serial' recording, whereas EDX is the same spectroscopy but with simultaneous or parallel recording. EDX can only handle much lower beam currents ($\sim 10^{-9}$A rather than 10^{-5}A) and it has much lower energy resolution than EDX (150 eV rather than 5eV). But the fingerprint spectra obtained with EDX as a result of parallel recording at currents not much above those used in normal SEM are extremely useful. Hence the SEM-EDX has become a widely available general purpose combination instrument.

New detectors and spectroscopies

It is clear that the scanning principle allows us to use several detectors which carry different types of information about the sample. SEM can provide topographic, chemical, structural (more specifically crystallographic) and electronic information on a microscopic scale. We have already seen that the first type of information listed can be obtained with a resolution of about 5 nm using secondary electrons and the second at about 1 μm resolution using X-ray emission.

Currently there is much interest in obtaining chemical information on a finer scale. Fig. 2 shows some details of the techniques adopted. The two most promising techniques are Auger electron spectroscopy (AES) for SEM and electron energy loss spectroscopy (EELS) for STEM. In both techniques a few hundred atoms present in a host material containing 10^{22} atoms/gram mol can be detected. AES is one of the surface analytical techniques and is complimentary to X-ray spectroscopy in several ways. First, it results from the same excitation process, in that a hole in an atomic inner shell produced by an incident electron results in the emission of either an X-ray photon or an Auger electron. Second, the Auger process is most efficient for low atomic number elements when X-rays become very inefficient, although in absolute terms they are both rather inefficient, requiring exposures of several minutes. Thir-

dly, it is surface sensitive since the Auger electrons come from within 1 nm if the surface energies are between 50eV - 500eV. Thus the depth resolution and also lateral resolution are much better than with X-rays. At present both AES and EELS are 'serial' spectroscopies in that the energy distribution can be obtained only by scanning the analyser energy.

A second type of spectroscopy aims to obtain crystallographic information from the sample. As a result of the sample being crystalline, either the detected particles will be emitted anisotropically or, if the beam is rocked, the incident electrons will interact anisotropically with the sample. This results in a two dimensional spectroscopy. The first technique of this kind, the electron channeling pattern (ECP) was discovered in 1967 and has since been much developed. In the selected area mode of operation the incident beam is rocked about a point (1-10 nm in diameter) on the sample and the variation in intensity (usually the sample current is used) is displayed on the TV tube of the SEM. At Sussex, a new technique has been developed called electron back scattering pattern (EBSP). In this technique the ECP is inverted and at the Auger distribution of the emergent back-scattered electrons is displayed on the screen.

These patterns contain crystallographic bands which can be indexed and used to orientate the crystallite. By using the elliptical shadows on the pattern to pinpoint the point of emergence of the back scattered electrons, orientation to $\pm 0.50°$ accuracy can be obtained. Because the pattern is recorded in parallel, i.e., using a camera, rather than serially it can be obtained much more quickly than an ECP, and can even be viewed directly by eye or by closed circuit television. In this way it is simple to see the orientations between different crystallites in the sample.

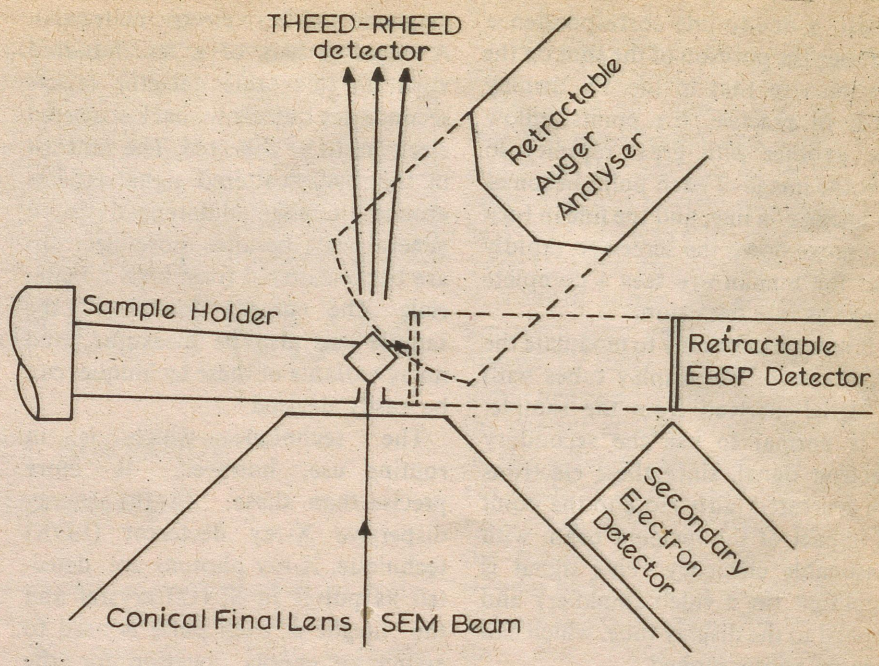


Fig. 2. Schematic diagram of detection facilities available in the ultrahigh vacuum SEM. Secondary electron —Auger; The detection facilities for diffraction information EBSP, THEED

The main disadvantage of this technique relative to the ECP is that the beam must strike the sample fairly near glancing incidence to obtain adequate pattern contrast.

A new technique called the X-ray Kossel technique has been developed at Bristol. This technique has identical geometry to the EBSP but records the angular distribution of emergent X-rays directly on to photographic film. The fine Kossel lines on the film arise from X-rays (Bragg) reflected in a volume about 10 nm around the incident electron probe. Although this is therefore not a technique capable of high spatial resolution and exposures are fairly long (several minutes), it nevertheless can produce the best lattice parameter data accurate to better than one part in 10^4. Thus both the Kossel and ERSP techniques will be very useful as crystallographic tools in future, probably overtaking the current uses of ECPS.

There are many other specialised operating modes which have been devised and which are useful in particular circumstances. For example, at Oxford it was shown that the electron beam induced conductivity (EBIC) mode is useful for studies of electron traps in semiconductors, and at Manchester and London, cathodoluminescence (CL) mode was developed for the study of phosphorous semiconductors and other light emitting materials. The low energy end of the secondary electron spectrum is sensitive to the work function of the sample and at Sussex this too was made into a quantitative SEM signal. There is ample scope in these techniques to determine the electronic structure of the sample in great detail.

Thus it is not unreasonable to claim that the recent advances have already gone a long way to provide SEM techniques for obtaining topographic, chemical, crystallographic and electronic information from bulk samples on a microscopic scale—at resolutions varying from $\leqslant 5$ nm up to $\leqslant 10\mu$m depending on the information sought and the technique used. It is noticeable that many of the most precise techniques are spectroscopies. Detectors which

detect the other variables in 'parallel' rather than 'serially' have very great advantages in terms of speed and signal-to-noise ratio and so will probably become important in future.

Electronics play a central role in SEM. All major instrument functions—scanning, signal detection, signal processing, and display—are controlled by electronic devices often of considerable complexity. Their role in SEM is not dealt with in the present article.

Physicists, however, have to get involved in the developments of SEM and use them to further our understanding of the interaction of electrons with solids. The development of specific SEM signal to provide detailed and quantitative information about the chemistry and structure of materials on a microscopic scale is a fascinating task.

K. VENKATESWARA RAO
Scientist
Central Electro Chemical Research Institute
Karaikudi

A. SUBRAHMANYAM
Deptt. of Physics
Birla Institute of Tech. & Sc.
Pilani

Plant tissue culture and pharmacy

Plants are not only the most important producers of natural products including foods, wood, fibers and oils but are also the richest source of medicinal substances. In recent years, however, there have been increasing difficulties in securing an ample supply of medicinal plants because of a drastic decrease in plant resources due to human disturbance of natural environment, ruthless exploitation, increasing labour cost, and technical and/or economic difficulties in cultivating wild plants. Efforts are being made overcome to some of these difficulties by introducing tissue culture system foı production of medicinal compounds.

Major advantages expected from tissue culture systems oveı the conventional cultivation of whole plants are : (1) Useful compounds could be produced under controlled environmental conditions independent of climatic changes or soil conditions; (2) Cultured cells would be free of microbes and insects; (3) Cells of any plants could easily be multiplied to yield their specific metabolites; (4) Automated control of cell growth and rational regulation of metabolic processes would contribute to the reduction of labour cost and the improvement of productivity.

Because of these merits, the exploration of biosynthetic capabilities of various tissue cultures has been carried out by a group of plant scientists during the last dedade. Studies made so far include production of catharanthus and camptotheca anti-tumour alkaloids, amino acids and proteins, antibiotics, allergens, cigarette tobacco and fatty acids, papain and other enzymes, steroid precursors and steroid biotransformation products.

Production of specific medicinal compounds

B. Kaul and E.J. Staba of College of Pharmacy, University of Minnesota (USA) have reported that diosgenin, a major raw material for the commercial production of corticosteroids and steroid contraceptives, can be produced by suspension cultures of Yam (*Dioscorea deltoidea*) with a 1.5% dry weight content. The cell cultures of valuable Chinese drug Ginseng have been found to produce ginsenosides in large amounts (21% of dry weight as crude saponins) by T. Furuya of Kitasato University, Japan. Production of saponins has also been reported *in vitro* by using cell cultures of *Panex quinquefolium*. The suspension cultures of licorice (*Glycyrrhiza glabra*) are capable of synthesizing glycyrrhizin in a fair amount (3% -4% dry weight), and cigarette tobacco treated with the extract from the cultures gave a better flavour as compared with that from the licorice root.

Plant tissue culture can form certain kinds of quinones. The callus cultures of Fetid cassia (*Cassia tora*), used as a laxative, contain more than ten times as much quinones as the anthraquinones. Similar results have been obtained by suspension cultures of Indian Mulberry (*Morinda citrifolia*) and Indian Senna (*Cassia angustifolia*).

In Gromwell (*Lithospermum erythrorhizon*) callus cultures, attempts have been successful in increasing the content of napthaquinone pigments used for the treatment of burns, skin diseases and haemorrhoids. Increase in the amount of naphthaquinones through callus culture is important especially because of the decreasing availability and unsuccessful cultivation of the plant. Ubiquinone-10, used as a remedy for congestive heart failure has also been produced by tobacco cell suspension cultures at a rate (360 kg/h dry weight) higher than that by microorganisms.

Unfortunately, there are quite a number of important medicinal compounds which have been reported to be completely absent in cultured cells. Also, there are some compounds whose presence in cultures remains ambiguous due to incomplete identification. Some of these compounds are morphine, codeine, vincristine, vinblastine, sparteine, senno-

sides, swertiamarin and methanol glycosides. However, it has been reported that callus cultures of Foxglove (*Digitalis purpurea*) produce about 15 cardenolides including purpurea glycoside A in small amounts, although the number and quantity of cardenolides decrease with subculturing (*Planta Med.*, **29**, 275-282, 1976). The callus tissues of Periwinkle (*Vinca rosea*) contained alkaloids apparently identical with the anti-tumour agents, vincaleucoblastine and vincristine, but the chemical structures of these compounds remain to be determined unequivocally. There are numerous useful plants whose biosynthetic capabilities await exploration.

Screening for new physiologically active substance

Screening of various tissue cultures by bioassays for definite pharmacological activities may be an effective method for exploiting active substances produced by cultured tissues. In fact, this method has proved fruitful in discovering some unexpected substances of possible medicinal use.

Some of the callus tissues isolated from Amla (*Emblica officinalis*) and *Isodon japonicus* have shown antimicrobial and anti-peptic ulcer activities, respectively. Cultured cells of *Scopolia japonica* produce proteinase inhibitor showing a marked antiplasmin activity. Dried callus of Periwinkle (*Vinca rosea*) is a cure for coccidium diseases of chicks and a powerful prophylactic against pathogenic protozoa.

Biotransformation of compounds

Biotransformation of particular substrates to more useful compounds by plant cell is now considered to be one of the most promising areas in the biotechnological application of plant tissue culture. It is expected that specific modifications of chemical structures of certain compounds may be performed more easily by cultured plant cells than by microorganisms or by chemical synthesis. E. Reinhard of University of Biology, Tubingen (FRG), has demonstrated that digitoxin and B-methyldigitoxin could be converted quite efficiently into medicinally more useful cardiotonics by specific hydroxylation of suspension cultures of Grecian Foxglove (*Digitalis lanata*). Cultured tissues of *Datura* posses a remarkably high capability for glycosylation of hydroquinone to form arbutin, used as a diuretic and urinary antiseptic.

Regulation of compound production

Efficient production of secondary metabolites by plant tissue culture is largely dependent upon environmental and biological factors. A characteristic alteration in the pattern of chemical composition between light and dark-brown callus has been reported for the volatile oil in Garden Rue (*Ruta graveolens*). It has been shown in a number of tissue cultures that light generally stimulates the formation of carotenoids, flavonoids, polyphenols and plastoquinones. Regarding the effect of light on flavonoid formation, it has been clearly demonstrated that large increase in the activities of all enzymes involved in the accumulation of flavone and flavonol glucosides occur upon illumination of the cultures, especially with UV light. In sharp contrast to the stimulatory effects of light, it has been found that either white or blue light almost completely inhibits the formation of shikonin derivatives in *Lithospermum* cultures at all stages of cell growth cycle. There are other secondary metabolites whose biosynthesis is not significantly influenced by light.

Plant growth regulators affect not only growth and differentiation of cultured tissues but also their secondary metabolism. Their effects on secondary metabolism vary greatly depending upon the kind of metabolites. Effect of auxins on nicotine synthesis in tobacco (*Nicotiana tabacum*) cultures have been studied by various workers.

