Science Reporter

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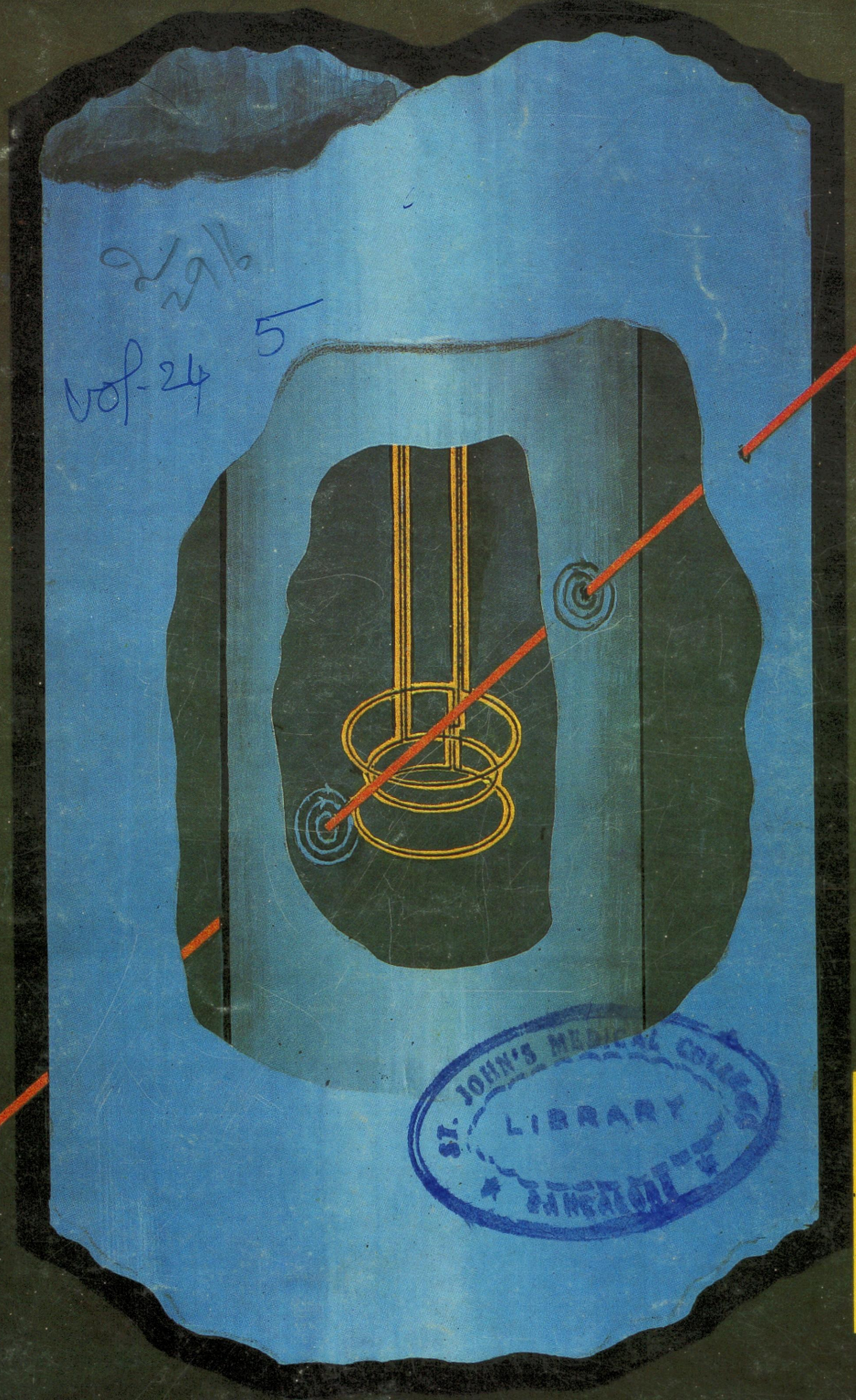

MAGNETIC MONOPOLES

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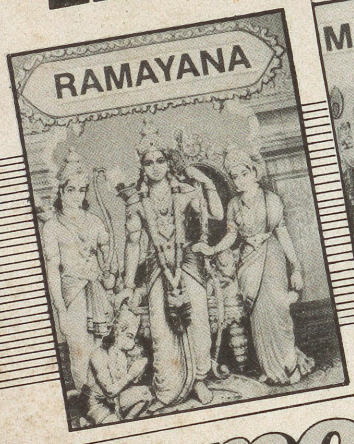

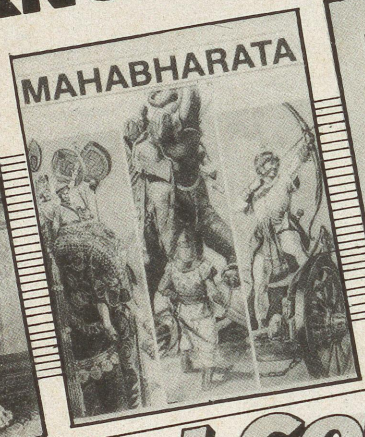

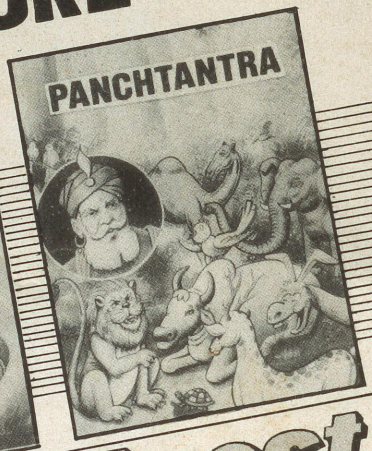

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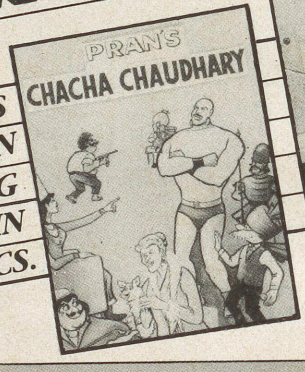

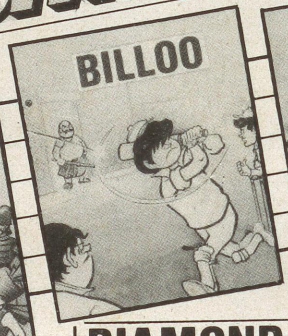

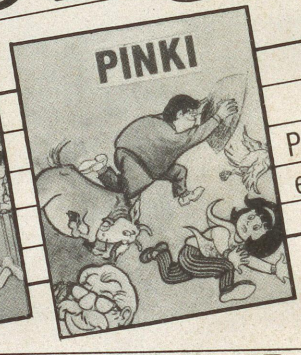

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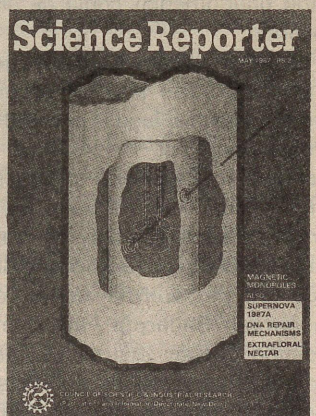
LETTERS

STARS AND PLANETS

MAIN ARTICLES



(Cover: **Painting by K.B. Dhingra) Cabera's detector with which he detected his monopole candidate event.**

LETTERS

Jatinga mystery: A new clue?

Sir, Sudhin Sengupta's exposition of the geomagnetic hypothesis regarding the phenomenon of mass deaths of birds at Jatinga (*S.R.*, December 1986) does not sound convincing for the simple reason that it has not been backed up by any confirmatory tests. The stated magnetic anomaly around Jatinga and topographical aspects to which he has attributed his conclusion are not unique to Jatinga alone as such anomaly zones with similar or even more rugged topography widely occur in the North-Eastern hilly regions. Yet the phenomena till date has not been reported from any other place. However, from the details as catalogued by Shri Sengupta, the death of the birds could be attributed to asphyxiation caused by the emission of natural gas. The reasons for this conclusion are as follows:

The critical elements leading to the phenomenon could be summed up as (i) geology of the area of occurrence, (ii) season of fatal fall being restricted from August to October, (iii) environmental conditions created by dense fog and southerly wind, (iv) the fact that moths and insects also die along with the birds, and (v) birds dying during luminous phases of the lunar nights only. Role of each of these critical elements leading to the phenomenon could be suitably explained.

The first in importance is the geology of the area. The area of occurrence around Jatinga village is covered by the Tertiary rocks of the Surma series belonging to Oligocene to lower Miocene systems which are known in the North-Eastern region to be petroliferous strata. Incidentally, rocks of the Bhubon stage of the Surma series of the Mashimpur-Badarpur area in the adjoining Cachar District yielded considerable hydrocarbons and was commercially exploited between 1915 and 1932. As of now, considerable exploration activity is being conducted in the region by the ONGC in search of oil and natural gas. From the brief geology as reported it is apparent that the ridge over which the falls of the birds take place is bounded by fault planes on three sides except the north. One of the fault planes is known as Haflong-Disang thrust fault which has been traced for hundreds of kilometres and is known to be a major structural lineament in the North-Eastern region. Through these fault planes which are exposed on the ridge flanks, it is possible that slow effusion of natural gas takes place.

During August-October, when the fatal falls of the birds take place, the entire region receives very high rainfall exceeding 270 cm in some season. It would be interesting to note that though in the region the rains generally set in during mid-June, the fatal fall of the birds commences from August. It is so possibly because the early rains of June-July period help to raise the groundwater level progressively which attains a critical level only around August when a correspondingly higher rate of effusion of the hydrocarbon from the sandstone reservoirs is caused by the rising water table. Heavy weather conditions aided by the hanging fogs possibly slow down the rate of diffusion of the effusive natural gas in the atmosphere which, therefore, spreads out along the ground surface instead of rising vertically up. This horizontal spread of the gas can take place only during the night since in the day time, due to the rising day temperature, the fog would either disappear or be less dense resulting in normal rate of diffusion of the gas.

The compulsive factor regarding the presence of the southerly wind in causing the deaths could be the source of the gas emission which by all supposition is located south of the railway station (conjunction point of Haflong-Disang fault plane with the fault delineating the Western flank of the ridge). The gas after emission from its source must be blown north by the southerly wind to eventually get trapped around the ravine near the ridge of this fault located to the north of the source.

With the spread of the effusive natural gas along the rock faces, the oxygen level in the environment would naturally fall. Since insects and moths cannot survive even the slightest fall in the level of oxygen in the atmosphere, they would be the first creatures to get affected by the spreading gas. From August to October, when the moon is bright, the birds get attracted to winged insects. However, as they descend down and come nearer to the ridge face for the insects, they themselves get suffocated by the gas. The sudden suffocation causes the birds to lose their natural balance which results in their hurtling down at great speed. It would be only natural to expect the fallen birds to lose all their reflexes and behave as if they are in a trance.

Bright artificial lights like Petromax, etc., aid the birds in their visibility and it is just possible that numerically the fatal falls within the area of occurrence could be directly proportional to the brightness of these lights.

To conclude, the fatal fall of the birds could be ascribed to their asphyxiation caused by effusive natural gas emanating from the faults delineating the ridge, trapping of the natural gas being caused by the dense fog. The moon, which happens to be brightest during the monsoon months, helps the birds in sighting their prey of insects and moths, which explains why the phenomena takes place during the bright phases of the moon only.

Mihir Bhattacharjee
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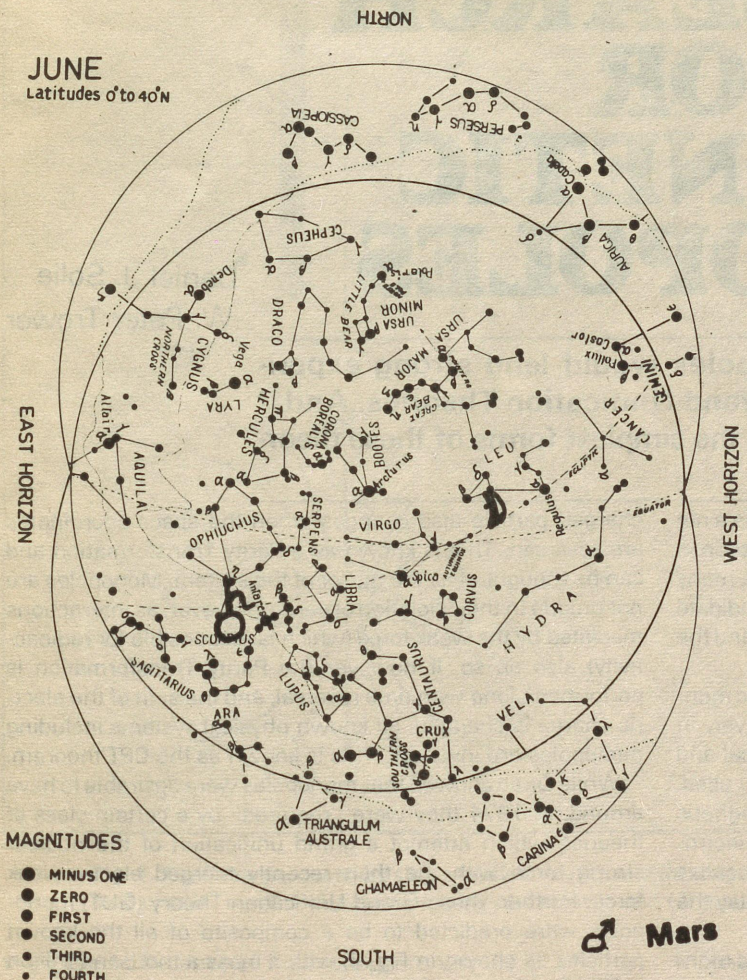
Calcutta-700068

Book review reviewed

Sir, I draw your attention to the review of my book *Computers for Everyone* done by S.K. Nag in the October '86 issue of *Science Reporter*. I was taken aback by the reviewer's style which verged on downright denigration. The review is almost void of any constructive criticism and becomes derogatory at places (that too without being correct).

Presumably my biggest mistake which the reviewer describes as "unpardonable" is not including memory unit in the CPU. Anyone who has read the subject of computer organisation well would agree

(*Continued on page 310*)



Planetary positions for June 1987

Date	*1st*		*10th*		*20th*	
Planets	*R.A.*	*Decln*	*R.A.*	*Decln*	*R.A.*	*Decln*
Mercury	6h 11m	25.5N	6h 53m	23.9N	7h 12m	*21.1*
Venus	3h 02m	15.7N	3h 46m	18.7N	4h 37m	*21.3*
Mars	6h 31m	24.4N	6h 56m	23.9N	7h 24m	*23.2*
Jupiter	1h 19m	7.0N	1h 25m	7.7N	1h 32m	*8.3*
Saturn	17h 10m	21.3S	17h 08m	21.3S	17h 05m	*21.2*

Adopted from figures supplied by Positional Astronomy Centre, Calcutta

The moon

FULL moon occurs on 12th at 2.19 A.M. and New moon on 26th at 11.07 A.M. I.S.T. The moon passes about six and a half degrees south of Saturn in the evening of 11th, about three degrees north of Jupiter on 20th, five and a half degrees north of Venus on 25th, and about three and a half degrees north of Mars on 28th.

The lunar crescent becomes first visible after the new moon in the evening of 27th.

The moon is at perigee or nearest to the earth on 13th and is at apogee or farthest from it on the 28th.

The earth is in summer solstice on 22nd.

The planets

Mercury (*Budha*), visible in the evening sky, sets about one and a half hours after sunset during the first three quarters of the month. Thereafter, it comes too near the sun to be visible. It is in greatest eastern elongation of about 24° on 7th. It becomes retrograde on 21st. It is in Gemini (*Mithuna*). Its visual magnitude varies between 0.0 to +2.8.

Venus (*Sukra*), visible in the morning sky, rises about an hour before sunrise during the month. It passes about five degrees north of the star Aldebaran (*Rohini*) on 19th. It moves from Aries (*Mesha*) to Taurus (*Vrisha*). Its visual magnitude is about —3.9.

Mars (*Mangala*), visible in the evening sky, sets about one and a half hours after sunset during the month. It passes about six degrees north of the star Pollux (*Punarvasu*) on 27th. It moves from Gemini (*Mithuna*) to Cancer (*Karkata*). Its visual magnitude is about +1.8.

Jupiter (*Brihaspati*), visible in the morning sky, rises about one and a half hour after local midnight during the first half of the month and about an hour after it during the second half. It moves from Pisces (*Mina*) to Aries (*Mesha*). Its visual magnitude is about —2.2.

Saturn (*Sani*) rises at about sunset and sets at about sunrise during the month being in opposition with the sun on 9th. It is in Scorpio (*Vrischika*). Its visual magnitude is about 0.0.

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

THE SEARCH FOR MAGNETIC MONOPOLES

Daniel J. Solie
W. Peter Trower

The discovery of monopoles would lend strong experimental support to the Grand Unification Theories. And if monopoles are not found, the simplest forms of these theories can be ruled out

A MAGNETIC monopole is any particle which carries a net magnetic charge. The magnetic field it radiates is seen in Fig. 1. They may, however, only be fictional, since the many searches have yielded but two undiscredited candidate events: one seen in 1982 at Stanford University, USA, and the other in 1985 at Imperial College, England.

The idea that magnetic fields can arise from magnetic monopoles has been around for over 700 years. However, in James Clerk Maxwell's 1864 unification of all electrical and magnetic phenomena no magnetic charges were used. Besides completely accounting for all known electromagnetic effects, Maxwell brilliantly predicted the existence of electromagnetic waves, which Gustav Hertz discovered two decades later. Thus, if free magnetic charges exist they do not play the central role of their electric counterparts.

In 1931, P.A.M. Dirac reasserted the idea of magnetic monopoles to explain the experiemental fact that electric charge occurs in integer multiples of its basic unit, (e). Dirac envisioned his monopole to be one end of an infinitesimally thin solenoid which extended to infinity. An electron interacting with Dirac's monopole under the rules of quantum mechanics and classical electromagnetism would cause the product of the electric charge and magnetic charge (g), to equal an integer number (n) times Planck's constant (h) and the velocity of light (c) divided by 4π, i.e., $eg=nhc/4\pi$. This relationship sets the strength of Dirac's monopole at 68.5 times that of a singly charged electric particle. Here for the first time was a specific prediction that could be tested experimentally.

A hypothetical thought experiment first articulated by Robert Adair of Yale University (USA), and illustrated in Fig. 2 shows monopoles to behave anomalously under the mathematical operations of time and space reversal. Time reversal, (which is analogous to viewing a film in reverse), is one of the basic symmetries in nature. All known physical processes, at a microscopic level (except neutral kaon decay), do not change when the flow of time is reversed. A charged particle moving in the field of a monopole violates this symmetry. The path of a charged particle also changes when the space coordinates are reversed. This is known as a Parity Transformation and can be thought of as the mirror of the system. Monopoles are not unique in their violation of parity, however, as interactions mediated by the weak force (which is responsible for radioactivity) also do so. If however the Parity Transformation is performed along with time reversal, and the sign of the electric charge is changed, all known physical systems including monopoles are invariant. This is known as the CPT theorem.

While Dirac showed that monopoles were desirable to have around, in 1974 they were "required" by a certain class of theories which attempt a grand unification of the nuclear strong force with the then recently merged electro-weak force. Further, these Grand Unification Theory (GUT) monopoles were predicted to be a composite of all the known particles as shown in Fig. 3, with a mass a thousand trillion (10^{15}) times greater than that of the proton! Such an enormously heavy particle could only have been produced in the earliest moments after the "big bang" creation of the universe.

Monopoles floating around in our galaxy would be accelerated by magnetic field, draining down the field's energy until it was extinguished. The presence of a magnetic field in our galaxy, about a millionth of that on the earth, places a limit on the number of these free primordial monopoles present in the galaxy. From this monopole number density limit, a maximum flux at the earth's surface was calculated by Eugene Parker of the University of Chicago (USA), to be less than one monopole per square meter every ten thousand years!

Detection of magnetic monopoles

To learn about the physical properties of a particle, its interactions with the material in a detector, in most cases electromagnetic, are studied. Magnetic monopoles would interact with a magnetic field just as electrically charged particles interact with an electric field, only more strongly. Monopoles interact with a material's electric field via the electric field that

W. Peter Trower is Professor of Physics at Virginia Polytechnic Institute and State University (USA); Daniel J. Solie is a graduate student working on his Ph.D. under Professor Trower

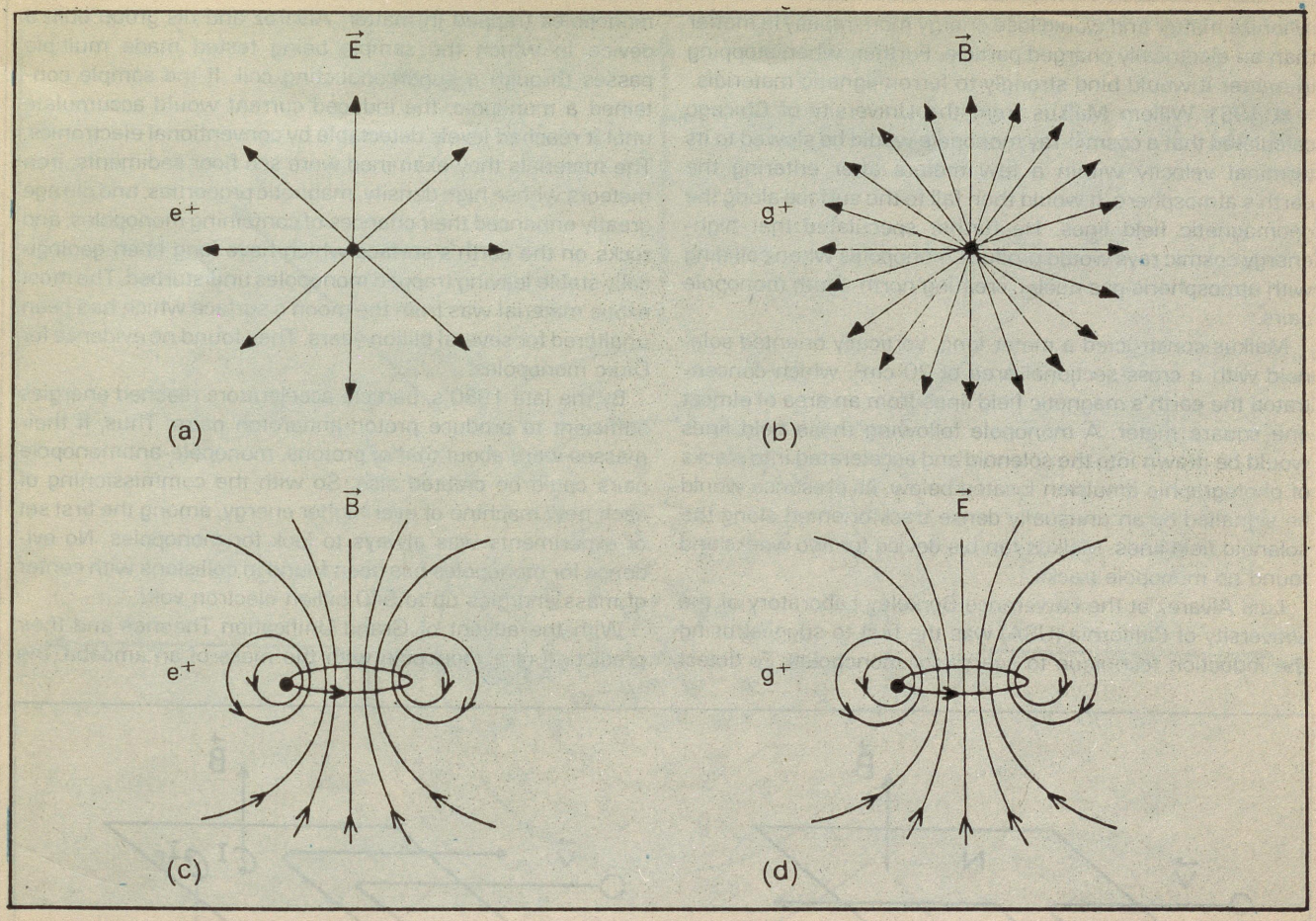


Fig. 1. The fields produced by single (a) electric (+e), and (b) magnetic pole (+g) charges; and the dipole fields produced by a circular current of a single positive (c) electric and (d) magnetic charge

is generated because of the monopole's velocity.