An exogenous supply of a biosynthetic precursor to culture medium may increase the yield of the final product, when the productivity is limited by lack of the precursors. In *Scopolia* and *Datura* cultures the production of tropane alkaloids can be increased by the addition of tropic acid, the direct precursor. Moreover, from the practical viewpoint, it is important that the precursor should be of low cost. In this respect, attempts have been made to increase the caffein content in tea suspension cultures by nearly four times by the supply of inexpensive ammonium salts, which is presumably the nitrogen source for the purine ring of caffein (*J. Exp. Botany;* **21**, 258-273, 1970.)

Nutrition for the cultured cells is also an important factor in deciding the production of secondary metabolites. The chemical composition of commonly employed culture media is primarily meant for improving cell growth, and may not necessarily be best suited for the production of secondary metabolites. Unfortunately, only a few studies have been devoted to a thorough examination on the effects of individual medium components and their interactions on secondary metabolite production.

In a batch culture system, the biosynthetic activity of cultured cells usually varies with cell growth or substrate utilisation. Kinetic studies of the rates of cell growth and product formation are essential for a basic understanding of secondary metabolic production. Little is known about the interrelation between the rate of product formation and the age of individual cells in plant cell culture. However, experimental data on the time-course of product formation indicate that production growth patterns may be classified into three major types: (i) Product formation proceeds

almost in parallel with cell growth; (ii) Product formation delayed until cell growth declines or ceases; (iii) The production curve is diphasic and lags behind the growth curve as in the case of diosgenin production.

In higher plants, there are certain compounds which are synthesized or accumulated only in particular organs or tissues. The failure of unorganised cells or tissue cultures to produce compounds such as morphine, menthol, carvone and tetrahydrocannabinol suggest that morphological differentiation of specific organs or tissues are required for their formation. In some cases, induction of differentiation in unorganised tissue cultures also induces production of desired compounds. There are also cases where unorganized tissue will produce compounds found exclusively in specific tissues of intact plants.

Cellular variation is another factor which can regulate secondary metabolism and has potential use in improving biosynthetic capabilities of culture strains. It is empirically known that callus cultures sporadically give rise to variant subcultures showing different concentration levels of particular secondary metabolities. Biosynthetic capability of cultured tissue may be improved by the artificial induction of genetic mutation. The chemical mutagen, N-methyl-N'-nitro-nitrosoguanidine has been successfully used to obtain variant clones of carrot cells which varied widely in their capability to synthesize B-carotene and lycopene.

Although recent advances in the production of medicinal substances by tissue culture have strengthened our hopes towards the realisation of industrial production in the near future, there remain many problems, both basic and practical, which must be solved before we reach the goal.

RAJANI VARMA
School of Studies in Botany
Jiwaji University
Gwalior-470042

Biological control of soil-borne fungal pathogens of plants

SOIL-BORNE fungal pathogens are responsible for many plant diseases like wilt, root rot, collar rot, damping off, etc. Because these fungi complete their entire life cycle underground, it is almost impossible to control them by conventional means. Fungicidal treatment of seed or soil protects crops only during early growth period because roots that grow beyond the chemically protected soil zone can get infected at a later stage. Soil fumigation, another method of controlling soil-borne pathogens, is also only an incomplete cure, because many of the dormant reproductive bodies of the pathogens can escape being killed by fumigation. Even leaving the land uncultivated does not help, because reproductive bodies of pathogens can persist in such fields for several years in dormant state. Owing to these reasons, scientists are looking for unorthodox means of controlling soil-borne diseases and from the results of some of the recent investigations biological control appears to be a promising new method.

Presence of naturally occurring agents that might be antagonistic to soilborne pathogens is indicated by the fact that certain soils seem to suppress the development of pathogens in them. Sometimes it is just the presence of some physico-chemical factor that prevents growth and multiplication of pathogenic fungi, but occasionally one comes across certain micro-organisms that too can cause this phenomenon to occur. Prof. Ralph Baker and his associates (Deptt. of Botany and Plant Pathology, Colorado State University, Fort Collins, U.S.A.) recently published reports of studies (*Phytopathology*, 1980, **70**, 412-417 and *Phytopathology*, 1980, **70**, 404-412) in which they investigated two such phenomena. In one case, the soil was reported to be suppressive to *Rhizoctonia solani*, which causes damping off in young seedlings and collar rot in older plants in a number of crop plants. In the second case the soil was found to inhibit the development of wilt-causing fungal pathogens belonging to the genus *Fusarium*. Studies conducted by Baker *et al.*, consisted of burying mycelial mats of the concerned pathogens into the respective suppressive soils and studying micro-organisms that were later found to be growing in association with the mats. Isolation of the micro-organisms and evaluation of their antagonistic effect on the concerned pathogen under laboratory and field conditions showed that in the case of the *Fusarium*-suppressive soil, a species of the bacterium *Pseudomonas* was responsible for the suppression, while in the case of soil suppressive to *Rhizoctonia solani*, the investigators could demonstrate a fungus, *Trichoderma harzianum*, to be responsible for the suppressive action. The antagonistic effect of *Trichoderma harzianum* on *Rhizoctonia solani* is a well-known phenomenon, but the antagonistic activity shown by *Pseudomonas* sp. against *Fusarium* is a new discovery. Another important mycoparasite, *Sporidesmium sclerotivorum* was discovered in 1978 by P.B. Adams and his associates at the Soil-borne Diseases Laboratory of the U.S.D.A. (Beltsville, U.S.A.). This fungus was found to control three important soil-borne pathogenic fungi, *Sclerotinia minor*, *Sclerotinia sclerotiorum* and *Sclerotium cepivorum*. The most interesting part of this discovery is the fact, that the mycoparasite destroys sclerotia, the hardy reproductive bodies of the pathogens,

which are generally quite resistant to the decay-inducing microorganisms found normally in the soil and also to the physical weathering action of the elements.

The findings reported above are no doubt very encouraging, but it should at the same time be borne in mind that biological pest control measures cannot generally be used as the sole means of pest control under field conditions. Owing to the fact that these measures make use of living organisms, they are effective only within a relatively narrow range of environmental factors. For example, the optimal environmental conditions under which *Sporidesmium sclerotivorum* can act against *Sclerotinia minor* are soil temperature ranging from 20°C to 25°C, soil pH ranging from 5.5 to 7.5 and soil water potential of −8 bars and above. Similarly, the antagonistic action of *Pseudomonas* sp. against *Fusarium* could be observed only when the soil was alkaline (pH above 7), whereas *Fusarium* can survive and remain infective even at pH 6.

As a result of the environmental restrictions, which limit the use of biological control measures, scientists have evolved the concept of integrated pest control, which combines several techniques of control, including the biological ones. A good example of the use of this concept is provided in a recent report (*Phytopathology*, 1980, **70**, 418-422) by Y. Elad *et al.*, of the Agricultural Faculty of the Hebrew University (Rehovot, Israel). These workers had previously found that solar heat, trapped by plastic mulch, could raise the soil temperature sufficiently to kill many microorganisms in the soil. They now show that combining the use of *Trichoderma harzianum* with solar heating of the soil not only increased the efficacy of the latter treatment against *Rhizoctonia solani*, but also controlled *Sclerotium rolfsii*, which is not completely controlled by any of the above control measures, if used singly.

A.D. KARVE
F.A.O. Expert
Agricultural Research Institute
Yezin, Burma

Menace of the marine foulers

THE bottom of a ship or boat, painted with an ordinary paint, soon becomes home for a variety of marine foulers, viz., barnacles (Fig. 3), moss animals, tube worms, clams and sea-squirts and wood borers, viz., crustaceans, Laminaria (Fig. 4), Sphaeroma (Fig. 5) and molluscan shipworms (Fig. 6). They are mostly confined to warm waters of high salt content. The foulers, particularly barnacles, attach in large numbers to the outer surface of the ship and seriously slow down speed of the vessel and, thereby increase fuel consumption. The borers, on the otherhand, take shelter inside the fixed and floating timbers and feed on for their nourishment on cellulose. Consequently, the timber is reduced to soft saw dust. It is said that Columbus lost all his ships during his IV voyage as a result of the ravages of shipworms.

How do these organisms take shelter

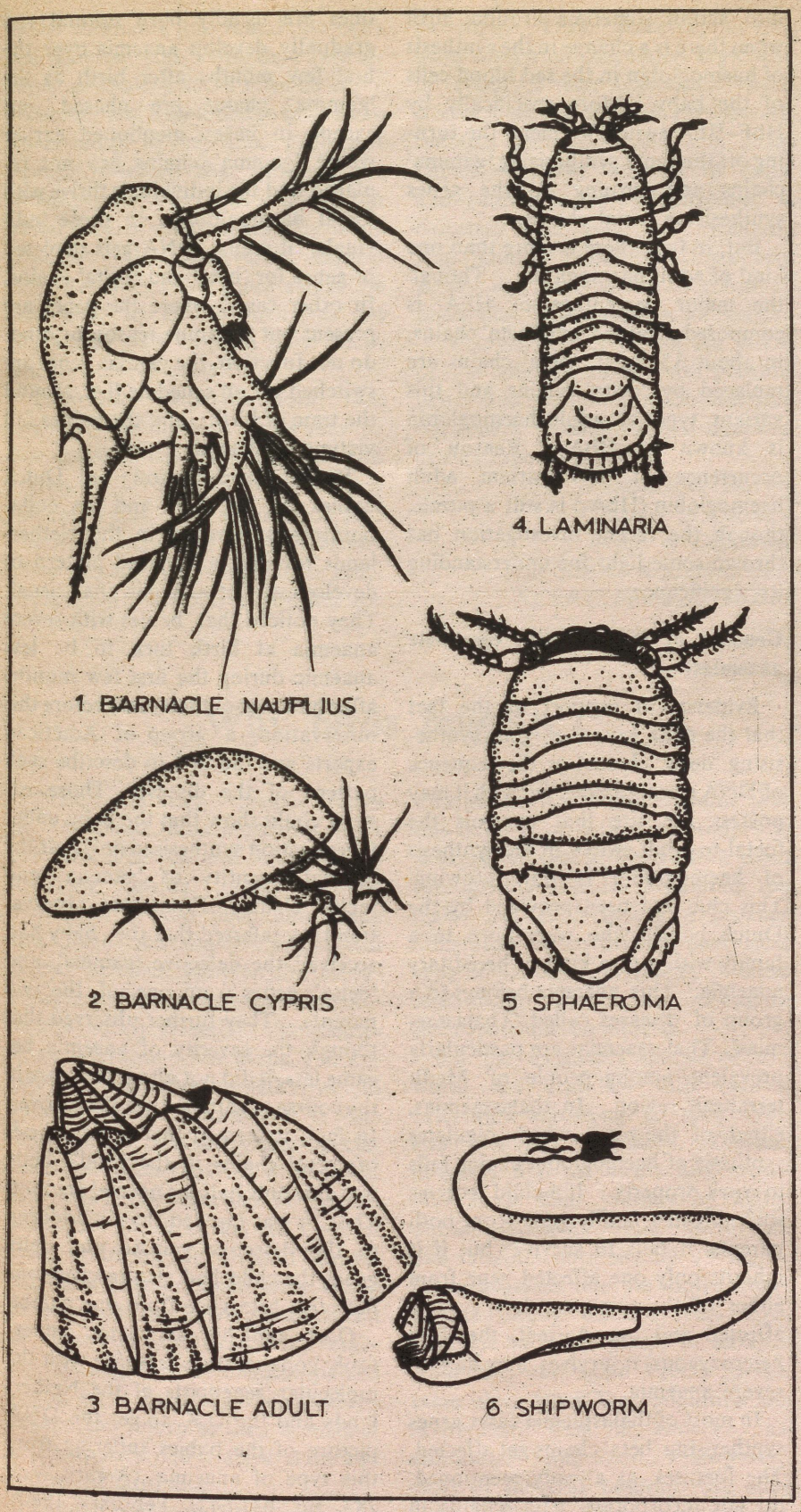
The larvae of barnacles (Figs. 1,2) swim actively for a number of days to find some suitable surface to land on. When a young barnacle finds such a surface, it crawls around over a small area in search for a choice location. It, then, anchors itself firmly on its two front legs with the help of a cementing material and slowly begins to form its familiar conical shell.

The borers, particularly the shipworms, release their larvae which are about .025mm thick. After 24 to 48 hours of free swimming, they bore and make a hole in the wood which resembles a pin point. Once they get into the wood, they grow rapidly and dig burrows which may be as much as 1.25 cm in diameter and 30 cm in length. The larvae may survive even when the wood is kept out of water for more than two weeks. It is, however, interesting to observe that fouling and boring do not occur simultaneously. Dense fouling effectively inhibits attack of shipworm borers as adult barnacles feed on shipworm larvae.

Measures for protection

In India alone the periodic cost of replacement of fishing craft destroyed by marine borers amounts to Rs. 2.5 million. In the United States, damage has been found to exceed 50 million dollars every year. With a view to eradicate foulers and borers antifouling and boring paints have been developed nowadays. Most of them contain cuprous oxide which dissolves slowly in seawater and is very poisonous to fouling organisms.

There are basically two different types of paint containing cuprous oxide. One is the 'continuous contact' type, which has considerable amount of the poison in the surface layers of the paint. Such paints need only be applied as a thin coat. The second type, known as 'soluble matrix' paints, contain a lower concentration of the poison but have a porous structure which allows poison to reach the surface from within the paint. The latter type is applied as a thick coating. The soluble matrix paints are more effective but both the types resist fouling only for two years. It is always advisable to have a prepainting with a special



Figs. 1-6. Marine foulers

paint before these paints are applied because they may cause considerable corrosion. Furthermore, vessels painted by these paints should be immersed in seawater before they are dry. Otherwise, the surface of the paint hardens and seals the poison beneath making it ineffective.