A charged particle travelling faster than the speed of light in a medium (but always slower than light in a vacuum) has electromagnetic wave-fronts that it emits compressed into a cone, forming a bow wave similar to that of a ship going through water. The photons are then emitted perpendicularly to this cone, which is centered on, but trailing, the particle. For magnetic monopoles with sufficient velocity this Cherenkov light would be polarized at 90° to that from electric poles.

When a charged particle passes through a material it excites and can ionize atoms along its path, losing energy in the process. Scintillation light is produced as these disturbed atoms return to their ground states. If the detector material is transparent, then these photons, whose spectrum usually peaks in the near ultraviolet, can be detected. Particles with large charge can produce permanent radiation damage in the material they traverse. Etching with acid can reveal pits at the points of the particle's entry and exit. The cone axis of a pit approximates the particle's direction, the cone angle its charge, and the cone depth its energy. Large sheets of inexpensive, easily fabricated plastic can be used as track detectors.

A magnetic monopole induces a tiny electric current change in passing through a wire loop as seen in Fig. 4. Magnetic monopoles, alone among all particles, will induce such a change. The magnetic field strength of a singly charged magnetic monopole is a million times weaker than the earth's field, and the current it generates is about one ten billionth (10^{-10}) of an ampere. Detection of such a minute current only became practicable when superconducting loops were available since the current persists undegraded by ohmic losses. The measurement of these currents is greatly enhanced by the recently invented Superconducting Quantum Interference Device (SQUID) which detects extremely small electric currents by their magnetic fields. Both surviving monopole candidate events were detected by this induction method.

Induction experiments can be of two types, static and dynamic. In the former, monopoles are assumed trapped in material which is passed through an induction loop to give a signal, while in the latter, the monopoles from accelerators or cosmic-rays actively penetrate a passive loop.

Searches

With Dirac's prediction of the monopole's magnetic charge and the assumption that its mass was comparable to the then known particles such as the proton, the modern era in the search for magnetic monopoles began. A Dirac monopole could easily attain relativistic velocities, and thus would heav-

ily ionize matter and would lose energy more rapidly in matter than an electrically charged particle. Further, when stopping in matter it would bind strongly to ferromagnetic materials.

In 1951 Willem Malkus from the University of Chicago calculated that a cosmic-ray monopole would be slowed to its terminal velocity within a few meters after entering the earth's atmosphere. It would then fall to the surface along the geomagnetic field lines. He further speculated that high-energy cosmic rays would produce monopoles when colliding with atmospheric gas nuclei, creating north-south monopole pairs.

Malkus constructed a meter-long, vertically oriented solenoid with a cross-sectional area of 20 cm^2, which concentrated the earth's magnetic field lines from an area of almost one square meter. A monopole following those field lines would be drawn into the solenoid and accelerated into stacks of photographic emulsion located below. Its presence would be signalled by an unusually dense track oriented along the solenoid field lines. Malkus ran his device for two weeks and found no monopole tracks.

Luis Alvarez at the Lawerence Berkeley Laboratory of the University of California (USA) was the first to suggest using the induction technique to search for monopoles. To detect monopoles trapped in matter, Alvarez and his group built a device in which the sample being tested made multiple passes through a superconducting coil. If the sample contained a monopole, the induced current would accumulate until it reached levels detectable by conventional electronics. The materials they examined were sea floor sediments; iron meteors whose high density, magnetic properties, and old age greatly enhanced their chances of containing monopoles; and rocks on the earth's surface which have long been geologically stable leaving trapped monopoles undisturbed. The most exotic material was from the moon's surface which had been unaltered for several billion years. They found no evidence for Dirac monopoles.

By the late 1950's, particle accelerators reached energies sufficient to produce proton-antiproton pairs. Thus, if their masses were about that of protons, monopole-antimonopole pairs could be created also. So with the commissioning of each new machine of ever higher energy, among the first set of experiments was always to look for monopoles. No evidence for monopoles has been found in collisions with center of mass energies up to 540 billion electron volts.

With the advent of Grand Unification Theories and their prediction of a monopole with the mass of an amoeba, the

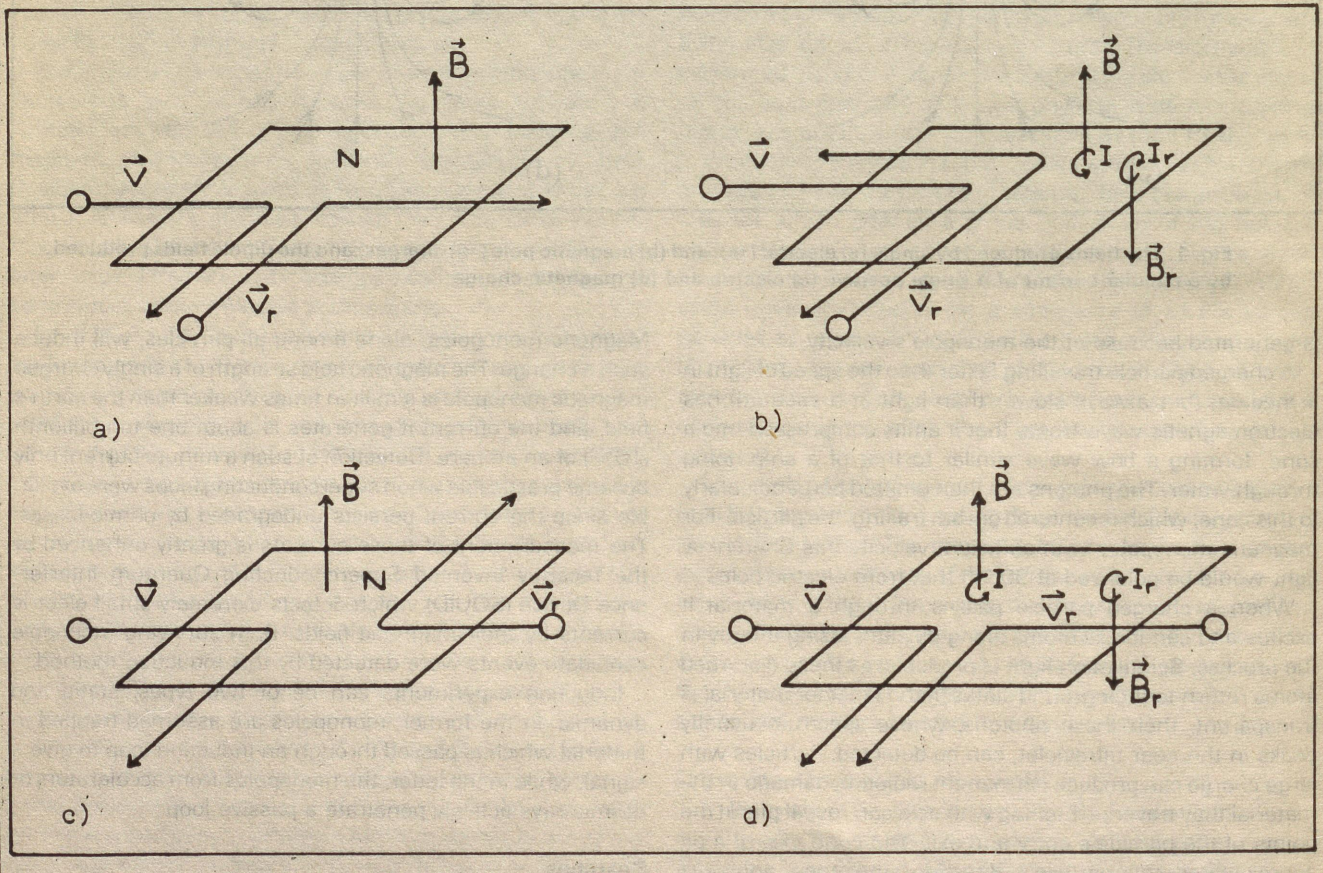


Fig. 2. A single positive electrically charged particle moving with velocity (v) in a (a) constant magnetic field created by north monopoles, which when time reversed ($v \rightarrow v_r$) has an altered path. In (b), the magnetic field generated by electric currents reverse sign ($I \rightarrow I_r$, $B \rightarrow B_r$) when time is reversed thus preserving the path. In (c) the magnetic field is generated by north magnetic poles, when a reflection is performed the incoming direction of the proton changes but not B, thus the direction of the proton is changed. In (d), the outgoing proton is unaffected by the reflection transformation

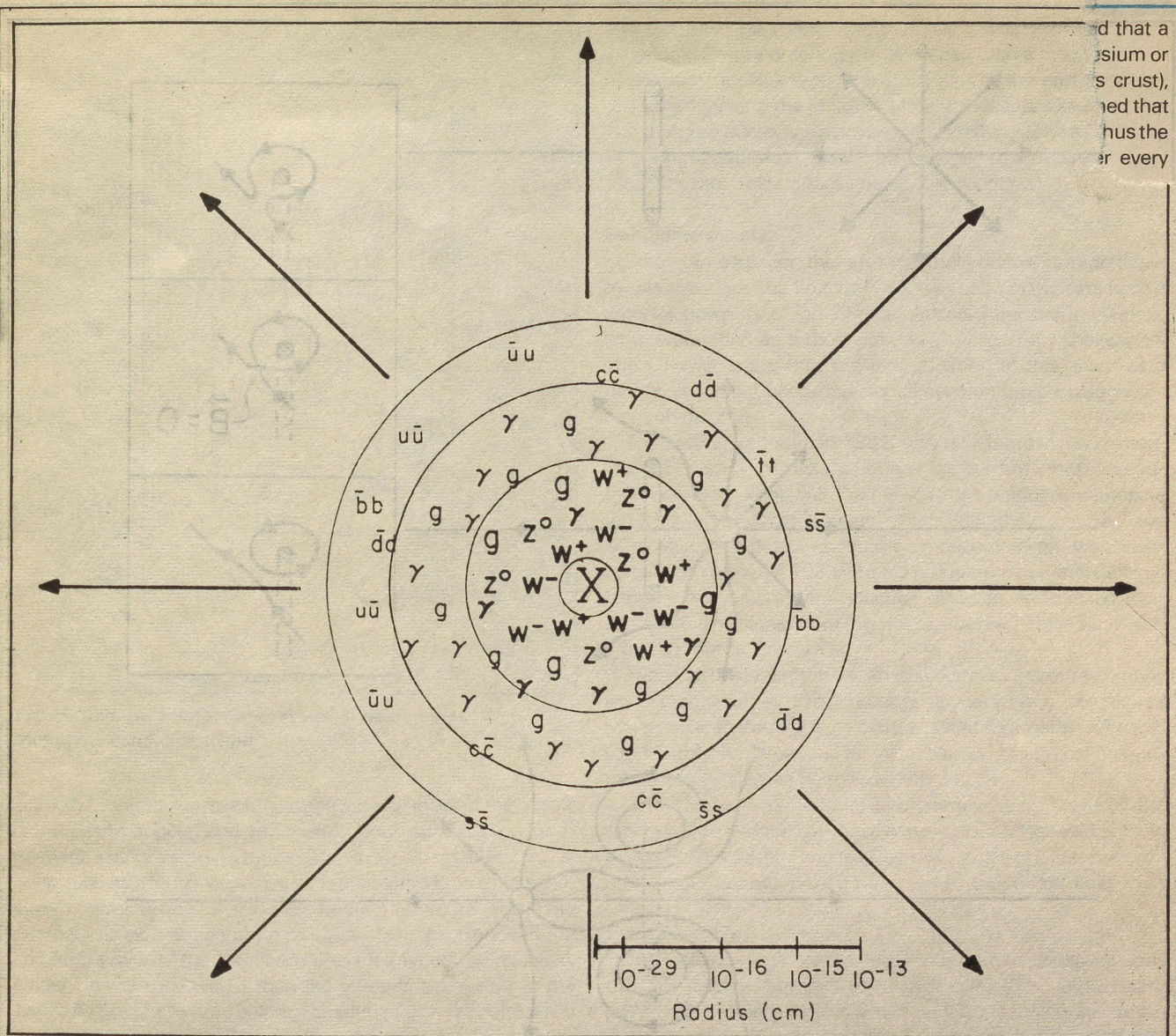


Fig. 3. The proposed GUT monopole structure. Each successive layer is composed of virtual particle-antiparticle pairs characteristic of the energy region. The further from the center, the less unified are the forces of nature. In the innermost region are the X Grand Unification bosons. Next, the W^{+-} and Z^0 gauge bosons of the electroweak field; photons (γ; and gluons (g), the mediators of the strong force. In the outer layer are quark-antiquark condensates as well as other fermion-antifermion pairs

prospects for creating such particles in accelerators became hopeless. Further, measurably deflecting them by any man-made magnetic field was improbable. Thus these monopoles had to be of cosmic origin and would by now have acquired a velocity characteristic of our galaxy, or about one thousandth the speed of light. Such a low velocity rendered the predicted ionization rate in matter unreliable, thus throwing into question the ability of ionization techniques to detect a monopole's passage.

Induction detection of a monopole, which depends only on its primary characteristic—its magnetic charge—was unaffected by the extreme properties of GUT monopoles. So when Blas Cabrera invented a way to make an ultra-low magnetic field cryostat, one of his first experiments was to look for monopoles in the various materials at hand in his laboratory. His superconducting coil was connected to a SQUID, inside a dewar whose shielding reduced the magnetic field within it to one millionth that of the ambient background. He later improved his sensitivity and looked for cosmic-ray monopoles. With the device seen in Fig. 5, Cabrera found the Stanford candidate event.

Induction detectors have small cross-sectional area and are expensive to build and operate. Although shielding can be replaced by macrame loop designs, a liquid helium dewar is still required. To reduce their susceptibility to fluctuating background magnetic fields large arrays are made by twisting a loop of wire into a series of figure-8's so that the currents induced in each pair of subloops cancel out. However, a monopole passing through only one of the loops will induce a current.

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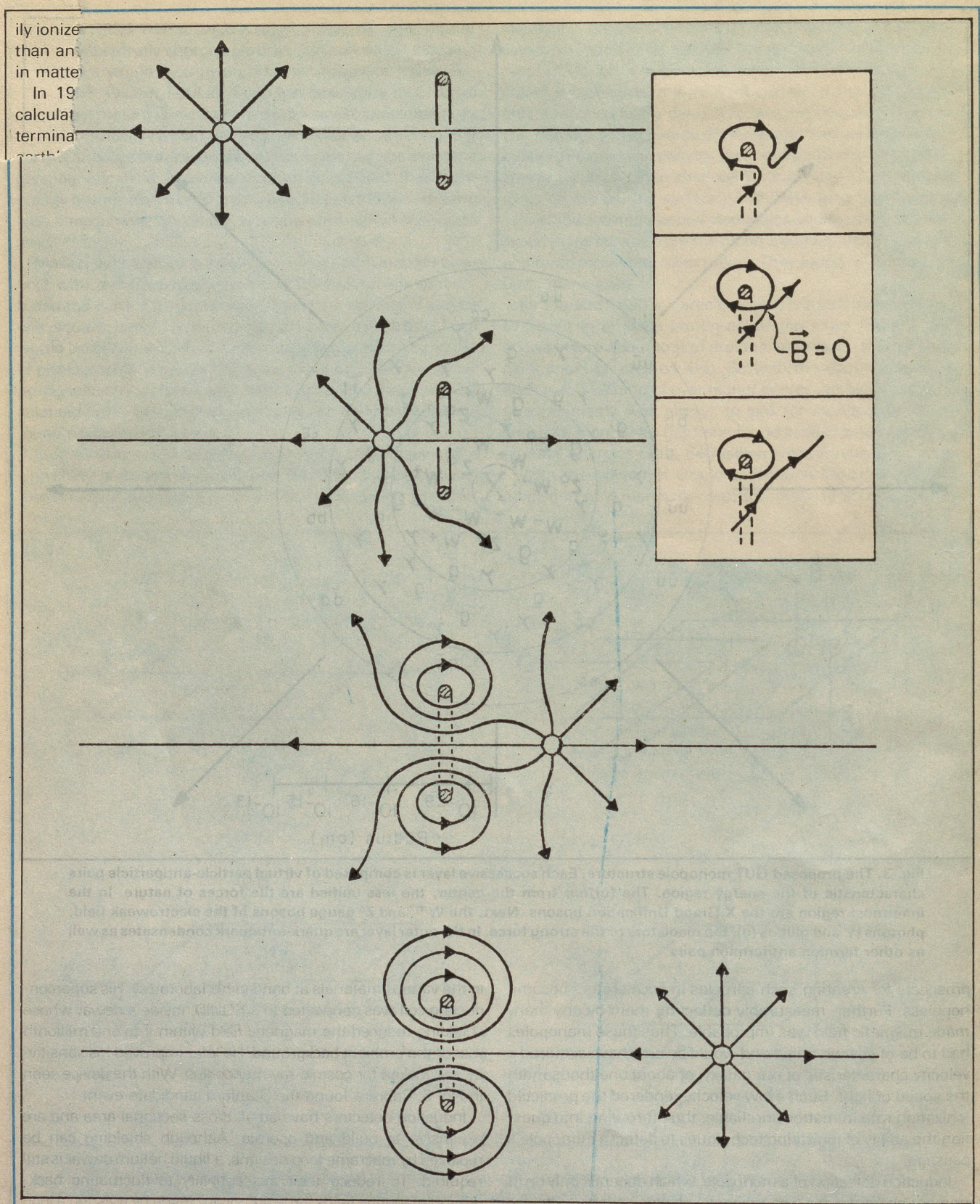

Fig. 4. A monopole passing through a superconducting ring will induce a persistent current change whose value is proportional to the monopole's magnetic charge. The magnetic field lines are excluded from the conductor and the insert shows how they are pinched off

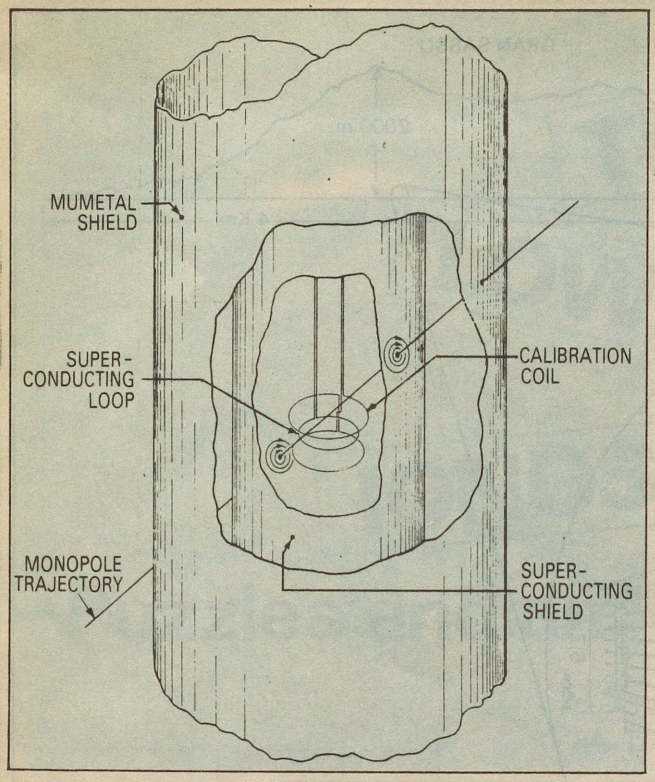

Fig. 5. Cabrera's detector with which he detected his monopole candidate event

A GUT monopole travelling at the virial velocity of the galaxy is not easily stopped and will pass through some seven earth diameters before coming to rest. However, old magnetic materials, such as iron ore deposits, with their large time-area exposure could capture a few. By heating this ore above its demagnetization temperature, an inevitable occurrence in the smelting process, the trapped monopoles would be released. Under gravity they would then fall towards the center of the earth. A detector located below a smelting furnace could detect these falling monopoles.

The predicted composite nature of GUT monopoles has led to the prediction that in their passage through matter they may actually catalyze nucleon decay. If such a process is physically possible then detectors built to see proton decay as predicted by the simplest GUT theories [SU(5)] could also detect monopoles. One such detector is located twentyeight hundred meters under the earth's surface in a mine in the Kolar gold fields in India. There, a collaboration from the Tata Institute of Fundamental Research in Bombay and the University of Tokyo, Japan, is currently searching for evidence of proton decay. To date, they and workers at the half a dozen other detectors with similar goals haven't seen a single proton decay. This null result does not impugn the existence of monopoles, but it is the death knell for the simplistic forms of GUT's.

Monopoles passing through some materials might leave a wake of radiation damage. These materials, when etched, would reveal detectable tracks. Mica samples, dated to be half a billion years old, examined this way have revealed no tracks. However, the radiation damage from a bare monopole is thought to be negligible in mica. Thus it was assumed that a monopole, before entering the mica, captured a magnesium or aluminium nucleus (which are plentiful in the earth's crust), greatly enhancing the ionization rate. It was also assumed that the captured nuclei were not cannibalized by catalysis. Thus the flux limit established, less than one per square meter every 22,000 years, rests on an improbable scenario.

Candidate events

Since Dirac's paper, there have actually been three candidate events reported. The first, in 1975, was seen in the data from a detector flown in a high altitude balloon. Almost immediately, its interpretation as a monopole was successfully challenged. Then it was found that the interpretation of this event as a monopole rested on a detector dimension which was incorrectly measured.

The second, reported in 1982, was registered in a superconducting ring as a persistent jump in the current whose magnitude was consistent with the passage of a magnetic monopole to within four percent. Although many, including Cabrera, have since sought to detect another, no monopole event was forthcoming until August 1985 when a group from Imperial College, London, again using an induction detector, announced their candidate. The signal from this event, however, is less compelling than that of Cabrera's.

These two events have been subjected to extreme scrutiny since magnetic perturbations, mechanical jarring, cosmic-ray interactions in the SQUID electronics and thermal shock could conceivably have caused a false signal. No probable non-monopole cause has been indentified to date.

One serious experimental discrepancy exists between the monopole flux implied by these two events, and the Parker limit, however. The former implies free monopoles are one hundred times more abundant than predicted by the Parker limit.