Scientists have recently found that a group of organic compounds of tin could also be equally effective like cuprous oxide paints. Two compounds, one liquid, technically known as bis (tri-n-butyltin) oxide and commonly called TBTO, and the other, solid, tri-n-butyltin fluoride (TBTF), have been successfully used in antifouling paints. These modern paints have several advantages. They are not corrosive. Also, they do not lose their effectiveness on drying. Consequently, boats do not need to be launched immediately after painting and may be repeatedly hauled without destroying the properties of the paint. Another method of controlling foulers and borers is the periodic taking of vessels to low saline regions like rivers which is said to kill these organisms.

R. SANTHANAM
K. VENKATARAMANUJAM
G. SANJEEVIRAJ
Fisheries College
Tamilnadu Agricultural University
Tuticorin 628 003

Genetic switches control formation of haemoglobin

RECENT research in the Netherlands on a rare kind of hereditary anaemia may help the geneticists to work out the vital genetic 'switches' controlling the formation of haemoglobin. This research was conducted on a Dutch family carrying genes for this rare kind of hereditary anaemia.

Anaemia is caused due to the deficiency of haemoglobin in the blood. Haemoglobin is a red coloured organic substance made up of protein, *globin,* of histone class and iron-containing *heme* units. Being enclosed in the red blood cells (R.B.C.) of the circulating blood, haemoglobin accomplishes the vital physiological function of respiration by transporting respiratory gases oxygen and carbon dioxide as oxyhaemoglobin and carboxyhaemoglobin, respectively.

It is a known fact that there is a considerable difference in the nature of haemoglobin present in the body during the foetal life and that of adult. Foetal form of haemoglobin (HbF) takes up oxygen more efficiently than the adult and thereby helps prevent the baby from any oxygen deficiency at birth. Foetal haemoglobin, in the course of first few months after birth, is substituted by adult form of haemoglobin (HbA).

In terms of four polypeptide chains that make up the haemoglobin molecule there is a difference between the foetus and the adult. In adult, haemoglobin is constituted of a complex formed of two identical 'alpha' chains and two identical 'beta' chains. In a foetus, on the other hand, haemoglobin contains 'gamma' chains instead of 'beta' chains which are different from the latter in amino acid composition. Each of all the types of polypeptide chains, that enters into the composition of foetal or adult haemoglobins is connected with a *heme* unit.

The genetic switches

As in the cases of other proteins of the body the haemoglobin synthesis is also directed by genes, i.e., DNA sequences. Since there is difference in the structure of haemoglobin in the foetus and the adult, there is switching off and on of genes to bring the change over from foetal form of haemoglobin (HbF) to adult form of haemoglobin (HbA). Turning off and on of the genetic switches comes into action sometime around birth when there is a change in the synthesis of haemoglobin in the red blood cells of the baby. More specifically by HbF–HbA switch we mean the turning off the genes synthesising 'gamma' chains and turning on the genes synthesising 'beta' chains.

But, in fact, there is more than one kind of adult haemoglobin. Though the major percentage of HbA is composed of 'alpha' and 'beta' chains, in about 3% of it 'beta' chains are replaced by 'delta' chains and this variant type of adult haemoglobin is known as HbA_2. Reason of occurrence of this variant adult haemoglobin (HbA_2) is still a puzzle, though the recent investigation has thrown some light for understanding its significance.

Genetics of thalassaemias (heritable anaemias)

Evidence in support of the fact that the delta gene (i.e., gene synthesising 'delta' chains) or the sequence of DNA closely associated with it may possess the site that controls the foetal-to-adult switch in the synthesis of haemoglobin is now growing. This clue had been provided by the Dutch babies who were born to a family with a rare kind of hereditary anaemia. This anaemia belongs to a group of diseases called 'Thalassaemias'. Thalassaemias are particularly prevalent among people of Mediterranean region. In thalassaemias, either of the genes which regulates synthesis of haemoglobin chains fails to work properly. If a child receives such affected family gene from both parents, it fails to survive but if it inherits only one affected gene from either of the two parents (i.e., one affected and one normal, therefore heterozygous) it survives, may be with severe anaemia.

In most of thalassaemia cases genes synthesising 'beta' chains get affected. The foetuses, as already mentioned, do not incorporate 'beta' chains in their haemoglobin. So the affected ones are usually born normal and gradually develop anaemia over the first few months after birth as the 'gamma' chains are phased out, except in cases mentioned earlier where 'gamma' chains are not replaced and the individuals thrive with foetal haemoglobin. In those indiviuals, it seems, DNA gets depleted of genes for 'beta' and 'delta' chains. In other cases, where the genes are present but for some reason or other do not function, the gamma genes are switched off on schedule (i.e., around the time of birth), and the babies fall victims to anaemia.

Recent investigation on Dutch babies by M. Oort and his collaborators at Emmen in the Netherlands revealed a reversed pattern of development of anaemia than usual. They noticed that babies with severe anaemia at birth turn to be less anaemic during the first few months after birth. About ten years before this observation, a group of American experts was the first to describe such pattern of the disease. Those experts could show that the baby under investigation synthesised only half the normal quantity of 'gamma' and 'delta' chains. From that observation they inferred that the baby had received the defective 'gamma' and 'delta' genes from one of the two parents. They further observed that though the severity of anaemia became less, it did not altogether cure in the course of gamma-beta switch over. In fact, it seemed that the synthesis of 'beta' chains in the child's body was also only half the normal amount. Thus, it was implied that in addition to the defective gamma and delta genes the child had also received one defective beta gene from one parent.

Oort and his associates undertook collaborative research with the molecular geneticists of the Netherlands and the U.K. to get the DNA picture of the babies suffering from this type of anaemia (*Nature,* Vol **283,** pp. 637-642, February 1980). They made use of the recombinant

DNA technique and found that both the 'gamma' and 'delta' genes are altogether missing in the affected chromosome. But they failed to detect any abnormality in the 'beta' genes and further observed that nothing was missing from the DNA chains, from either side of these genes, for some distance. This observation suggested that the beta genes might be controlled by DNA which was not the actual part of beta gene itself, but was placed close to it.

The Dutch workers hold that switching on the beta genes may be due to something in the gamma-delta region of the DNA and these genes remain inactive in absence of that important stretch of DNA molecule. They suspect that it is the delta gene, in particular, which is responsible for switching. They, however, put forward somewhat speculative argument in favour of their suspicion. There is also a second possible explanation for this pattern of anaemia. The babies might be deficient in delta and gamma genes and possessed a defective beta gene (not deleted). The Dutch researchers, however, accept this explanation as a formal possibility, but consider it unlikely.

Further researches on the DNA of the affected babies will provide better understanding of the underlying genetic mechanism that operates in this type of anaemia.

JAGANMAY MITRA
Reader in Zoology
Deptt. of Education
in Science & Mathematics
NCERT, New Delhi-110016

Why birds migrate?

FOR centuries people have observed birds departing from one area each fall and returning the following spring. This periodic oscillation of the pendulum—back and forth movements of several species of birds, between the breeding area and wintering area—a phenomenon which essentially constitutes avian migrations has along challenged the imagination of man, from all spheres of life. Surely, it is one of the most fascinating and spectacular behaviours of all animal life. Desire for migration has become an obligatory phase in the life cycle of these avian species. Human reasoning faced bewilderment while trying to grasp the underlying mechanism of migration—how and what urges the untaught and unaccompanied young birds to make their maiden voyage and return to their homeland at an approximately fixed time and controlled destination.

Though environmental origin has been suggested for arousal of migratory habits, it is more probable that this habit is of biological origin. It is suggested that bird migration arose through the urge for expanding the realm or rather giving a broader dimension to an existing biological urge of periodic movement, in close relationship with the changing environmental conditions.

All the migratory species of the world are classified into several categories according to their type and line of migration. Diurnal migrants like the swifts and crossbills cover their journey by flying during daytime, while nocturnals like thrushes normally fly at night. Some migrants like the alpine inhabitants simply descend from high altitudes to lower plains in adverse conditions and again return to the same place when the conditions are favourable. This is known as altitudinal migration. However, most of the true migrants are latitudinal fliers. Conspicuous transnational travellers migrate from northern hemisphere to southern hemisphere. Reverse directional movement occurs in the southern hemisphere but the occurrence is less conspicuous on account of small land masses and scant bird population. Interestingly, the migratory path is fixed for individuals of a particular species. Nevertheless, it is certain that migration is restricted to a narrow and well-defined flight lines which remain the same year to year. During the past centuries, bird 'ringing' by ornithologists and their subsequent recovery programme had answered the question—where do they migrate? But as yet it is not completely known why and precisely what factors induce these birds to the precision pendulum of migratory activity.

Migratory navigation — a spectral view

It is seen that the movement which occur during migration are not random but spatially oriented. The actual factors guiding the migratory navigation are very complex and not necessarily same for all birds or at all times.

Despite a lot of questions little is known about the accuracy and versatility of the birds' navigational abilities. Are they aware of their geographic location? Do they rely on simple compass system to reach the goal? Do they compensate for their replacement if blown off by wind or other factors? Experiments regarding these problems have yielded perplexing results.

Many diurnal fliers with good activity are influenced by general topography beneath them. They are capable of recognizing salient features of the terrain and retain for long time while making their transcontinental journey encompassing a stretch of thousand kilometers pathway. Utilisation of the position of the sun is another cue for diurnal fliers. Experiments with a model sun in planetarium support that the sun

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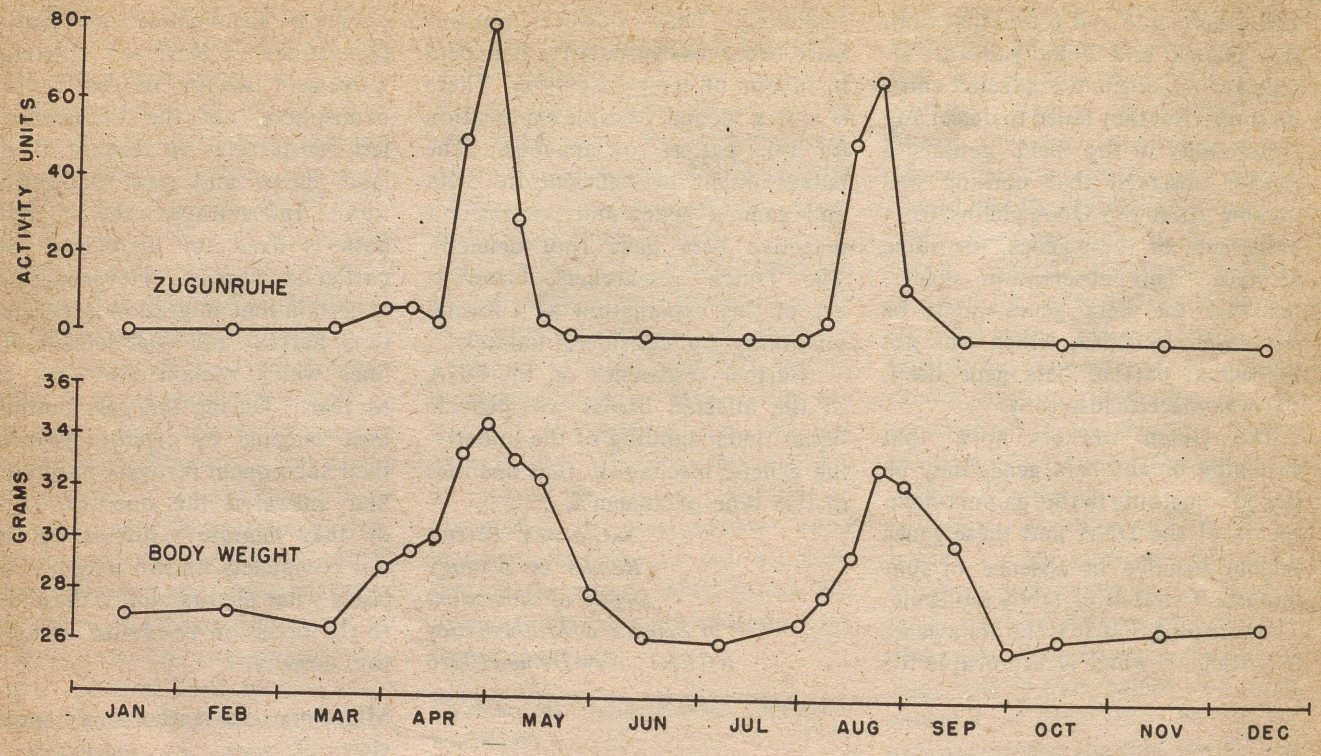


Fig. 1. A schematic representation of the body weight and Zugunruhe (restlessness) of a typical migrant over one year period. Note the gradual increase in both body weight and Zugunruhe with a peak immediately prior both spring migration and fall migration

provides accurate information about geographic location or the precise direction towards a predetermined goal. For nocturnal migrants, star orientation in the sky is of great help. Long distance migrants follow star orientation by pattern recognition which is really a complex affair. Experiments by conditioning the birds to respond to magnetic stimuli and the effect of magnetism on the birds shows that possibly the birds utilise the intensity of the earth's magnetic field for migratory activity and selection of their pathways. The migrants are also thought to be excellent meteorologists, possibly they can utilise the best time for their travelling after predicting the whether correctly.

Migrants are capable of detecting displacement and reorientation towards a goal by means of bicoordinate navigational system based on celestial and geophysical cues which change with time in an internally programmed sequence that brings the bird to its geographic destination at the end of the migration period.