Future searches

The boldest large-area detector now under construction is the Monopole, Astrophysics and Cosmic-Ray Observatory (MACRO), the first 12% of which will be installed inside the Gran Sasso mountain in Italy in July 1987. This detector, immense by any standards, is being constructed modularly in 12×12 meter sections over 5 meters high, and will eventually be 110 meters long and arrayed as seen in Fig. 6. MACRO is designed to detect ionization by three redundant, and overlapping detector systems: a layer of liquid scintillator tanks completely surrounds the detector volume; in this volume is placed a ten-layer horizontal sandwich of concrete and gas-filled ionization detectors (streamer tubes) with plastic sheets suitable for track etching in the medium plane. MACRO, in a year of operation, will be able to establish if monopoles exist at the Parker limit

Conclusion

Why keep searching for such an elusive particle—that may not exist at all? Partially, it is the sheer historical weight of a question unanswered for centuries. Since monopoles are a general consequence of Grand Unification Theories, the discovery of them would lend strong experimental support to these theories, and if monopoles are not found, the simplest forms of

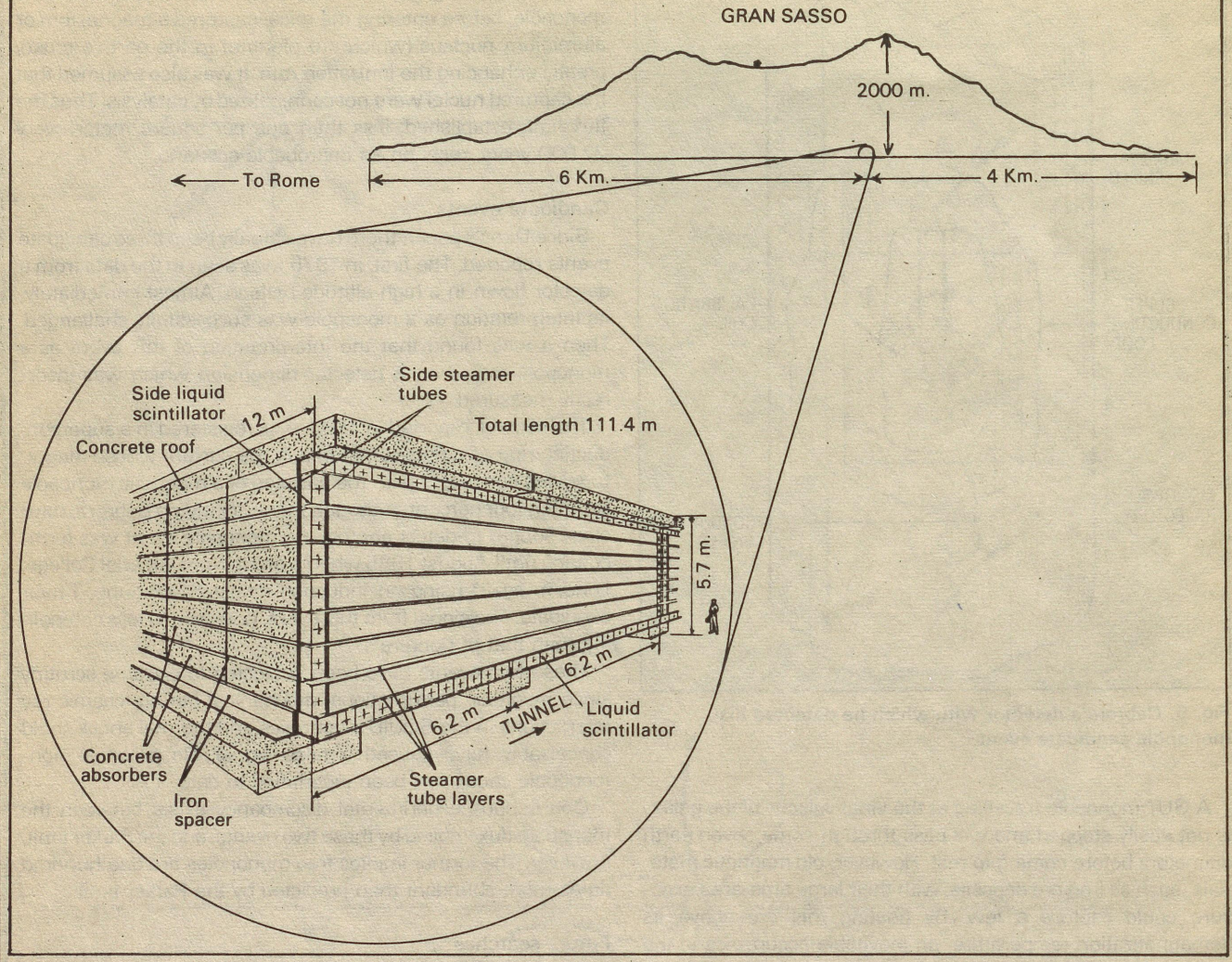

Fig. 6. The Gran Sasso Laboratory in Italy where the MACRO detector is being constructed

Grand Unification Theories can be ruled out. This modern search for monopoles typifies the convergence of ideas in the microcosm of particle physics with cosmology and the study of the early universe. Maybe, however, it is the challenge and difficulty of the search itself, as much as anything, that draws us on.

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THE LOWER IONOSPHERE

–Puzzles and answers as seen today

A. DANILOV

Progress in ionospheric physics has been mainly confined to the region between 90 km-100 km above ground level. This article discusses some of the peculiar features of the lower ionosphere, the region below 90 km, about which little was known till recently

THE ionosphere of the earth in popular literature is often called "the magical mirror of the planet" because of its capacity to reflect radio waves. Indeed, only due to the existence of the ionosphere, long-distance radio-communication is possible, as also the operation of various navigation systems; for example, that of "Omega" which uses radiowaves in the VLF-range. Practical use of the ionosphere is of course not limited to the above cited examples—there exists a whole bunch of radiofamily members: radiocommunication,radiolocation, radionavigation. They are in one way or other connected with ionosphere and depend on its variability.

As soon as we appreciate the fact that the terrestrial ionosphere plays such an important role in our technological civilization, it becomes obvious that a lot of effort should be concentrated on studying its properties and behaviour. And that is what in fact took place during the last few decades, since the first detection of "Kennels-Heaviside" layer more than half a century ago. With the advent of the "space age" in the second half of the fifties, ionosphere became an area of numerous direct measurements using artificial satellites, meteorological and geophysical rockets.

As a result of these efforts, we may say that today we know the principal morphological features and details of behaviour of the main part of the ionosphere, above the height of 90 km-100 km. We understand the principal physical processes behind that behaviour which determine spatial or temporal variations of ionospheric parameters.

Our understanding of the morphology and physics of the ionosphere above the height of 100 km is continuously being checked by various practical programs(like the International Ursigram and World Day Service). On the basis of these programs, different kinds of predictions of the behaviour of the ionospheric parameters and radiocommunication conditions are being currently produced.

All the progress made in the study of the ionospheric physics and morphology refers to the so called "major part of the ionosphere", or to the ionosphere above about 90 km-100 km. But what is happening below? Why do we put such a fixed limit while speaking about the progress in ionospheric studies? This very part of the ionosphere, often referred to as "lower ionos-

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phere", situated below 90 km and called D-region, will be the subject of our discussion in this article. But before we start, let us make a brief excursion through the whole ionosphere to know some basic facts about it.

The layer in the terrestrial atmosphere starting from about 50 km and going upto several thousand km is called ionosphere, because there exists charged particles—electrons and ions. Electrons are of primary interest because they determine the radio propagation properties of the ionosphere. So the altitude (about 50 km) where electron concentration is as small as 1-10 electrons per cubic centimeter is considered as the lower boundary of the ionosphere even though there are charged particles (heavy positive and negative ions) below 50 km level down to the surface.

It was found useful to divide the ionosphere into regions or layers. The main ionospheric maximum at about 250 km-300 km is called F-layer and the altitude interval 150 km-500 km F-region. Between 90 km and 150 km, E-region is situated with the peak of electron concentration around 110 km-120 km (E-layer). Now we are approaching the lowest part of the ionosphere—D-region at altitude 50 km-90 km. There is as a rule no pronounced peak on the electron concentration profile at these altitudes, so in this case the terms D-region and D-layer denote the same thing.

The ionosphere is "the child of the sun", which means that its behaviour above 100 km is strictly controlled by solar short-wave radiation, ionizing neutral atmospheric molecules and producing free electrons and positive ions. Since the atmospheric gas at ionospheric heights principally consists of oxygen and nitrogen, the ions in the ionosphere above 100 km are O^+, NO^+, O_2^+, N_2^+, and N^+. The chemistry of these ions provides (as we understand now in detail) a recombination system, which leads to loss of electrons and ions. The equilibrium between ionization of neutral species by solar radiation and loss through recombination processes provides equilibrium concentrations of electrons and ions.

The nearest but not the best known

Now we know the D-region is the lowest part of the ionosphere, and that means it is the nearest to us. It would be then reasonable to assume that we know more about the D-region than about other ionospheric regions and that we understand the processes determining its behaviour better than those for the E-and F-regions. But the opposite is true.

The amount of experimental data about the D-region is much poorer than that for the ionosphere above 100 km. The principal method of ionospheric study, so called ground-based vertical sounding, which had provided a big bank of information about the E-region and F-region, gives nothing, or nearly nothing about the D-region.

Mass-spectrometers have been used to provide information about the ion composition of the ionosphere at various altitudes, to understand ionospheric chemistry and to reproduce the ionization-recombination cycle of processes maintaining the ionosphere. But mass-spectrometers do not operate in a dense neutral gas at the D-region heights. (Due to general decrease of atmospheric density with height the density at 80 km is about a million times more than that at 300 km). The same is true of various types of devices which are used for measurements of electron concentration and temperature in the E-and F-regions. To use them in dense atmosphere of the D-region, one has to take special precautions: use pumping systems to reduce pressure in the device, use artificial cooling and so on. All that makes *in situ* measurements of ionospheric parameters in the D-region quite a difficult job and that explains why we still do not have enough experimental data to solve all the problems of the D-region physics. We will discuss them now.

Some important technical difficulties are due to the fact that in the D-region there appears a third kind of charged particles (in addition to electrons and positive ions) —negative ions X^-. Methods based on radio-wave propagation tell nothing about the number of such ions because radio waves "feel" only free electrons in the ionosphere. Direct measurements of X^- face the same problems of dense neutral gas, which creates severe difficulties for normal operation of devices such as mass-spectrometers, probes of various kinds and so on.

Variations, variations...

From the very beginning, three main types of variations in the behaviour of the ionospheric electron concentration [e] with the solar zenith angle, with solar activity and with geomagnetic disturbances were known. The former two reflect the solar control of the ionosphere, while the latter, geomagnetic control (appearance during geomagnetic disturbances of the so called "ionospheric storms").

The three types of variations describe well the principal features of the ionospheric behaviour above 100 km at middle latitudes(in polar regions there are some special problems which are out of scope of this article). Now is the proper moment to ask: "What about the D-region?".

In the D-region the picture of [e] variation is quite confusing. For a long time it was difficult to produce any systematic picture at all—various authors have been suggesting different concepts of the D-region behaviour.

Recently (especially due to investigation under the big international project called Middle Atmosphere Programme (MAP), 1982-1985), the picture has cleared a bit, and that allows us to summarize the findings.

In summer, electron concentration behaves "very well"—in full agreement with the theory that ionization is controlled by solar radiation. That means, when the sun is going down to the horizon (i.e., the solar zenith angle χ increases) and solar radiation is absorbed stronger and stronger, the [e] values decrease. If we put the results of electron concentration measurements from different summer days on the same figure, we will have a rather smooth curve (Fig. 1. top), representing [e]-χ dependence which is valid for any summer day. The picture is quite different for winter days. Two consecutive winter days may show absolutely different [e] (h) profiles, the amplitude of variation reaching 10-100 times at 70-80 km (!).