Indices of avian migration

In addition, birds of migration possess certain features which serve as a faithful index while interpreting the basis of avaian migration—one is known as 'Zugunruhe' or migratory restlessness and the other as 'Zugdisposition' or migratory fattening.

It has been established that in captivity, if their migratory flight is prevented, the migrants display an intense madness-like manner by jumping, whirling and fluttering. This display is called 'Zugunruhe' or migratory restlessness exhibited by a migrant immediately prior to distant migratory flight in nature (Fig. 1).

Also twice a year, before their migratory flights, the body weight reaches its maxima (Fig. 1) due to enormous gathering of fat in their body (Fig. 2). This reserve serves as a fuel for their journey. Long distance migrants gain about 50% of their body weight, while the short migrants gather upto 20%-30% of their body weight.

In most cases, energy reserve is greater in spring than in fall. This may be due to an emergency reserve for breeding ground and it permits for a more rapid vernal migration. Again, prior to a long flight, a bird needs an intact wing. So moulting often occurs prior to every migration. These three events—migration, reproduction and moulting—have a great demand on energy. These three events are harmonised economically with premigration stored fuel.

Basis for avian migration

It is believed that birds feel the urge for migration as an outcome of the interplaying of several factors.

Exogenous initiating factors

Urge to survive and successfully bringing their nestlings are perhaps the most important causative factors

for migration. Underscoring of environmental status (availability of food), photoperiod (availability of light during the day, required for their food collection and also certain organ development), temperature (giving warmth) may initiate migratory activity. Experimentally by restricting food and lowering the temperature, the autumnal migratory restlessness can be initiated and inversely spring-time restlessness and fat deposition can be enhanced by increased temperature.

Nonetheless, a great regularity in the seasonal changes in the daylength plays an important role in bird migration. Pioneering scientist in this field W. Rowan (1925) demonstrated that light treated birds show typical migratory activity. So far many complex experiments have been done to show that fat deposition and migratory restlessness can be regulated artificially by using prolonged day lengths and photoperiodic manipulations in association with changing endogenous controlling factors discussed later. However, such activities are not seen with the resident non-migrants.

Endogenous controlling factors

Some typical migrants known as 'calender birds' maintain a specific time to arrive at their wintering or breeding ground and display restlessness 'relatively independently of environmental factors'. It was speculated that additionally migratory birds feel an urge for migration that is dependent on (prompted by environmental changes) or independent of, certain endogenous factor(s) rhythm particularly of the hormones secreted by the 'ductless' glands of the body which helps maintain an 'internal calender' that brings about a change in migratory restlessness (zugunruhe) and fat deposition (zugdisposition). They drive the birds towards migratory oscillation.



Fig. 2. Two individuals of a typical migrant in different periods. *Right* bird was caught in early wintering time, the *left* one prior to migration; note enormous increase in the subcutaneous fat deposition

Chronobiological assistance

In order that the endogenous factor(s) rhythm, particularly of the hormones and other essential chemical components may directly synchronize with the environmental abiotic rhythms (viz., seasonal/daily fluctuations in day length, temperature, etc.); there is a certain time-keeping machinery known as the 'biological clock' or the internal chronometer. The most promising components of this time-keeping machinery in the birds are brain neurones and the pineal gland, an essentially humble organ situated beneath the dorsal meninges of the skull. It has also been found that pinealectomy abolishes migratory restlessness, so typical feature of the migrants.

Final pathway—Endocrine regulation

Scientists of the present decade

all over the world through experimental reseazch are of the opinion that the exogenous cues and the endogenous (daily=circadian; annual=circannual) rhythmicity guided by the time-keeping machinery are the controlling devices of the migratory activity.

However, the final outcome of synchronized wish of these two most important and obligatory devices is materialised by the endocrine complex of the individual that prepares migrants physiologically for the distant flights to and fro.

As a fundamental component of this endocrine complex, the brain neurones particularly of the hypothalamic origin serve as the key for locking and unlocking the pituitary gland to regulate the endogenous hormonal rhythm of different glands like gonads, adrenal and thyroid. They all act in concert to prepare the bird for migratory flight. Experiments so far have confirmed that 'prolactin'—an anterior pituitary hormone, possibly plays the 'big brother' role amongst the hormone family as a whole. Prolactin can induce fat deposition and migration activity which resemble in magnitude and temporal pattern to that of premigratory period; gonadotropic and adrenocorticotropic hormones of the pituitary are also synergistic with prolactin in fattening and restlessness respectively. Since migration is always parallel with gonadal development or regression, gonad and its hormone do have some influence on the behaviour and disposition of migrants.

SANJIB CHATTOPADHYAY
SUBRATA CHAKRABORTY
SAUMEN MAITRA
Histophysiology Laboratory
Zoology Deptt.
Calcutta University
35, Ballygunge Circular Road
Calcutta- 700019

LETTERS (*Continued from page 68*)

Leaves are a very important class of vegetables, but are much neglected despite the fact that there are perhaps thousands of edible tropical leaves. Highly productive and nutritious leafy vegetables are either perennial or annual. The perennials are easy to grow and yield more per unit area than most food plants. Leaves are always available because they are produced continuously. The annual species often grow quite rapidly and produce for a much longer time.

Leaves are the best plant source of calcium and iron. Vitamin A deficiency is common in the Tropics and is the principal cause of irreversible blindness among children. Yet all leaves contain provitamin A (carotene). Some leaves are particularly rich in it (dark-green leaves are usually the best source). Vitamin A requirements can be fulfilled by including a normal portion of green leaves in the daily diet. Since leaves often contain vitamin C also, a person can fulfill all of his vitamin A and C requirements by eating 100 grams of the right leaves daily.

Some leaves cotain toxic substances perhaps the most common of which is oxalic acid. Leaves that have a high oxalic acid content should not be eaten daily. Oxalic acid interferes with the body's uptake of calcium and if ingested too often could lead to chronic calcium deficiency. A few leaves contain glycosides of hydrocyanic acid and must be cooked 10 to 15 minutes before use.

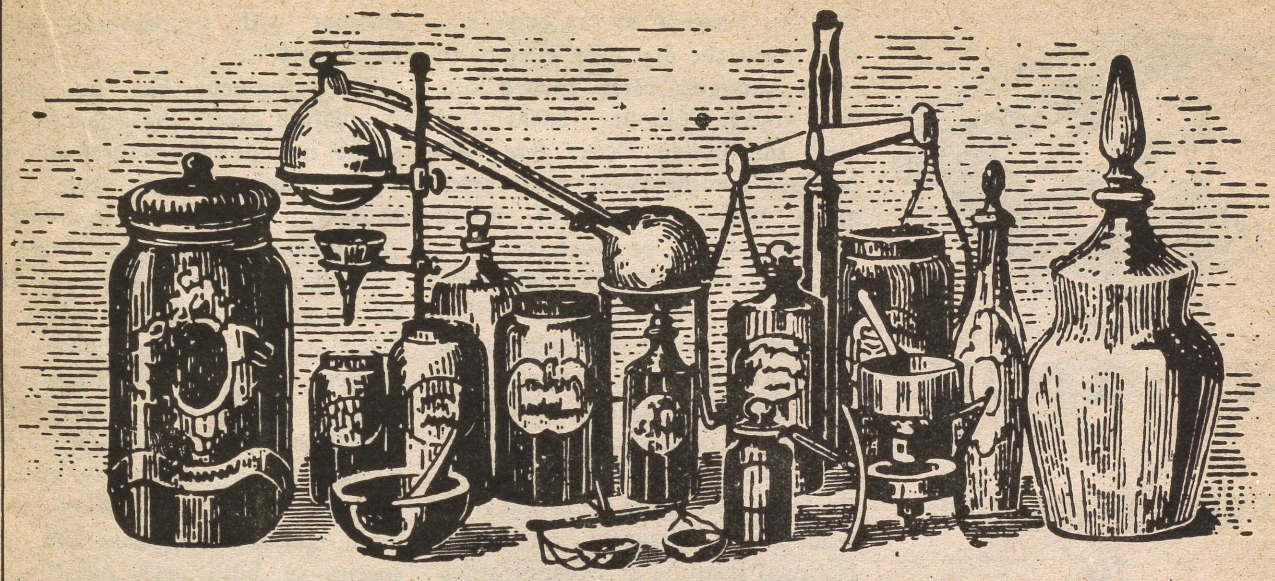
D.N. SEN
B.K. SINGHAL
Botany Dept., Jodhpur Univ., Jodhpur 342001

Blood as a growth promoter

SIR, the practice of application of blood to the roots of grape plant (*Vitis* sp. family *Vitacae*) is very common in the plains of Punjab, Haryana, Delhi and Uttar Pradesh, where there are plenty of slaughter houses or at places where there is excess consumption of mutton. Usually about 250 ml of blood is given per plant at intervals of one month, from about 3 months before the start of fruiting season. The first dose is given just after the appearance of the first leaf, i.e., root initiation. It would not be out of place to mention here that the soil at the base of the plant is irrigated and aerated about 12 hrs. before putting in blood. It has been observed that the leaves turn dark green and become bigger and more numerous. The length of internodes also increases considerably. There is also significant change in quality (taste) and size of the fruit. Often double and sometimes triple yield of fruit can be obtained which is more than yield from plants manured with compost only.

No specific dose of blood per plant is known yet. But it can be determined by research. Once standardised, the use of blood as growth promoter for grape cultivation can revolutionize the brewery industry.

S.D. LAL
Deptt. of Botany, Kurukshetra University, Kurukshetra-132119
DEEPAK SHARMA
Deptt. of Zoology, Kurukshetra University, Kurukshetra-132119



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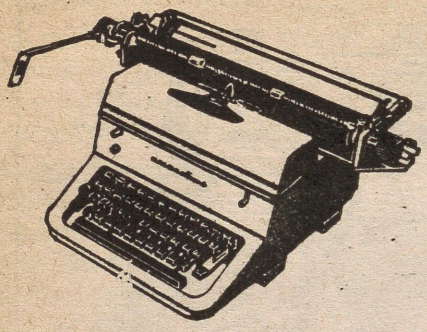

NEWS & NOTES

Indian expedition to Antarctica

WITHIN a year of their first haul of precious undersea metallic nodules from the depths of Indian Ocean, Indian oceanographers achieved yet another historic success—they conquered Antarctica, world's coldest, driest and stormiest continent. The success came on the night of 9th January when a scientific team led by Dr. S.Z. Qasim landed on the shores of the southern continent after a gruelling 33-day cruise from Goa. The ship was a small 600-tonne Norwegian ice-breaker *Polar Circle* chartered by the team. The expedition was a joint effort of a number of different organisations with the Council of Scientific & Industrial Research as the lead organisation. The whole project was funded and coordinated by the newly created Department of Ocean Development of the Central Government. The Indian Navy with its two helicopters and a 8-member team provided medical, photographic and logistics support.

Strictly speaking, this was not the first time Indians have landed on Antarctica; a few had earlier gone there as part of other expeditions. But this was the first time that a full-fledged Indian scientific expedition has made it to the continent. Also it was the first ever attempt to reach Antarctica after such a long sea voyage (about 18,000 km) from the Indian Ocean side. All previous landings were made from much nearer shores of South America, Africa or Australia.

The 21-member expedition team comprised 13 scientists from various departments and a 8-member team from the Indian Navy. The scientists were Dr. S.Z. Qasim, Secretary Department of Environment, Leader, C.P. Vohra, Deputy Director, Geological Survey of India and H.N. Siddiquie, Assistant Director, National Institute of Oceanography, deputy leaders, R. Sen Gupta, E. Desa, A.H. Parulekar, M.C. Pathak, D.V. Rama Raju and S.G.P. Matondhar (all of NIO), A.K. Sharma and K.N. Katyal (Indian Meteorological Department), Amitabha Sen Gupta (National Physical Laboratory) and R.V. Iyengar (Indian Institute of Geomagnetism).

After rigorous acclimatisation in sea and in the frigid Himalayan conditions, the team sailed out from Goa on 6th December, 1981. The first lap was from Goa to the Indian Ocean island of Mauritius. After refuelling at Mauritius the team started its second lap through one of the world's roughest and most dangerous of the high seas—the Roaring Forties—before reaching the fringe of the icy continent shortly before midnight local time on 9th January 1982. As it was midsummer in Antarctica, a golden sun low on the horizon greeted the Indian team.

Antarctica, a vast desert of snow and ice, is the fifth largest continent of the world. With an area of more than 14 million sq. km, it is larger than the size of India and China put together. Its ice cover is at places more than 4.5 km thick. Summer temperature in Antarctica normally ranges between −10°C to −20°C. But the Indian team experienced an unusually 'warm' summer with temperatures often touching 0°C.

The continent has no native population except the scientific personnel manning the several stations. Their number ranges from 1700 to 2000 in summer and from 600 to 700 during winter when there is total darkness for six months. The land is completely barren except for a few species of mosses, lichens and grasses. There are also the friendly penguins which freely entered the tents of the Indian expedition. Other animal life recorded by the expedition include two species of seals, three species of whales and one species of bottle-neck dolphins.

During its 10-day stay, the team members carried out a number of expriments and collected specimens for analysis. They analysed more than 1500 samples and brought back many more. Rock samples brought back for a closer secrutiny is expected to provide valuable clue about the Gondwanaland hypothesis of continental drift according to which India and Antarctica was once part of a single large landmass. The data collected during the expedition would help in studying the climate and pollution levels in the southern Indian Ocean and the Antarctic sea. Meteorological observations carried out included measurement of temperature, pressure, wind speed, humidity, ice formation and also studies on upper atmosphere and propagation of radio waves. Oceanographic studies indicated a rich potential of marine food resource, especially of shrimp-like animals known as krill around the Antarctic sea. The data are still being processed and the final report is expected by the year end.