Consequently, if we plot the [e] – values for various winter

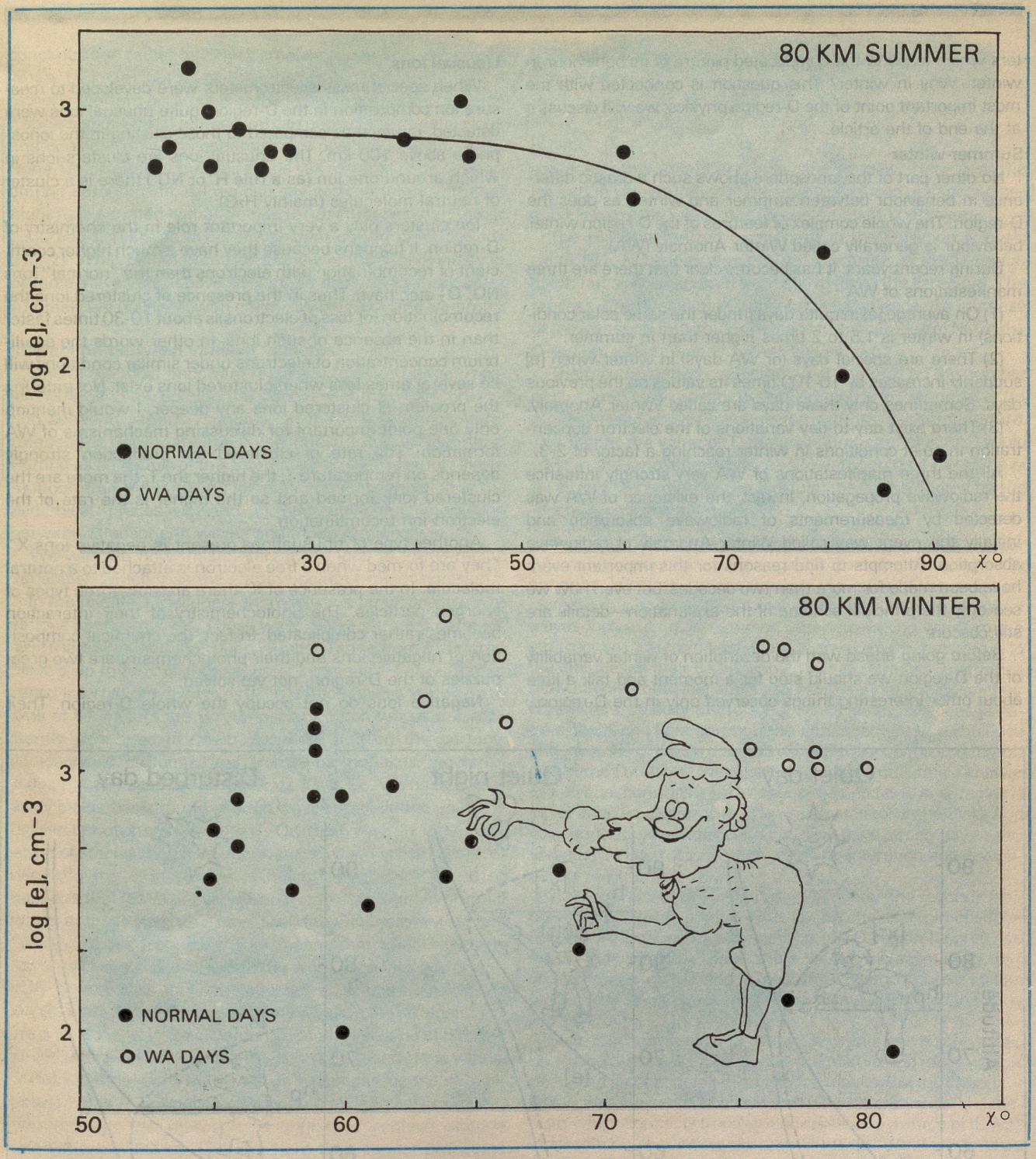

Fig. 1.

days on the [e]- χ figure for fixed altitude (as we have done that for summer data), we will have a mixture of points (Fig. 1. bottom) rather than any distinguished variation of the electron concentration along with the solar zenith angle.

Now, what has happened? Has the D-region stopped being the "child of the sun"? Or some other processes have distorted its behaviour? The latter is true. The sun is still the parent of the winter D-region. Solar radiation gives birth to the electrons and ions in this region. But meteorological factors such as temperature, humidity, circulation do influence the D-region parame-

ters which leads to the complicated picture of its behaviour in winter. Why in winter? This question is connected with the most important point of the D-region physics; we will discuss it at the end of the article.

Summer-winter

No other part of the ionosphere shows such a drastic difference in behaviour between summer and winter, as does the D-region. The whole complex of features of the D-region winter behaviour is generally called Winter Anomaly (WA).

During recent years, it has become clear that there are three manifestations of WA:

(1) On average,[e] in quite days (under the same solar conditions) in winter is 1.5 to 2 times higher than in summer;

(2) There are special days (or WA-days) in winter when [e] suddenly increases by 10-100 times its values on the previous days. Sometimes only these days are called Winter Anomaly;

(3) There exist day-to-day variations of the electron concentration in quiet conditions in winter reaching a factor of 2-3.

All the three manifestations of WA very strongly influence the radiowave propagation. In fact, the existence of WA was detected by measurements of radiowave absorption and initially the event was called Winter Anomaly of radiowave absorption. Attempts to find reasons for this important event have been made for more than two decades, but even now we see only the principal scheme of the explanation—details are still obscure.

Before going ahead with the description of winter variability of the D-region we should stop for a moment and talk a little about other interesting things observed only in the D-region.

Unusual ions

When special mass-spectrometers were developed to measure ion composition in the D-region, quite unusual ions were detected, unusual as compared to those existing in the ionosphere above 100 km. The unusual ions are clusters-ions in which around one ion (as a rule H^+ or NO^+) there is a cluster of neutral molecules (mainly H_2O)

Ion clusters play a very important role in the chemistry of D-region. It happens because they have a much higher coefficient of recombination with electrons than the "normal" ions NO^+, O_2^+ etc., have. Thus,in the presence of clustered ions the recombination (or loss of electrons)is about 10-30 times faster than in the absence of such ions. In other words the equilibrium concentration of electrons under similar conditions will be several times less when clustered ions exist. Not entering the problem of clustered ions any deeper, I would mention only one point important for discussing mechanisms of WA formation. The rate of clustered ion production strongly depends on temperature T; the higher the T, the more are the clustered ions formed and so the higher is the rate of the electron-ion recombination.

Another type of unusualions present is negative ions X^-. They are formed when a free electron is attached to a neutral molecule. In the presence of X^- there are now three types of charged particles. The photochemistry of their interaction becomes rather complicated. In fact, the chemical composition of negative ions and their photochemistry are two great puzzles of the D-region, not yet solved.

Negative ions do not occupy the whole D-region. Their

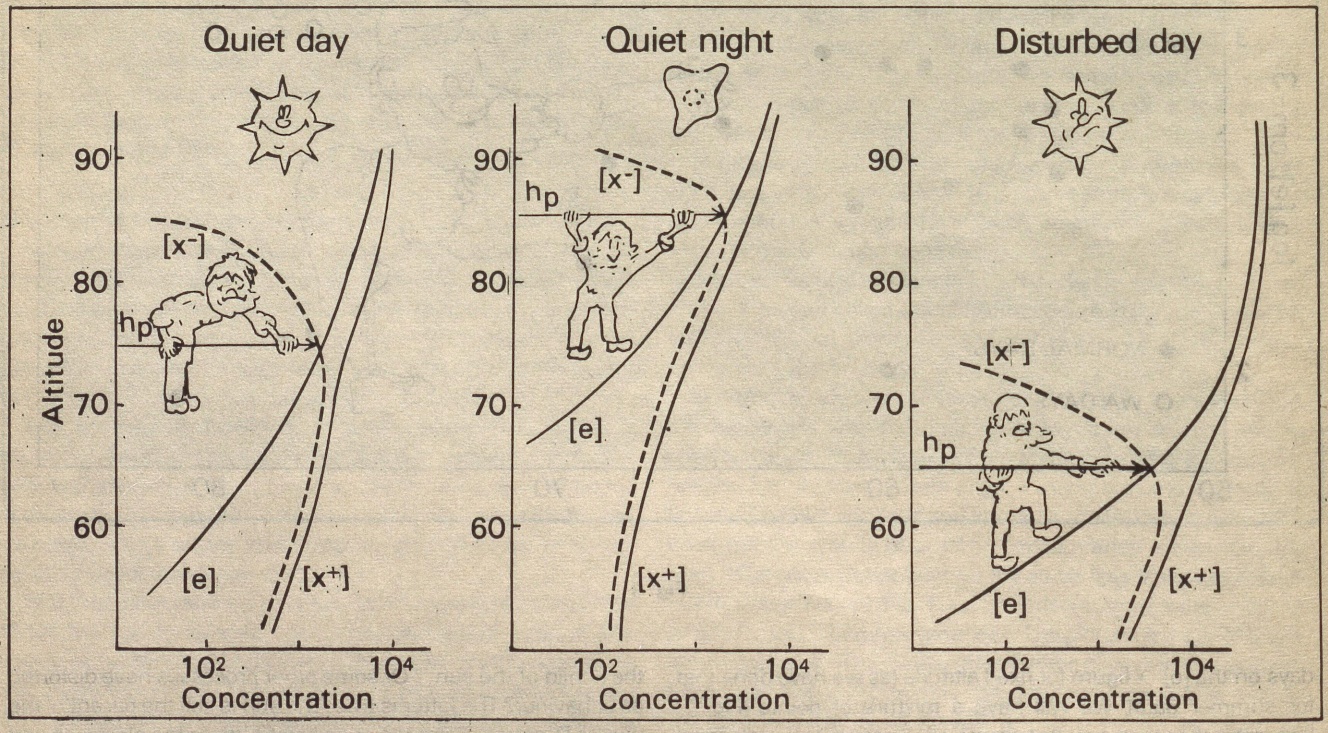

Fig. 2

concentration rather quickly decreases above a certain height where $[X^-] = [e]$. Let us call this height h_p. The height h_p is a rather important parameter of the lower ionosphere, because it shows above what altitude we can neglect the negative ions and consider only photochemistry of positive ions and electrons. Unfortunately the value h_p is still a matter of discussion among aeronomists. All we can say with certainty is that at night h_p is situated higher than in the daytime and that under disturbed conditions, h_p is lower than during quiet periods (Fig. 2). What is important for us now is that h_p obviously in daytime never lifts above 75 km, so discussing the Winter Anomaly we may deal with chemistry only of X^+ and electrons.

Interaction between various "spheres"

One of the most important results of the international project MAP is in my opinion the discovery of the close connection between various "spheres" in the middle atmosphere: troposphere-stratosphere-mesosphere-lower ionosphere. Putting aside details of this interesting problem. I would like to mention that the initiating force for such a connection is the dynamical processes, and in particular, the interaction between atmospheric waves and mean motions(winds).

We will see how these interactions lead to the D-region variability, which was the starting point of this discussion.

In the middle atmosphere there exists a broad spectrum of various kinds of waves. These waves have different parameters, the wavelength has been found to range from a hundred meters up to tens of thousands of kilometers. For us the so called internal gravity waves (IGW) which have λ -value up to tens of kilometers are very important. Such waves are constantly generated in the troposphere and on the surface. Atmospheric cyclones and fronts, earthquakes, powerful industrial explosions—all generate IGW. So, we have a relatively stable background of such waves propagating up to the higher atmospheric "spheres". On their way up they meet some obstacles the more important of which is the system of winds in the stratosphere at heights 20 km-30 km. It so happens that IGWs are very sensitive to the direction of zonal winds at these heights. They "like" the winds from west and "dislike" those from east. That means that IGWs relatively easily pass the stratosphere under westerly winds and practically do not pass (but are reflected or scattered below 20 km-30 km) when there are easterly winds in the stratosphere. Thus stratospheric zonal winds produce some kind of filtering effect, which depends on the direction and speed of the winds.

But what happens to the waves which passes the stratospheric "filter"? They successfully propagate in vertical direction through the mesosphere until they achieve altitude interval about 80 km-120 km. Here they cannot propagate upwards any more because the atmospheric density becomes too low, so they die. Their energy dissipates changing atmospheric gas at altitudes 80 km-120 km. This process leads mainly to an intensification of turbulent mixing of the gas and to an increase of its temperature T. Both these effects influence the state of the ionospheric D-region.

In fact, electron concentration in the D-region depends on two principal processes: ionization in which electrons are born, and recombination in which they are lost. The following simple formula

$$q = [e]^2 \ \alpha \ ef$$

expresses this statement in a shorter way. Here q is the ionization rate (number of electrons produced per second per cubic centimeter) and α ef, recombination coefficient.

The principal ionized component in the D-region is nitric oxide NO. NO molecules are not produced in the D-region itself, but are transported from above (from the E-region). The process which facilitates transport is turbulence. An increase of the transport by turbulence leads to an increase of NO in the D-region, which means higher values of q.

The recombination coefficient α ef depends on the number of clustered ions present in the D-region and that number (as we discussed above) is connected with the gas temperature. The higher the value of T, the less number of clusters would exist in the ionospheric gas, and lower would be the value of α ef and (according to the formula) the higher would be the electron concentration.

Now we can look at the three manifestations of Winter Anomaly, described earlier, against the above formula. To enhance electron concentration we should have either increase in q or decrease in α ef. Dissipation of internal gravity waves increases q. In summer, when prevailing winds in the stratosphere are from east a few, if any,IGWs, penetrate up to the altitudes of their dissipation. In winter, stratospheric winds blow mainly from west and a part of waves (depending on their parameters, velocity of the zonal winds and so on) does penetrate there and lead (through the enhancement of turbulence and increase of [NO]) to an increase of the electron concentration in the D-region. That gives us at least a qualitative answer to two questions: Why [e] under quiet conditions in summer is lower than in winter (the first manifestation of the WA), and why under quiet winter conditions we have strong day-to-day variability. In both cases the reason is penetration and dissipation of IGW.

The existence of anomalous days in winter (the second manifestation of WA) is probably due to two effects. From observations of atmospheric parameters at the D-region heights, we know that in those days there is an increase of both—concentration of NO and temperature. Both of these factors work in the same direction (see the formula) and lead to strong increase of [e].

Such is scheme of Winter Anomaly events as it is seen today. Up to now we have only a qualitative picture and more work is needed to present detailed qualitative results. But the important fact is that we see (or believe that we see) a principal mechanism which connects tropospheric conditions (source of IGWs), stratospheric circulation, and the D-region. We have thus an answer to the question: Why is the behaviour of the D-region controlled not only by solar and geomagnetic conditions, but also by meteorology of the lower atmospheric layers? And, as it is usual in science, one answer gives rise to many new questions; for example—Why on some days do we have strong penetration of IGWs? How to predict the anomalous days of WA? Probably studies of the middle atmosphere in the scope of new project—MAC (Middle Atmosphere Cooperation 1986-1988) will answer some of these questions.

INFRARED DETECTORS

JITENDRA PAL GUPTA

Heat energy has innumerable uses in day-to-day life, but in the form of infrared radiation it has several scientific, technological and military uses

IN 1800 Sir William Herschel discovered infrared radiation. He was determining the heating power of various colours in sunlight with the help of a sensitive mercury-in-glass thermometer. He found that the temperature continued to increase even beyond the red end of the spectrum. He repeated the experiment and established that some invisible radiation does exist beyond red light. From several optical experiments, he established that the radiation is very much similar to light in nature. Initially, he called the radiation "invisible light", but later on it was named "Infrared radiation" (IR).

Infrared radiation is electromagnetic radiation like radiowave and microwave. Sun is the biggest source of IR radiation. As such all objects having temperature above 0K emit continuous band of IR radiation. The wavelength of the peak intensity in the continuous spectrum emitted by hot bodies depends on the temperature of the body; the higher the temperature smaller is the wavelength of peak intensity of radiation (Wien's displacement law). The continuous spectrum of IR radiation lies between the wavelength range from 0.75 μm($1\mu m = 10^{-3}$mm) to 1 mm on the electromagnetic spectrum.

IR radiation produces several effects in the object that receives it; the most important among them is heating. That is the reason why IR radiation is also called heat radiation. The type and extent of the effect depends upon the wavelength of IR radiation because the energy of the radiation depends upon its wavelength. Max Planck found that smaller the wavelength, larger is the energy of radiation, and vice-versa. The energy confined to one wavelength of a particular type of radiation is known as one quantum of energy. This one quantum of radiation is called "photon". Mathematically, it can be written as

$$E = h \frac{C}{\lambda} = h\gamma$$

where E is the energy of the photon, h the Planck's constant, C the velocity of light, λ the wavelength of radiation, and γ the frequency of vibration of radiation. As the smallest wavelength of radiation in IR region possesses the highest energy, it can remove electrons from the outermost orbit of atoms and molecules. On the other hand, longer wavelength of radiation with lesser energy produces heat in the receiving object. For scientific studies and applications of IR radiation in different technologies, the IR spectrum has been divided into three regions. The wavelength region from 0.75 μm to 1.5 μm is known as near IR region, 1.5 μm to 25 μm as middle IR region, while 25 μm to 1 mm as far IR region. This classification is not precise. The near infrared radiation has the property of producing most of the physical phenomena of visible light. The middle region of IR spectrum has special importance in molecular spectroscopy as this radiation can interact with the vibrational-rotational motions of heteronuclear diatomic molecules and poly-atomic molecules like CO, CO_2, CH_4, SO_2, H_2O, NO_x and O_3, etc. The main effect of far infrared radiation is heating and it is generally used for that.

The atmosphere of the earth comprises 79% nitrogen and 20% oxygen. Remaining one per cent is made up by other gases

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like carbon dioxide, water vapour, oxides of nitrogen, etc. Gases like nitrogen and oxygen do not absorb infrared radiation. The IR radiation coming from the sun along with light is not absorbed by these two gases. It is absorbed only by carbon dioxide, water vapour and a few other gases. The earth absorbs the remaining solar radiations and heats up. The atmospheric air gets heated partly by coming in contact with the heated earth surface and partly due to the absorption of IR radiation by the aforesaid gases.

Uses of infrared radiation

Heat energy has innumerable uses in our every day life, but in the form of IR radiation it has several scientific, technological and millitary uses. Solar heaters are widely used for heating water and for room heating in cold countries. In fact, the infrared region presents several important and fascinating features. With the use of "Infrared eye" which can detect IR radiations emitted by objects even in the dark one can watch the movement of persons, vehicles, etc., during night. Such an "Infrared eye" has been designed and developed at Bhabha Atomic Research Centre, Trombay. It is now being manufactured on a large scale by Bharat Electronics Limited, Pune. The heat generated by a flying aircraft can be used to spot it so that guided missiles could be fired at it. As the wavelength of infrared radiation is larger than the visible radiation, their scattering by fine dust particles in the atmosphere is small. Infrared photography has therefore been used to take pictures of distant landscapes even during mild haze. High power infrared laser is also used for cutting, welding and drilling holes in thick metallic plates and in hard materials like diamonds. In scientific research, infrared spectroscopy is a well known tool for the determination of molecular structure. Infrared absorption spectroscopy is widely used for the quantitative analysis of gas mixtures and liquid mixtures. On this principle, infrared gas analysers have been designed at Bhabha Atomic Research Centre in India and in several other countries. Infrared radiation has several medical applications. The most common use is to keep the body warm and also to warm the internal, injured parts of our body. Infrared thermography is widely used in detecting hot spots in industries so that defects in a system could be revealed. Thermal plants and other industries are monitored by thermovision. Integrated infrared measuring systems are used for non-destructive testing of composite materials. Infrared imaging techniques have proved useful in the remote sensing of earth resources and environment. Through remote sensing, one observes the features and phenomena on the surface of earth. Similarly, infrared astronomy is used in studying our galaxy, the Milky Way.

Infrared detectors

An infrared detector is a transducer which converts infrared energy into electrical energy or some other form and also measures it. Eye is also a transducer but it is sensitive only in 0.4 μm to 0.75 μm wavelength range. The most familiar method of detection of infrared radiation is the sensation of warmth by the skin of our body. Scientists have designed several sensitive and accurate IR detectors for the measurement of intensity of IR radiation. All IR detectors commonly used in IR technology can be divided into two categories, "thermal detectors"and "photon detectors". The essential difference between a photon detector and a thermal detector is that a photon detector counts the number of quanta effectively absorbed in the detector whereas a thermal detector responds to the total energy absorbed. A photon detector is therefore sensitive to some particular region of radiation the photons of which are effectively absorbed by it, whereas a thermal detector responds to the total band of

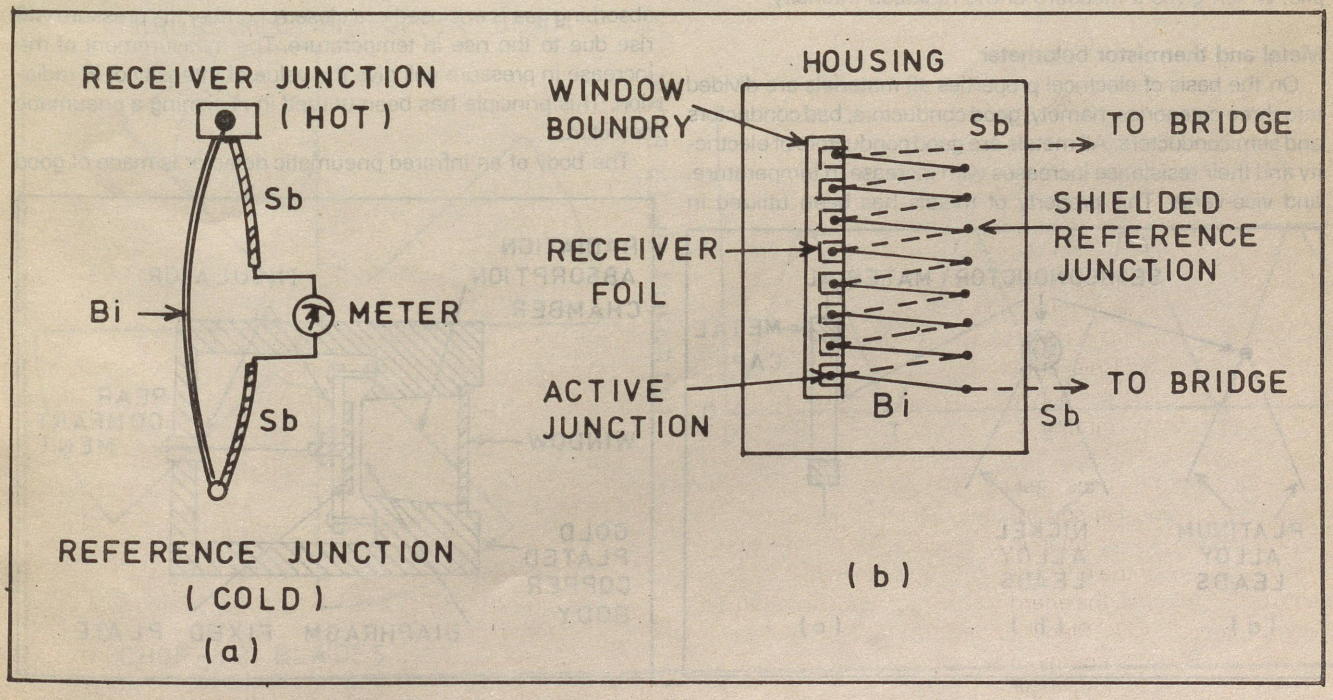

Fig. 1. Radiation thermocouple and thermopile

infrared radiation. In principle, any temperature-sensitive device or effect can be used as the basis of working of a thermal detector. The mercury-in-glass thermometer is a conventional thermal detector. The other well-known thermal detectors are thermocouple, bolometer and Golay cells. Recently, scientists have designed pyroelectric detectors which are widely used in infrared engineering.

Thermocouple

When the ends of two different metal wires are joined together and one joint (junction) is cooled and the other one heated, an electromotive force (emf) if developed across these wires. This combination of two wires is called a thermocouple. The magnitude of emf depends upon the metals of the two wires are made and the temperature difference between the hot and cold junctions. The emf can be measured by electronic instruments and gives the difference in temperature between the two junctions. Several combinations of wires are used, but the most popular combinations are bismuth-silver, copper-constantan and bismuth-bismuth/tin alloy. These thermocouples are widely used for measuring the temperature of hot bodies and the intensity of IR radiation. For improving their sensitivity, several such thermocouples are joined in series as shown in Fig. 1 (b). This combination of thermocouples is called "thermopile". One junction of every thermocouple is mounted on a blackened surface, while the other junction (reference) on an ordinary surface. The entire arrangement is housed in an enclosure. The blackened surface junctions are left open to receive IR radiation, while reference junctions are covered to shield them from IR radiation. IR radiation falling on the blackened junctions is absorbed by their black surface and raises their temperature with respect to reference junctions, leading to the induction of an emf across the two ends of the thermopile, which gives a measure of the radiation intensity.