Before returning, the expedition set up an unmanned weather station at a rockey plateau about 80 km inland from the base camp which it named Dakshin Gangotri. The station is equipped with continuous weather recording instruments

powered by Indian-made solar cells and storage batteries. The records, made on special magnetic tape cassettes, are to be recovered by the next Indian expedition planned for later this year.

BIMAN BASU

Indian Science Congress—1982

"BASIC Research as an Integral Component of a Self-reliant Base of Science and Technology" was the focal theme for the 69th session of the Indian Science Congress in Mysore. Symposia, public lectures, paper reading sessions and a whole-day plenary session organised during the Congress, all highlighted the need for more basic research keeping in view the long-term perspective of national development.

The tone of the six-day session was set by Prof. M.G.K. Menon in his presidential address on January 3. He said, a crucial element of self-reliance, in a world whose economy and lifestyles are dominated by scientific and technological advances, has to be a self-reliant base of technology. And this base cannot be built without at the same time doing significant basic research. Differentiating basic research from applied research, Prof. Menon said that basic research had to be supported in educational institutions which he lamented had been allowed to be run down badly in recent years.

Prof. Menon made it clear that basic research does not mean any research that is carried out which does not qualify as applied research. Basic research, he said, is characterised by high quality and innovation. It is subject to a peer review, and must arise from a deeper urge to find out. It must in the ultimate be competitive at a truly international level.

There are certain areas of thrust in basic research which are of interest scientifically, and at the same time has relevance in terms of possible tangible fruits in the not too distant future. Prof. Menon cited a few examples to illustrate his point. Researches in genetic engineering, for instance, may eventually enable man to develop crop plants that can fix atmospheric nitrogen like the bacteria in root nodules of leguminous plants do obviating the need for chemical fertilisers. Researches in photobiology may enable us to improve the efficiency of photosynthesis by plants thereby increasing biomass production substantially for future energy needs. Then there are problems of diseases in plants. Pesticides pollute the environment. Researches in insect physiology may lead us to a better method of pest control without pesticides. The newly emerging discipline of biotechnology holds tremendous promise for the future. A range of interesting chemicals and pharmaceutical products may be produced using the new technologies for application in a wide range of areas including agriculture, animal and human health and population control. All these can be achieved only through more basic research.

Speaking about the role of the Indian Science Congress in fostering basic research Prof. Menon said, the Congress should not be a place for reporting of routine measurements or for discussing pedestrian details of science policy. It should be a forum to generate a sense of enthusiasm and elan in the scientific community. Basic research always happens to be an area of innovation, originality and excitement. The Science Congress should attempt to focus in this direction if it is to be dynamic and relevant and excite the young minds.

Earlier, inaugurating the session the Prime Minister Mrs. Gandhi spoke of the many achievements of Indian science in the recent past. In the past year, she said, our space scientists brought credit to themselves and to our country. They showed what Indian science could achieve with clear goals and team work. In this context she mentioned the launching of APPLE and Bhaskara, the experiments at Kolar Gold Fields and the first Indian Expedition to the Antarctica.

Mrs. Gandhi also announced a number of initiatives taken by Government to streamline research in science and technology in the country. Among them are the setting up of the Science Advisory Committee to the Cabinet and the Cabinet Committee on Science and Technology. On the recommendation of the SACC, she said, Government have decided to launch a three-pronged programme to remedy unemployment among qualified scientists and technologists. Another initiative taken at the instance of the SACC is the formation of a National Biotechnology Board.

Referring to problems faced in basic research in India, Mrs. Gandhi said "Grant-givers tend to relate allocations to tangible results. In basic research, results are not measureable." She expressed the hope that scientific leaders, on whose advice grants are given, would be sensitive to young and non-conformist talent.

A special feature of this year's Science Congress was a whole-day plenary session on the focal theme on January 4. Held in the spacious Crawford Hall of Mysore University,

it drew a packed house. After introduction by the General President Prof. Menon and remarks by Mr. C.P.N. Singh and Prof. Nurul Hasan, a galaxy of our leading scientists spoke on the focal theme. Each spoke about his own area of research; together they illustrated how basic research was fundamental to many of our past achievements in agriculture, health care, medicine, materials science and nuclear power development. Among those who spoke at the plenary session were Dr. Cyril Ponnamperuma, Dr. M.S. Swaminathan, Prof. V. Ramalingaswami, Prof. A.K. Sharma, Prof. C.N.R. Rao, Dr. S. Varadarajan, Dr. S. Ramasheshan and Dr. Devendra Lal.

Some of the sectional presidential addresses were interesting and informative. In the Section of Botany, Dr. T.N. Khoshoo of the National Botanical Research Institute, Lucknow gave an illustrated talk on "Energy from Plants: Problems and Prospects". Describing the enormous potential of plants as a source of renewable energy, he disclosed that over 385 species of potential 'Petroleum plants' have been identified in India which can yield oil or high quality liquid fuel after conversion. The plants have been identified by scientists of NBRI and the Indian Institute of Petroleum, Dehradun under a joint screening programme. The two institutions have now prepared a preliminary list for assessing the hydrocarbon content and amenability to cultivation of the prospective plants. Dr. Khoshoo estimated that by 2000 A.D. India's entire diesel requirement for water pumping and rural industry could be replaced by renewable materials from plants.

In the Section of Engineering Science, Prof. T.R. Anantharaman of Banaras Hindu University gave an interesting talk on "Rapidly Solidified Metals." Rapid quenching of molten metals, he said, gives rise to a unique class of materials with unusual physical properties. Known as 'metallic glass', these materials are unbreakable like metal and at the same time uncorrodable like glass. Prof. Anantharaman's team at the BHU Institute of Technology has developed an advanced technique for producing metallic glass which, he claimed, was better than the American and Soviet techniques. One of major applications of these materials, said Prof. Anantharaman, could be in electric transformers where it could cut down power transmission losses by as much as 50 per cent to 75 per cent.

As always, the evening public lectures drew large audiences. On January 3, Dr. Raja Ramanna, Director, Bhabha Atomic Research Centre, gave an illustrated talk on "Nuclear Future" in which he dealt with the future of nuclear energy in India. He pointed out that India's future nuclear power programme depended on breeder reactors which could make use of our nuclear fuel reserves to the maximum. But the technology is not fully developed. A lot of basic research is needed to find out all about breeders. After breeders, Dr. Ramanna said, the next step would be to go in for fusion energy and accelerators for producing high energy particles. He ruled out accelerators and fusion reactors in the immediate future because of their high cost and technological constraints. But he made it clear that only nuclear energy can meet our future energy needs.

Dr. Cyril Ponnamperuma, the renowned chemical evolutionist from USA gave a delightful talk entitled "How did life begin?" With the help of beautiful slides he narrated the exciting discoveries that have led to new clues to chemical evolution of life. The evidence came not only from the rocks on earth but also from deep space—from interstellar space and meteorites, the stoney visitors from outer space.

The 19th B.C. Guha Memorial Lecture was delivered by Dr. H.K. Jain, Director of Indian Agricultural Research Institute. Speaking on "India's evolving agriculture—Genetic reconstruction and phenotype gap" he said modern agriculture, like modern industry, was not only technology and input intensive but depended heavily on management support. In his opinion "agriculture must become a joint venture with the Government for the millions of small and marginal farmers if the average agricultural yield in India were to become comparable to those of the developed countries. Government, he said, could take over the responsibility of providing to farmers at minimum cost a wide range of agro-services which he called the "missing link" in Indian agriculture. He said this missing link was responsible for the low average yields despite significant progress in development of high yielding varieties of crops.

A new feature of the Mysore session was the institution of 20 awards for young scientists by the Indian Science Congress Association. The cash awards of Rs. 3,000 each are to be given every year to young scientists selected on the basis of their presentation of papers at a special session. The General President Prof. Menon announced the names of 19 awardees for this year at the valedictory function on January 8. He said the awards are basically intended as recognition of talent; but they would also help meet the travelling expenses of young scientists attending the sessions of the Science Congress to present papers and to enable them buy small equipment for research.

The 70th session of Science Congress next year is to be held at Tirupati under the Presidentship of Prof. B. Ramachandra Rao, Vice-Chairman, University Grants Commission.

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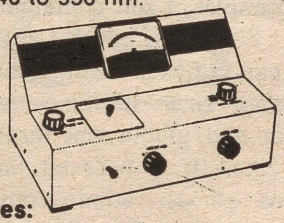

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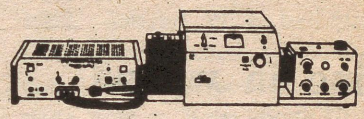

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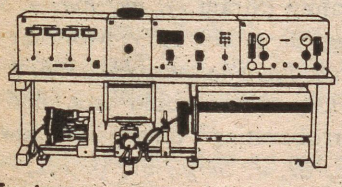

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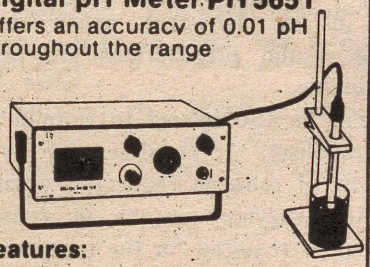

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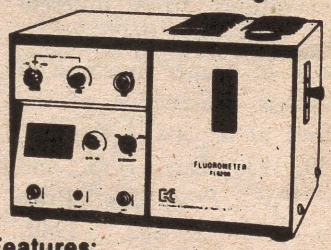

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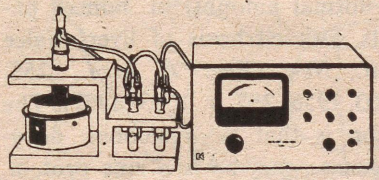

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- Determination of mercury in nanograms
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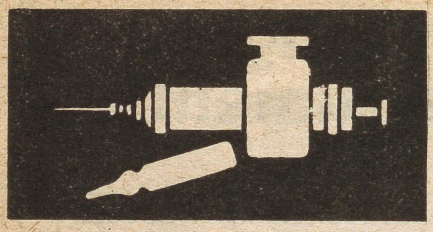

MEDICAL NOTES

Zinc in wound healing

THE involvement of zinc in animal nutrition has been known since 1934, when scientists reported that animals maintained on diets containing only 1.6 mg of zinc per kilo of ration suffered from poor body and fur growth (Todd *et al., Am. J. Physiol.*, **107**, p. 146, 1934). Later other observations from different laboratories confirmed the requirement of zinc in proper nutrition in animal systems irrespective of the species (Hove *et. al., Am. J. Physiol.*, **124**, p. 750, 1938; Day, H.G. and McCollum, E.V., *Proc. Soc. Expl. Biol. Med.*, **45**, p. 282, 1940; *J. Nutrition*, **33**, p. 27, 1947).

In human system also zinc plays a significant role in nutrition. After absorption which occurs mainly in the small intestine, specially from the duodenum, zinc is widely distributed in the tissues of the body. Adult human body contains about 1.5 gm to 2.5 gm of zinc of which approximately 20% is present in the skin. Bones and teeth contain considerable amounts of zinc. Zinc is also stored in liver (to some extent) and can be accumulated in spermatozoa, prostrate, and epididymis. Physiological importance of zinc appeared in the literature when it was observed that carbonic anhydrase (mol. wt. 30,000), a vital enzyme present in red blood cells, parietal cells and renal tubular cells in many animal species, contains one Zn^{++} per molecule (Keilen, D. and Mann. T., *Nature*, **144**, p. 442, 1939). Superoxide dismutase present in the cytoplasm of liver, brain and blood cells, leucine aminopeptidase of intestinal juice, carboxypeptidase A of pancreatic juice, alcohol dehydrogenase of mammalian liver and many others are examples of zinc-containing enzymes. Zinc is an integral and essential part of the insulin molecule. Protamin zinc insulin, isophane insulin and globin zinc insulin contain zinc. It is believed that exogenous glucose administration increases release of insulin and simultaneously lowers the zinc content of pancreas. The zinc content of pancreas also falls during diabetes mellitus, indicating the participation of zinc in the storage and secretion of insulin. However, active zinc-free insulin preparations are now available.

Zinc is also related to vitamin A metabolism. It regulates the synthesis of retinene reductase, a zinc metallo-enzyme present in retina, which is required for the reconstitution of retinene, i.e., vitamin A aldehyde, during the rhodopsin cycle. Further, zinc may stimulate the release of vitamin A from the liver into blood and thus increase its concentration in plasma. Researches have shown that there is increased urinary zinc excretion (about double the normal amount) in human patients with cirrhosis of liver(Valee *et al., New. Eng. J. Med.*, **255**, p. 403, 1956; **257**, p. 1055, 1957). The reason is that since alcohol dehydrogenase enzyme is a zinc protein, the continued use of alcohol may alter the enzyme in some way leading to excretion of zinc in the urine. Zinc is also required for normal growth, development of skin and full reproductive maturity (Tucker, H.F. and Salmon, W.D., *Proc. Soc. Exp. Biol. Med.*, **88**, p. 613, 1955).

Although the role of zinc in nutrition is well established, its involvement in wound healing in nutritionally normal individuals has remained controversial. As early as 1958, it was suggested that topical zinc sulphate stimulates healing of indolent ulcers (*Extrapharmacopoeia*, Vol. I., Edn. 24, p. 1248, London, The Pharmaceutical Press). Since then a number of contradictory reports related to the involvement of zinc sulphate in wound healing have appeared in the literature. While some suggested that in human system, zinc deficiency relates to poor wound healing (Pories *et al., Ann. Surg.*, **165**, p. 432, 1967; Serjeant *et. al., Lancet*, Vol. ii, p. 891, 1970). Others challenged the claim (Barcia, P.J., *Ann. Surg.*, **172**., p. 1048, 1970; Myers *et al., Am. J. Surg.*, **120**, p. 77, 1970). Animal experiments also differed in their result. When experiments from different laboratories indicated the beneficial effects of addition of zinc in wound healing (Strain *et. al., Eur. J. Surg., Res.*, **3**., p. 279, 1971; Morton *et. al., Arch. Int. Pharmacodyn.*, **196**, p. 117, 1972), others could not find any corroborating data (Groundwater, W., *Br. J. Surg.*, **57**, p. 222, 1970; Norman *et. al., J. Nutr.*, **105**, p. 815, 1975). Rather there are reports which suggest that zinc sulphate did not influence the wound healing in control animals whose wounds were allowed to progress normally (O' Rian *et al., Br. J. Plast. Surg.*, **21**, p. 240, 1968; Oberleas, D., *Am. J. Surg.*, **121**, p. 566, 1971). This controversy which is also valid in case of vitamin A when involved in healing procedure of wounds might be due to the differential action of zinc on wound healing (Hunt, T.K., *Ann. Surg.*, **170**, p. 633, 1969).

To verify this, recently a group of Indian workers from Pharmacology Department, J.N. Medical College, Belgaum (Karnataka) had undertaken a study on the influence of zinc sulphate on normal and steroid depressed wound healing in rats, rabbits and guinea-

(*Continued on page 124*)



SCIENCE FOR THE YOUNG

Diurnal motion in a bath tub

I think all of us are acquainted (at least through cinema) with the bathtub in a modern bathroom, where a person can get himself immersed in water during bathtime. What happens when the bath is over? The plug inserted into the hole at the bottom of the bathtub is taken out and water flows out.

If one observes the flowing out of water with a little care, one will find a small but significant phenomenon. The running water forms a vortex on the surface of water, it spins round as it goes out; and the direction of whirling is always anticlockwise.

India is situated in the northern hemisphere, that is, on the northern side of the equator. There are also many countries in the southern hemisphere, and big cities like Buenos Aires, Lima, Cape Town, Sydney, etc., are all situated south of the equator. What happens when the plug is taken out from a bathtub in these cities? Here, the water does flow out spinning, but the direction of spin is different. The water spins in a clockwise direction.

Equador is a country in South America. Its capital city Quito is situated right on the equator. If anyone in that city removes the plug of a bathtub after bath what does one observe? The water goes down through hole all right, but it does not spin!

You must be wondering, what is the matter? Who spins the water in the bathtub? Wind? Or is it something else? Why is the direction of the spin different in the two hemispheres? Why is no spin observed on the equator.

All these questions once puzzled scientists. In order to find out the correct answer, Professor Ascher H. Shapiro, Head of the Department of Mechanical Engineering at the Massachusetts Institute of Technology, U.S.A, did an experiment in 1962. Instead of a bathtub, Professor Shapiro used an enormous saucer, 2 metres across but only 15 cm, deep with a hole about 10 mm in diameter exactly at the centre. He placed the saucer in a dark, almost airtight compartment and filled it up with water. After allowing the water to settle for 24 hours, he opened the plug and found that the water flowed out spinning in the anticlockwise direction. Professor Shapiro's laboratory was in the northern hemisphere.

In southern hemisphere, Professor Shapiro's experiment was repeated



Fig. 1. All places on the earth's surface do not move with the same velocity. A and C which are away from the equator move slower than B which is on the equator. Due to this, bath tub water spins anticlockwise at A and clockwise at C. There is no spin at B.

by L.M. Trefethan and others of the University of Sydney, Australia. They placed a circular tank, 2 metres in diameter and 23 cm deep with a central outlet hole in a basement room with no windows. A uniform temperature of 20°C was maintained in the room throughout the experiment by thermostatic control. The tank was filled with water and covered with two plastic sheets, leaving only a small slit for observation. After allowing the water to settle for 18 hours the experimenters opened the plug and observed through the narrow slit to their astonishment that the water swirled in a clockwise direction while it flowed out!

The last experiment was conducted in a hotel bathroom at Nanuki, a small town in Kenya. The hotel is situated just on the equator. A bathtub in the hotel was filled up with water and paperdust was sprinkled on the surface. When the plug was pulled out, water alongwith the paperdust went straight down the drain without spinning in any direction.

Now, here is the explanation: The earth is spinning round its own axis, once in about 24 hours. Angular velocity of this diurnal motion is equal everywhere on the surface, viz., 360° per 24 hours, but not so the linear velocity. Linear velocity is maximum on the equator where the surface of the earth moves eastwards with a velocity of 1600 km per hour. As we move away from the equator, towards the north or south, the velocity diminishes proportionately. In Delhi, where the latitude is about 29°. 30′ North, this velocity is 1133 km per hour.

Now, if one constructs a giant sized bathtub whose southern part touches the equator and northern end is in Delhi, then water on the southern part will move eastwards with a velocity of 1600 km per hour, whereas that on the northern end will move with a velocity of 1133 km per hour in the same direction. Due to this difference of velocity an anticlockwise spin is imparted to the water as it drains away.

Though in practice no bathtub of such large dimension is possible to construct, this principle is applicable to any smaller bathtub. In the northern hemisphere southern part of any bathtub moves with a velocity slightly greater than that of the northern part. Similarly in the southern hemisphere, northern part of a bathtub moves faster than the southern part. So in the northern hemisphere, bathtub water spins anticlockwise whereas in the southern hemisphere, it is spun in the reverse direction. On the equator both ends of the tub move eastwards with the same velocity of 1600 km per hour. So there is no spin in the outflowing water.

The bathtub experiment has close resemblence to the classical experiment conducted by Jean Foucault in Paris in 1850. Foucault suspended a heavy weight on a long rope from the hook in a high ceiling in such a manner that the weight hung exactly over the centre of a circle on the floor graduated into 360 subdivisions with 0° as the true north. He set the 'pendulum' swinging from 0° to 180° (i.e., North-South) across the circle and observed with astonishment that this to-and-fro motion of the weight changed direction anticlockwise from 0°-180° axis, after sometime, towards 1°-181° axis, 2°-182° axis and so on. Here too the spin is imparted to the pendulum by the earth's rotation as in the case of the bathtub water.

PRATAP CHATTOPADHYAYA
Taki Govt. College
Taki, 24 Parganas
(West Bengal)

The fascinating world of the number 142857

WHEN one divides 1 by 7, one gets, after a decimal sign, the mysterious number 142857 as many times as one can persue the calculation. This number has some interesting characteristics. For example:

142857 × 1 = 142857
142857 × 2 = 285714
142857 × 3 = 428571
142857 × 4 = 571428
142857 × 5 = 714285
142857 × 6 = 857142

In the above multiplications, the results contain the same digits as the number 142857 but arranged in cyclic order. That is why Shakuntala Devi, the human computer, named the number as 'revolving number'.

Recently, D.R. Kaprekar, the well-known mathematician, has pointed out another interesting property of the number. This is as follows:

$(142857)^2$ = 0 20408122449 (the number 0 is added on the left hand side to make the number of digits even). Now, divide the number 020408122449 into two halves. These are 020408 and 122449. When the halves are added together one gets the number 142857 again (020408 + 122449 = 142857).

The digits of the number 142857 when arranged in a cyclic order yield the numbers 428571, 285714, 857142, 571428, 714285 and 142857. The square of any of these numbers, Kaprekar has pointed out, when treated in the above manner, gives a number from the group of these six numbers. For example:

$(428571)^2$ = 183673102041 (the addition of 0 on the left hand side of

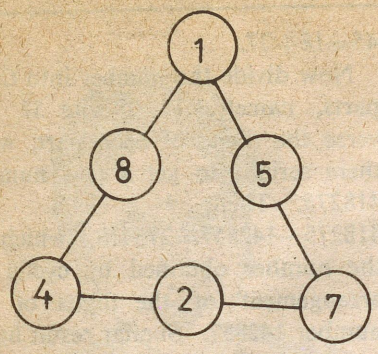

Fig. 1

the number is not necessary because it contains an even number of digits).

When the halves of the number 183673102041 are added together one gets, 183673+102041=285714.

The number 142857 has many other interesting properties. Each digit of the number is expressible by other two digits using addition and subtraction sign.

For example:

1=5−4
4=5−1
2=7−5
8=7+1
5=1+4
7=5+2

The number 142857 itself is also expressible by the help of its digits as follows:

$142857 = 7+5 \times 7 \times (8+2)^2 + 7 \times (8\times 2-1)^{4-1} + 5 \times (8+2)^4$

Now, put the digits of the number on the vertices and on the midpoints of the sides of a triangle as shown in Fig. 1. One gets the sum of the digits on each side of the triangle equal.

Divide the number 142857 into three numbers of two digits. They are 14, 28 and 57. Each of these numbers is expressible by other digits of the number. For example:

14=2×8+5−7
28=4×5+1+7 and
57=(4)×2+1+8
(4= 4 ×3×2×1)

The factors of the number 142857 are 3,3,3,11,13, and 37 which are prime numbers. Moreover, the factors add upto 3+3+3+11+13+37 =88 .....a palindromic number; (A number is said to be palindromic if it is the same number when viewed from the right hand side or left hand side. For example, 44, 121, and the like are palindromic numbers).

Also, 1×4 + 2×8 + 5×7 = 55
4×2+ 8×5 + 7×1 =55
1×4 × 2×8 + 5×7 =99
71+58+42=171
51+72+48=171
78+52+41=171
428+157=585 and
142+857=999.

All these are palindromic numbers.

Number-digit of a number is the digit obtained by adding the digits of the given number. If the sum of the digits of the given number contains more than one digit, repeat the procedure till a single digit is the result. For example, take the number 2475. The number digit of this number is 9 (2+4+7+5 = 18, i.e., 1+8=9).

Take the number 142857. Place below each digit, the number digit of the number formed by the other digits. So, one has to place the number digit of the number 42857, which is 4+2+8+5+7=26, i.e., 2+6=8, below the first digit 1.

Similarly, one has to place the number digits 5,7,1,4 and 2 below the digits 4,2,8,5 and 7 respectively. So, the new number obtained will be 857142. If one treats this number in the above manner one gets the number 142857 again, i.e.,

142857
857142.....new number
142857

Same holds true for the numbers obtained by the cyclic arrangements of the digits of the number 142857.

The devisors of the number 142857 except 1 and the number itself are 11, 13, 27, 37, 143, 297, 351, 407, 481, 999, 3861, 5291, 10989 and 12987. These numbers are expressible as the difference of squares of two numbers as follows. :

$11 = 6^2 - 5^2$
$13 = 7^2 - 6^2$
$27 = 6^2 - 3^2$
$37 = 19^2 - 18^2$
$143 = 12^2 - 1^2$
$297 = 21^2 - 12^2$
$351 = 20^2 - 7^2$
$407 = 24^2 - 13^2$
$999 = 32^2 - 5^2$
$3861 = 85^2 - 58^2$
$5291 = 210^2 - 197^2$
$10989 = 505^2 - 494^2$
and $12987 = 506^2 - 493^2$

Moreover, when all the divisors are multiplied it gives the number $(142857)^7$.

The number 142857 gives 9 in many different ways. The digits of the number add up to

142857 → 1+4+2+8+5+7=27→ 2+7=9

The sum of all the numbers from 1 to 142857 is equal to 102039 89796 which is also 9 as follows

10203989796→1+0+2+0+3+9+8 +9+7+9+6=54→5+4=9.

The missing digits, that is, the digits from 1 to 9, which are not in the number 142857 are 3, 6 and 9. The numbers formed by these digits are 369, 396, 693, 639, 963 and 936 respectively.

When any of these numbers are added to, subtracted from, or multiplied by the number 142857, one gets 9. For example, 142857+369= 143226 → 1+4+3+2+2+6=18 → 1+8=9;

142857—369 = 142488 → 1+4+2+ 4+8+8=27→2+7=9;

and

142857×369 = 52714233 → 5+2+7 1+4+2+3+3=27→2+7=9.

Now, divide the number 142857 into three blocks of equal number of digits. These are 14, 28 and 57. The number-digits of these blocks are 5, 1 and 3 respectively. The number formed by these number digits are 513, 531, 351, 315, 135, and 153. When any of these numbers are added to, subtracted from, or multiplied by the number 142957, it again gives 9. For example:

142857+513=143370→1+4+3+

$3+7+0=18\rightarrow 1+8=9$,
$142857-513=142344\rightarrow 1+4+2+3+4+4=18\rightarrow 1+8=9$,
and $142857\times 513=73285641\rightarrow 7+3+2+8+5+6+4+1=36\rightarrow 3+6=9$.
Also,
$21^2+45^2+78^2=8550\rightarrow 8+5+5+0=18\rightarrow 1+8=9$;
$15^2+24^2+78^2=6885\rightarrow 6+8+8+5=27\rightarrow 2+7=9$;
$51^2+42^2+87^2=11934\rightarrow 1+1+9+3+4=18\rightarrow 1+8=9$;
$18^2+24^2+57^2=4149\rightarrow 4+1+4+9=18\rightarrow 1+8=9$;
$12^2+84^2+72^2=12384\rightarrow 1+2+3+8+4=18\rightarrow 1+8=9$;
$21^2+48^2+27^2=3474\rightarrow 3+4+7+4=18\rightarrow 1+8=9$;
$81^2+42^2+75^2=13950\rightarrow 1+3+9+5+0=18\rightarrow 1+8=9$; and
$12^2+54^2+87^2=10629\rightarrow 1+0+6+2+9=18\rightarrow 1+8=9$.
Moreover,
$4257^2+18^2=18122373\rightarrow 1+8+1+2+2+3+7+3=27\rightarrow 2+7=9$, and
$4257^2-18^2=18121725\rightarrow 1+8+1+2+1+7+2+5=27\rightarrow 2+7=9$.
Similar result holds good for different numbers formed out of the number 142857 in the above manner.

Again, divide the number 142857 into three blocks of equal number of digits, the sum of which is 9, the digits being in ascending order of magnitude. These are 18, 27 and 45. Each of these numbers is expressible by other two. For example,
$18=45-27$,
$27=45-18$, and
$45=18+27$.

Now divide the number into three parts, namely, 14, 28 and 57. Reverse the digits of each part, write them serially to get a new number 418275. Then,
$418275-142857=275418$, which is the number obtained by cyclic rearrangement of the digits of the number 142857. Similar result holds good for the numbers obtained by cyclic arrangement of the digits of the number 142857.

Finally, when the number 142857 is multiplied by 7, it gives
$142857\times 7=999999$.

AJOY ROY CHOUDHURY
Deptt. of Mathematics
Karimganj College
Karimganj—788710 (Assam)

HOW BODY FIGHTS STARVATION (*Continued from page 96*)

which the ruminant's need for glucose is satisfied. The pregnant ruminant has greater demands placed upon gluconeogenesis due to the glucose requirement of the fetus, but the demand becomes even larger during lactation when glucose production increases by over 50%. The udder needs glucose for milk production; glucose is necessary for the formation of lactose and it provides glycerol phosphate for triglyceride synthesis and glucose-6-phosphate for the pentose phosphate pathway which generates NADPH for fatty acid biosynthesis. In an attempt to produce as much glucose as possible for milk formation, the animals sometimes develop "bovine ketosis" in which the ketone bodies in plasma rise very high and result in acidosis and toxicity. No problem of this nature is encountered in man.

Compared to adult animals, many species show marked hypoglycemia (low level of sugar in blood) immediately after birth. This, in all probability, reflects utilisation of glucose in excess of its formation possible at that time. Considerable evidence has accumulated to show that gluconeogenesis plays a significant role in meeting the glucose needs of the animal as soon as the readily available stores of liver glycogen are rapidly depleted in the immediate postnatal period. Premature babies often show symptomatic hypoglycemia, which continues perhaps due to the lag in the initiation of gluconeogenesis.

Conclusion

Gluconeogenesis is a significant metabolic event in higher animals in various physiological and pathological conditions. It ensures the supply of glucose to the brain even during starvation, so that the function of the organ is preserved. It achieves the recovery of carbon during exercise and metabolic acidosis. However, the process is not entirely economic in view of the energy transfer from high-energy phosphates necessary at the initial steps. The switch of the glycolytic liver to a gluconeogenic organ is an important transition in the post-natal development. In ruminants, gluconeogenesis is the principal means for providing glucose essential for milk production.

Degradation of amino acids to produce glucose should be viewed as a waste, since it involves loss of nitrogen as urea. Unfortunately, this is the situation in diabetes, fasting and glucocorticoid excess. However, in prolonged starvation muscle proteins are relatively conserved and amino acid gluconeogenesis gradually declines. These effects together with brain's shift from glucose to ketone bodies as its main oxidative fuel contribute to the surival of the organism.

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FOR HER

Why women are fatter than men

ONE of the normal body tissues is adipose tissue or fat. We have internal fat storage areas, mainly in the abdominal cavity. A certain amount of fat is healthy and normal, but the question is how much?

Excess fat in body is deposited both subcutaneously, leading to flabby skin, and intrà-abdominally, producing the familiar "Pot bellies". In women, the bust, buttocks, and thighs, which naturally contain more subcutaneous fat than those of men, are often sites for excess deposition (Fig. 1).

It is often said that this uneven distribution of female fat evolved because of its sexual attractiveness to males. The significance, however, lies not in the distribution of female fat but in its quantity. The role of fat in women, as one might expect, is closely tied to reproduction. A certain amount of body fat seems necessary in order to release eggs. Excessively lean women may be sterile for this reason. This may be nature's way of protecting both mother and child. A glance at Table 1 shows that pregnant women need more calories; if food supplies temporarily fail, adequate maternal fat stores can be mobilized to see mother and child through the crisis.

Table 1. Recommended (approx.) daily dietary nutrients for adults

	Male	*Female*	*Female (pregnant)*
Total calories	2700	2000	2300
Total protein (g)	56	46	76
Unsaturated fatty acids (g)	6	6	6
Fat-soluble vitamins (mg) (A, D, E, K)	55	52	55
Water-soluble vitamins (mg) (B&C)	470	465	885
Minerals (mg) (Calcium, Phosphorous and Magnesium)	1950	1900	2850

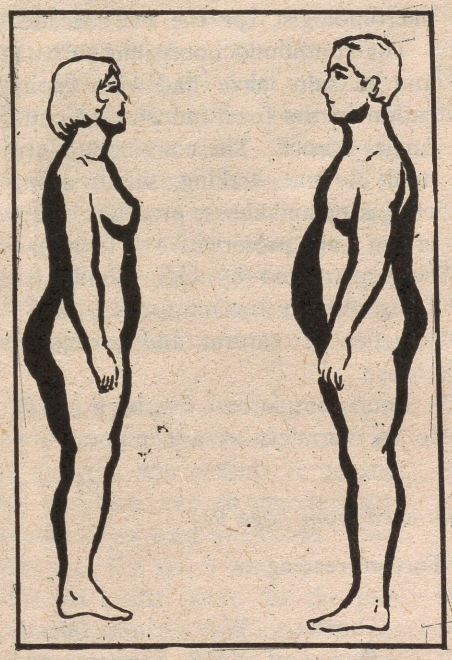

Fig. 1. Sites of fat deposition on obese men and women

In general, fat men suffer more often from heart disease, diabetes, and other disorders. The diet of the overweight too, is often slanted towards foods that increase blood lipid levels, which may be correlated with fat deposition in the arteries, or "atherosclerosis". Nearly every case of obesity is caused by "hyperphagia" or overeating.

G. RAJARAMI REDDY
L. MANIRAJ BHASKAR
S.V.U.P.G. Extension Centre
Kavali-524 202(A.P.)

Preservation of butter

BUTTER is a familiar article on the dining table practically in all the countries. It is mainly produced from cow's and buffalo milk and also to some extent from the milk of other animals. It is a mixture of milk fat, butter milk and water usually with salt and added colour containing not less than 80 per cent by weight of milk fat.

Keeping quality of butter is of interest to all butter manufacturers and consumers alike. In spite of the comparative stable character, butter undergoes spoilage and deterioration in quality due to the influence of chemical agents and microbial activities. Chemists attribute the spoilage of butters to various factors such as storage temperature, sunlight, moisture and metallic contamination. During storage oxidation of fatty acid esters is believed to be responsible for the spoilage. But microbiologists trace the cause of deterioration and spoilage in erratic enzymatic activities of microorganism, which give rise to the development of hydrolytic rancidity and other defects in butter. The undesirable consequences such as decomposition of fats, proteins, and

lactose, take place generally in water phase due to microbial activity.

Mold growth on butter is rather a widespread and serious problem. The grown of this group of organism is favoured by high humidity and comparatively low temperature. These organisms are highly aerobic in nature and grow readily on humid surfaces resulting in rancid, moldy flavour and other defects in butter, making it unacceptable for human consumption. Among the bacteria probably *Escherichia coli* is of prime importance, as spoilage organism of butter. The cause may be attributed to unclean water supply and unhygienic procedures of production. Strict hygenic control in the manufacture of butter and proper care in the packaging and transport in summer months can, to a large extent, reduce the chance contamination of butter by microorganisms.

Traditionally sodium chloride is added to increase the shelf life of butter without any adverse effect on its nutritive value, texture and taste. With the advancement of knowledge the property of sodium chloride (common salt) as a bacteriostatic and fungistatic agent has been found to be limited. Search for better substitutes of sodium chloride had been engaging the dairy microbiologist for the last decade.

The compound potassium sorbate and its salts have had wide application in the food industry as antifungal agents. These are commonly used in wine, baking, salad, meat, margarine and cheese products. This is the only preservative which has been permitted by U.S. Food and Drug Administration for use in 27 varieties of natural and processed cheese.

Potassium sorbate has been found to be harmless as a compound of food because of its outstanding quality in comparison to other fungistatic agents and its nontoxicity in dietary constituents. The widely acclaimed quality of this compound as fungistatic agent was studied with respect to butter by the authors. The effect of addition of potassium sorbate alone was found to be less pronounced on the inhibition of the growth of mold irrespective of storage temperature. The study revealed that the addition of potassium sorbate alongwith sodium chloride in butter reduces the release of free fatty acids, brings about a check on microbial population of butter and thereby enhances the shelf life manyfold to the great benefit of both manufacturers and consumers.

AJAY KAUL
JASJIT SINGH
Division of Dairy Bacteriology
National Dairy Research, Institute
Karnal (Haryana)

ORGANIC MOLECULES (*Continued from page 91*)

and thermodynamic parameters of such conformational exchanges could be determined by variable temperature NMR spectral measurements. In recent years extensive use of high resolution NMR has been made to study the conformational changes in both cyclic and acyclic molecules. Barriers to various rate processes have been determined in the range of 5-25 Kcal/mole. Large barriers occur in the stereoelectronically hindered rotation about single and partial double bonds, hindered inversions of atoms like nitrogen, sulphur, etc., and strained ring inversions.

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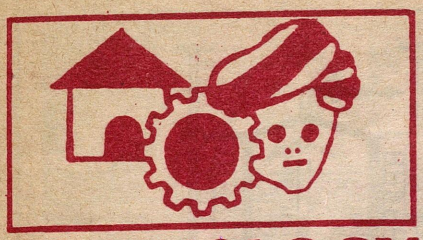

TECHNOLOGY FOR VILLAGES

An improved gobar gas plant

METHANE gas, a combustible fermentation product of cattle dung, has been used as a domestic fuel and had been suggested as an energy source in India as far back as the 1930s at the Indian Agricultural Research Institute, then the Imperial Agricultural Research Institute, Delhi. Original contributions on the designing of the gobar gas plant are those of Professor N.V. Joshi and Jashbhai Patel. Patel's III design of 1951 was adopted by the Khadi & Village Industries Commission (KVIC) a decade later. By the end of 1974, over 7000 of such plants had been installed under many village-development programmes. The number of such plants has shown a manifold increase recently.

The KVIC plant has two main parts, viz., a digester and a gas holder (Fig. 1 *Left*). The digester, in which fermentation of cattle dung takes place is dug below the surface level like a well. It is brick lined and made water proof with cement. The dimensions vary according to the gas generating capacity and the quantity of raw material fed daily. The digester is vertically divided into two semi-cylindrical parts by a brick-wall partition. The raw material is fed in the form of a slurry (dung: water=4:5) from an inlet chamber to the bottom of the digester by means of a cement pipe. Initially the first semi-cylindrical half fills with the slurry and after several days of use it overflows into the second half. The second semi-cylindrical half is connected to the outlet chamber through a cement pipe, which is at a little lower surface level than the inlet chamber. Slurry from the outlet chamber is directed to compost pit. When both the semi-cylindrical halves are full of slurry, if more raw material is added from the inlet chamber, an equal amount of exhausted slurry flows out of the outlet chamber and the process continues.

The gas holder, usually a mild steel drum, fits in the upper part of the digester, where there is no vertical partition, like an inverted cup. Because of its own weight gas holder sinks into the slurry and rests on a projected collar made for the purpose. Upon fermentation, the gas bubbles collect in the gas holder and due to gas-pressure the holder rises and floats freely on the surface of slurry. A delivery valve is fixed at the top of gas holder for distribution of gas. The gas holder is held straight with the help of a guide pipe fitted in the centre of the frame and is fixed at the bottom in the masonary work.

In the KVIC design the gas holder, made from mild steel, suffers the problem of fast corrosion as it comes in direct contact with the slurry. Other materials like ferro-cement, reinforced polyester, treated wood, plywood, plastic, polythene with bamboo-basket reinforcement, etc., have been tried for the gas holder; but none has proved to be a suitable replacement for mild steel.

For mild steel gas holder, KVIC has suggested both mechanical and chemical treatments to partially overcome the problem of corrosion. In mechanical treatment, daily cleaning of scum around the holder is suggested as a preventive measure. Whereas chemical treatment involves coating of synthetic enamels. But scratches to the surface increase the rate of corrosion. Besides, this, long-time contact with slurry deteriorates the enamel itself. This leads to an increased maintenance cost.

In view of the above problems of treatment of gas holder and in order to cut down the maintenance cost of the plant. The KVIC gobar gas plant has been redesigned. Some preliminary investigations (bench scale) on the corrosion of gas holder indicate that the modified design is more economical with an increased life span of the gas holder.

In the modified gas plant (Fig. 1 *Right*) the digester remains almost the same as in the KVIC plant but tank for the gas holder and the main digester are separated horizontally by a concrete partition, forming a ceiling for the digester well and a floor for the gas holder tank. A leak-proof pipe open from both ends is fixed in the centre of concrete floor. This pipe connects the digester and the gas holder and leads the gas formed in the digester into the gas holder above the liquid level. This arrangement enables filling of gas holder tank with pure water, which in turn adds to the life span of gas holder by reducing the corrosive effect of dung slurry. Moreover, daily cleaning of the gas holder is not required. The rusting of mild steel gas holder may further be reduced by pouring a few liters of burnt mobil oil from automobile engine on the surface of water after installing the gas holder.

The arrangements for dung feed-

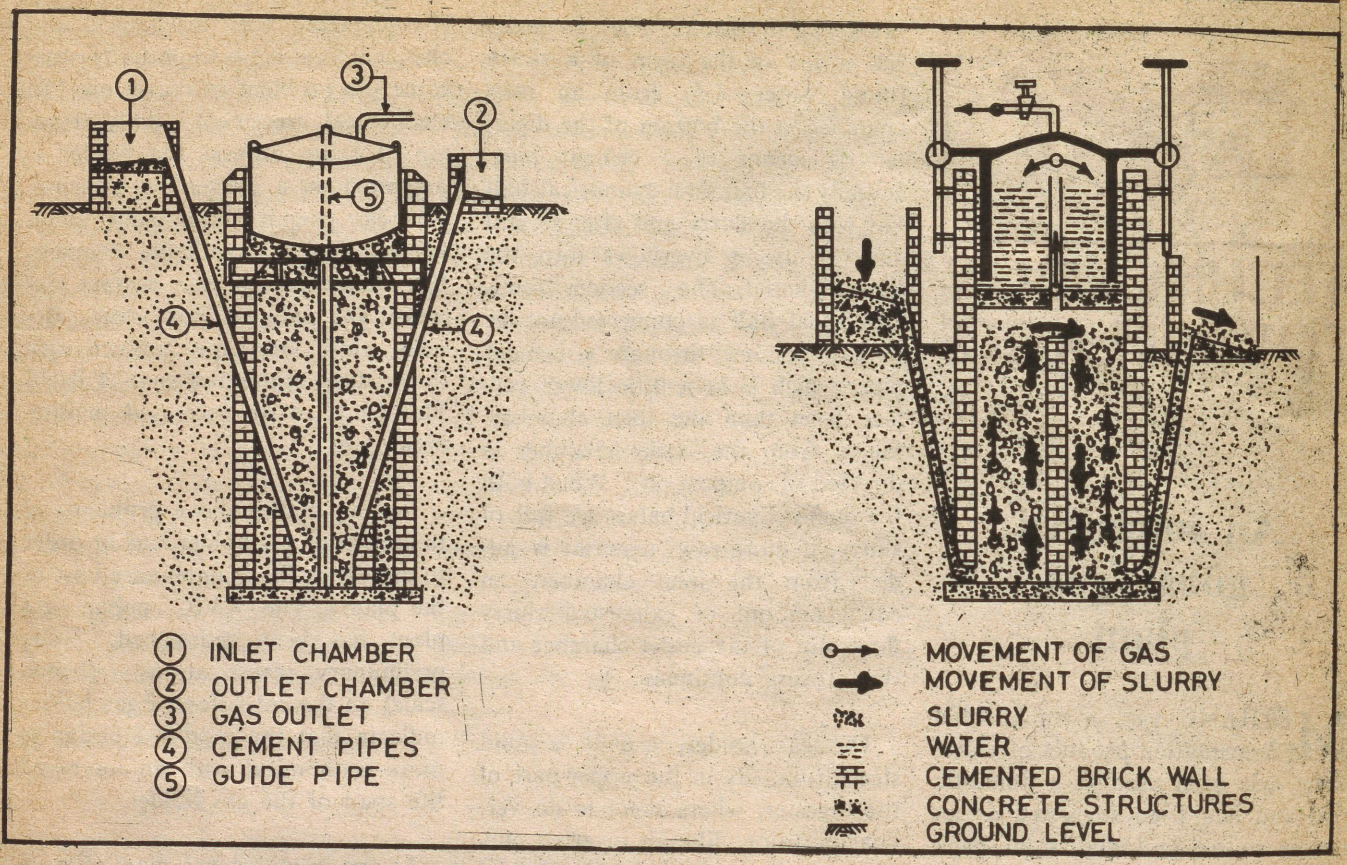

Fig. 1. (*Left*) The KVIC plant; (*Right*) Modified gobar gas plant

ing and exit of exhausted slurry are similar to those of KVIC design except the surface levels of inlet and outlet chambers. As apparent from Fig. 1 (*Left* and *Right*), the main difference in the construction of the improved plant is that the gas holder tank is constructed above the ground level. Three or four guide pipes are fixed at the periphery instead of one at the centre in the KVIC design. Besides, this, openings of inlet and outlet pipes have been extended to the bottom of the digester, thereby increasing the effective fermentation volume.

Further investigations on commercial exploitation of the plant are in progress to work out the economical aspects of the new design.

NARENDRA J. SINGH
Geochemical Laboratory
Deptt. of Earth Sciences
Roorkee University
Roorkee 247672

MEDICAL NOTES (*Continued from page 116*)

pigs. They employed excised, incised and granulation tissue as test objects. Results indicated that zinc sulphate, whether through topical or parenteral application, did not affect granuloma weight, wound contraction and time for epithelisation in control animals whose wounds were allowed to progress normally. On the other hand, the steroid induced depression of healing was significantly prevented by zinc sulphate treatment. The scientists thus concluded that pro-healing effect of zinc sulphate on steroid depressed wounds is independent of any possible influence of steroid on serum zinc level and is different from the mode of action of vitamin A considering the same aspect (Diwan *et. al.*, *Ind. J. Pharmac.*, **11**, p. 257, 1979).

SHIKHA DAS
Deptt. of Pathology
PRASANTA KUMAR MITRA
Deptt. of Biochemistry
N.B. Medical College
Siliguri, Darjeeling-734432



BOOK REVIEWS

IMPACT OF THE DEVELOPMENT OF SCIENCE AND TECHNOLOGY ON ENVIRONMENT, *Eds.* A.K. Sharma and Archana Sharma, *Indian Science Congress Association,* 14, Dr. Biresh Guha Street, Calcutta, 700 017, Pp. 196, Rs. 150.

THE annual sessions of the Indian Science Congress have today become a major event in the country's scientific calender. In the present day world of specialised seminars and conferences, the Science Congress offers perhaps the only common meeting ground where leading scientists of different disciplines can meet and exchange notes. Such an interdisciplinary approach becomes counterproductive with no specific sense of direction. In the past many critics of this approach have dubbed the annual sessions of Science Congress as nothing but 'melas' out of which nothing substantial ever came out. May be, they had a point. But things have changed. For the past seven years, each session of the Science Congress has been devoted to a 'focal theme'. This approach has given a sense of direction and purpose to these annual meetings.

The volume under review is a collection of selected papers presented on the focal theme "Impact of the Development of Science and Technology on Environment" at the 68th session of the Science Congress at Varanasi in January 1981. Besides the Prime Minister's inaugural address and the General President's address, the volume contains 18 papers by leading scientists from India and abroad. They touch upon almost every aspect of the focal theme. They not only bring out the real magnitude of the problem of environmental degradation due to technological progress, but also suggest remedial measures.

The topics covered include: Genetic Manipulation (E.A. Bevan, UK), Genetics and Society (H. Rees, UK), Environment and Development (Margaret and A.K. Biswas, USA), Biodegradation of Pesticides (C.R. Krishna Murti, India), Methods of Analysis of Genetic Damage in Man Caused by Environmental Agents (T. Caspersson, Sweden), Forest Ecology as an aid in pollution Control (P.S. Ramakrishnan, India), Water Pollution and its Control in India (N.S. Deodhar and K.J. Nath, India), and many more. Each paper is written in a lucid style and includes an extensive list of references for the benefit of the serious reader. Recommendations made at the Varanasi session are given in the Appendix. As a work of reference the volume will be useful for anyone concerned with environment. It is hoped ISCA would bring out similar volumes in future also.

BIMAN BASU

CATASTROPHE THEORY AND APPLICATIONS edited by D. K. Sinha, *South Asian Publishers Pvt. Ltd.,* New Delhi, 1981, pp xii+158, Rs. 75/-.

ONCE in a long while, the world of science witnesses the emergence of a gigantic personality or a new idea holding the centre of the stage for quite some time and opening up an entirely new way of looking at a whole range of phenomena. Albert Einstein and Chomskian linguistics are but two examples. Catastrophe theory, pioneered by Réné Thom and made popular by E.C. Zeeman, was a potential candidate to be added to this short list of developments of far-reaching and wide ranging consequences but is still struggling to make the grade.

Catastrophe theory (which in essence concerns sudden effects produced by gradually changing forces) finds application not only in mathematics and the physical, earth and engineering sciences but also in life sciences, sociology and linguistics.

The volume under review is a collection of thirteen papers, originally presented at a seminar on applications of catastrophe theory at Jadavpur University in 1979. The first five papers are by E.C. Zeeman of Warwick University. Almost all the other contributions come from Calcutta or Jadavpur Universities; one each comes from Burdwan University and the Indian Institute of Technology, Kanpur. The topics covered include bifurcation in biophysical systems, mechanism of aggression, decision theory, biochemical oscillators, game theory, rolling of seawaves, anorexia, thought and language, nuclear scattering, etc.

A select bibliography on catastrophe theory by two experts and short answers by E.C. Zeeman to questions from the floor are also included in the volume.

None of the papers is provided with an abstract. Many are very brief and in the nature of review papers. There are a few spelling mistakes and the print appears emaciated in a few pages.

SUBBIAH ARUNACHALAM

PHYSICS FOR ENTERTAINMENT *by* Ya. Perelman, *Mir Publishers,* Moscow, 1975, Reprinted 1980; (Available from: *Peoples Publishing House,* 2 Marina Arcade, Connought Circus, New Delhi-110001), Book 1, Pp. 264, Book 2, Pp. 331 (Price not stated).

YA. Perelman's *Physics for Entertainment* has been entertaining Russian readers for more than sixty years now. Its popularity has

sustained through the two lakh copies printed till the thirteenth edition in 1936 and has survived the author's death in 1942. It has been translated into many languages including Yiddish and Hebrew.

In its English version which first appeared in 1962 from the 18th Russian edition and has been reprinted in 1980, the book is an equally entertaining and engrossing one not only for professional physicists but also the layman interested in the world around him.

Seen through Perelman's eyes the world is indeed fascinating. What would happen if the world suddenly stopped spinning, or if the air became stationary, or if man developed the ability to see events occurring in a thousandth of a second. The events, obeying known physical laws, which would occur under those circumstances are described in interesting details.

Interspaced in these accounts are references to the insights of the famous scientists and writers like H.G. Wells, Jules Verne and the "German Galileo",Otto von Guericke who on May 8, 1654, dramatically demonstrated that even 16 horses could barely pull apart 2 evacuated copper hemispheres of 37cm diameter. While many of us may be familiar with this experiment, relatively few people may know that it is the same atmospheric pressure which holds the human pelvis together.

An interesting feature of the two-volume set is the historical descriptions of the evolution of applications or inventions based on common physical principles like Bernouilli's principle or atmospheric pressure. There is an account of a small pitcher with many holes at its rim from which the noblemen in 17th and 18th centuries would ask their guests from the lower classes to drink wine. Because of the holes, it was not possible to drink without getting wet, unless one knew the trick, and this would send the nobles into fits of laughter. A sadistic pleasure perhaps, but the invention itself was quite novel!

History is full of accounts of 'inventors' trying to create the so-called "perpetual motion machines", which would keep on running indefinitely without any external source of energy. What is a "perpetual motion machine" is explained clearly and succinctly: It is "an imagined mechanism which continues its motion without end and meanwhile can also do some useful work, as lifting a load, for instance."

There are interesting features about many common phenomena; how sound plays tricks on the human ears, why photographs appear "flat" to the viewer, why there is a difference in heights of the Eiffel Tower during summer and winter.

The two volumes have been divided into various sections—mechanics, properties of liquids and gases, heat, light, sound and magnetism and electricity. At the end of each volume, 99 questions based on the contents of the books are provided, presumably to test how much the reader has understood them.

The author has been able to show that physics, if properly studied, is not only very interesting and encourages scientific thinking, it is also a subject which is intricately linked with our everyday lives. What a pity there are few books of this type published in India!

RAVI P. BHATIA

PRINTED CIRCUIT BOARDS FOR MICROELECTRONICS *by* J.A. Scarlett, *Electrochemical Publications Limited*, 29, Barns Street, Ayr, Scotland KA 7, 1X6, Pp. 284 (1980), $70 (plus $ 3.00 for postage).

PRINTED Circuit Board or PCB is a reinforced plastic base carrying copper tracks in the form of a thin foil. It is now an essential ingredient of microelectronic devices which produces an electrical interconnection system providing necessary mechanical support and a favourable environment for the components it enterconnects. It has a number of advantages and provides a cost effective technology for the electronic industry.

The book under review is the second edition. Its first edition has already been widely accepted as a standard text-book on the design of PCBs. The author J.A. Scarlett, who is an authority on the subject, has used his expertise and long experience in bringing out this second edition with additional chapters on computer-aided design for PCBs.

The first three chapters of the book introduce the microelectronic packages, the printed circuit boards and their properties. The fourth and fifth chapters present an overall picture of board manufacture and its art work. Chapters 6-9 give in detail the board layout, track routing, power distribution and packing density, board size and its guides and connectors. The flexi-rigid boards, printed circuit back wiring board assembly, etc., are discussed in the last five chapters. In the discussions, emphasis is on the design techniques which are efficient and cost-effective.

The beauty of this book is that it provides a fundamental but practical background of the rapidly growing PCB technology in a lucid form. It presents an excellent expose of the subject matter. It is truely designed to be an introduction to students, circuit designers, board manufacturers and system engineers. The easy language of the text would educate even a person who is not working in this area.

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ELECTRONICS BOOKS

FOULSHAM TAB BOOKS

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FM Stereo/Quad Receiver Servicing Manual by Caar Rs. 31.00

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