Metal and thermistor bolometer

On the basis of electrical properties all materials are divided into three categories, namely, good conductors, bad conductors and semiconductors. All metals are good conductors of electricity and their resistance increases with increase in temperature, and vice-versa. This property of metals has been utilized in designing metal bolometers. Made up of fine platinum wires, this type of bolometers is largely used for the measurement of temperature of hot bodies and of intensity of IR radiation. Such metal bolometers are also called platinum resistance thermometers.

Electrically, a semiconductor behaves as if its conductivity is intermediate between that of an insulator and a metallic conductor. Further, its resistance decreases with the rise in temperature, and vice-versa. This property of semiconductors has been utilised to measure the temperature of various systems as well as intensity of IR radiation. IR detector element made of such a semiconductor material is called thermistor bolometer. The size of the element varies from 0.5 mm to a few mm (Fig.2).

Golay cell and pneumatic detector

Golay cell is a gas-filled cylindrical chamber one face of which is closed by a flexible membrane and the other by a fixed, blackened IR absorbing film. The flexible film has a bright reflecting surface on the side opposite to the cylinder. The IR radiation falls on the blackened film and heats it. The heat from the film is transferred to the gas in the cylinder, the temperature of which increases. The increase in the temperature of the gas increases its pressure, which bulges the membrane. The bulging of the membrane can be measured by an optical system. It is a measure of the intensity of radiation falling upon the blackened surface.

BARC, Trombay, has designed a pneumatic detector which is somewhat similar to Golay detector. This detector operates on the principle that gases like CO_2, CO, SO_2, CH_4, NH_3, O_3, etc., absorb some particular parts of infrared radiation while gases like N_2, O_2, Cl_2, etc., do not. The part of IR radiation which is absorbed by a gas is called its absorption band. The absorption of infrared radiation by the gas increses its temperature. If the absorbing gas is enclosed in a closed chamber, its pressure will rise due to the rise in temperature. The measurement of the increase in pressure will give the value of intensity of IR radiation. This principle has been utilized in designing a pneumatic detector.

The body of an infrared pneumatic detector is made of good

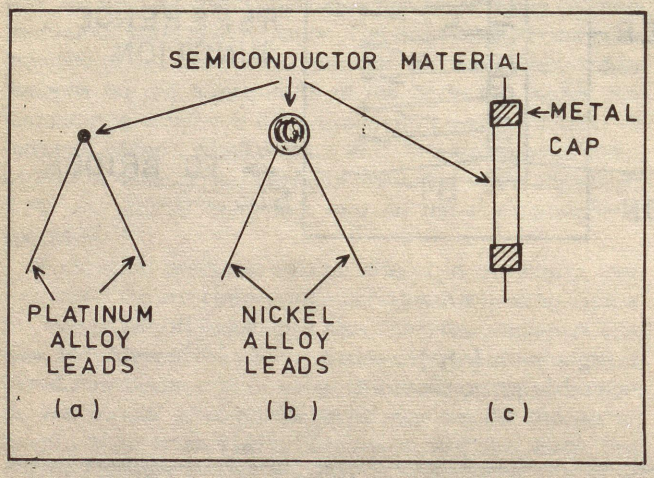

Fig. 2. (a) Ultra small bead, (b) Disc, and (c) Rod thermistor bolometer

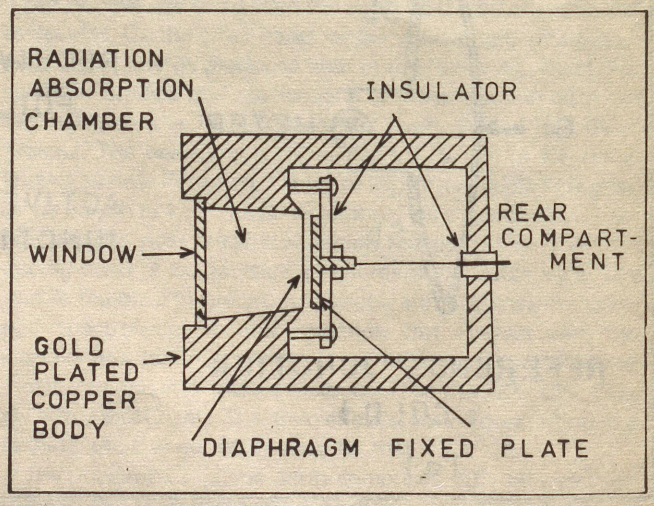

Fig. 3. Schematic of Trombay infrared pneumatic detector

quality brass or copper (Fig. 3). The body comprises two chambers: one small and the other large. These two chambers are separated by a thin aluminised plastic film. The mouth of the front small chamber is closed by calcium fluoride window which allows IR radiation to enter it. The two chambers are filled with a pure gas, which can absorb IR radiation of the required band. The beam of IR radiation enters the front chamber through calcium fluoride window and the gas pressure increases as a result of the absorption of IR radiation. The increase in pressure distends the plastic film. To measure its distention a condenser microphone is attached to it. The aluminised film serves the purpose of diaphragm of the condenser microphone. The capacitance of the condenser changes with the distention of the film, which is directly proportional to the intensity of IR radiation. The change in capacitance is measured by an electronic circuit. These pneumatic detectors are used in infrared gas analysers.

Pyroelectric detector

Certain materials possess a unique axis along which a permanent electric dipole moment exists. This implies that surface cut normal to this axis should be electrically charged. But this effect is normally not observed because the charge becomes neutralised by stray ones. However, its presence can be detected by changing the temperature of the material. The change in temperature alters the dipole moment slightly. If this change occurs quickly, the stray charges do not redistribute themselves and the temperature coefficient of the dipole moment can be measured. This temperature effect is called "pyroelectric effect". All materials having permanent dipole moment possess this property. Triglycine sulphate (TGS), barium titanate, lead germanate, lithium niobate, etc., are some pyroelectric materials. BARC scientists are also trying to produce these materials.

Small and thin wafers are made from pyroelectic materials and metallic coatings are applied on both sides of these wafers. These metal coatings act as electrodes. Fig. 4 shows the schematic diagram of a pyroelectric detector. When chopped IR radiation falls on a pyroelectic detector the polarization of permanent electric dipole changes and an electrical signal is generated across its electrodes. The chopping of IR radiation is carried out by circular blades rotating at a constant speed. It varies the radiation intensity from zero to maximum in a cyclic manner as shown in Fig. 5. The signal generated across the electrodes is the measure of the intensity of the incident radiation.

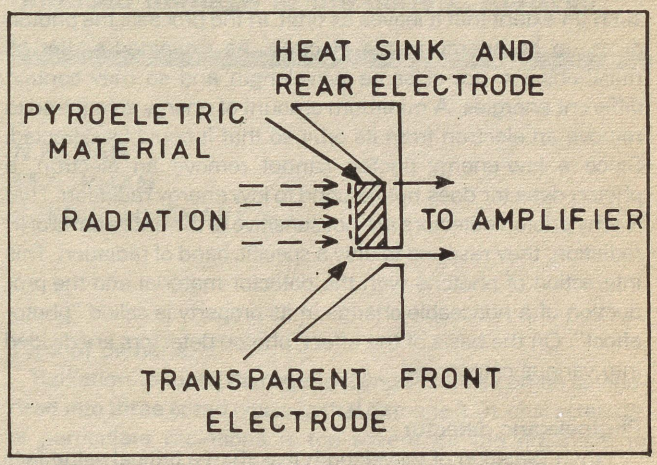

Fig. 4. Pyroelectric detector

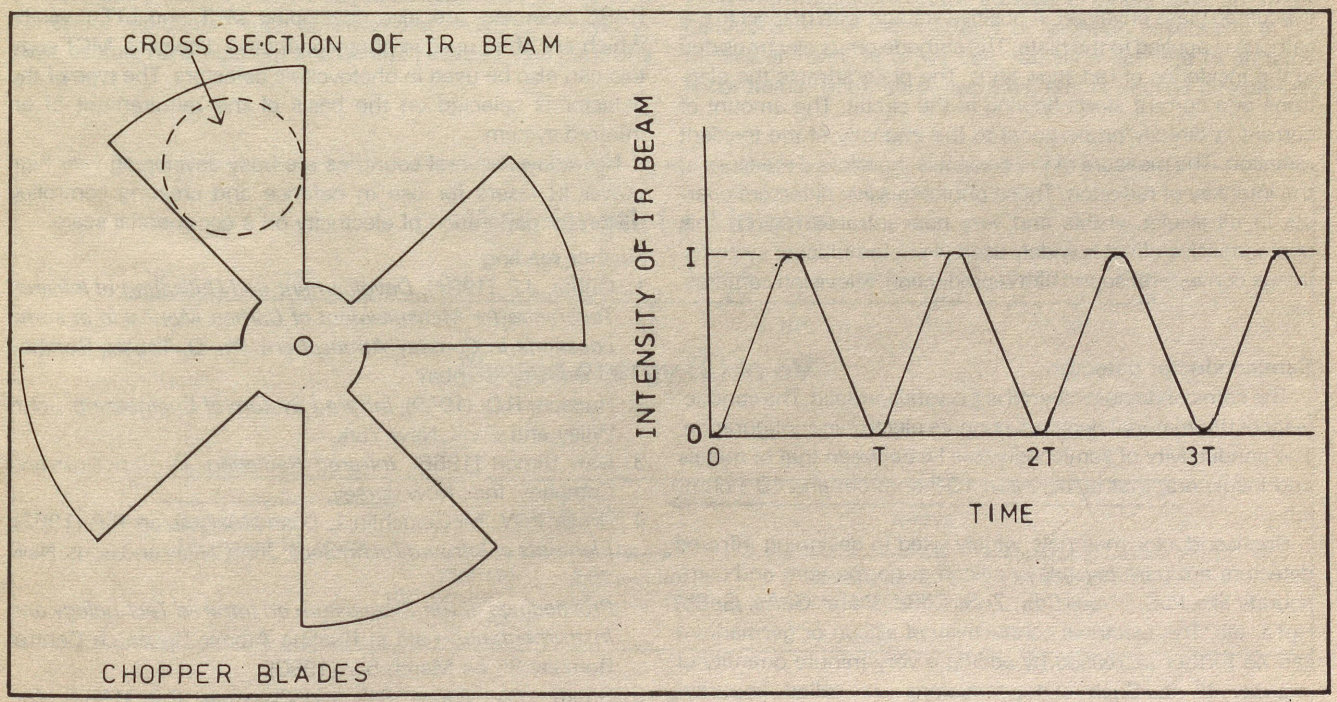

Fig 5. Schematic of chopping mechanism and graph showing the periodic variation in intensity of IR beam due to chopping

Photon detectors

The sensitivity of a photon detector is quite high in comparison with that of a thermal detector. Moreover, the output of a photon detector does not depend on the rise in temperature. It depends upon the capability of a photon to excite an electron to such an extent that it leaves its orbit. In the process, the photon gives up its energy to the electron. As explained earlier all radiations are not of same wavelength and so they contain different energies. A minimum amount of energy is required to remove an electron from its orbit so that it could be detected. Since a low-energy photon cannot remove an electron, a photon detector does not respond to low energy radiation. That is why photon detectors are not sensitive to the entire band of IR radiation; they respond to only a specific band of radiation. This interaction of photons with the detector material and the production of a noticeable change in its property is called "photoeffect". On the basis of the effect, photon detectors are divided into various categories.

Photoelectric detector

When radiation of wavelength less than a critical value falls upon the surface of certain materials, its photons collide with electrons in the material surface and transfer their energy to them. If energy gained by electrons is sufficient to cross the surface boundary of the material, they leave it. This surface boundary is called "potential barrier". In crossing the potential barrier, every electron loses some energy which it has gained by absorption of photon. The energy 'E' of the electron leaving the surface is given by $E = h\upsilon - \phi$, where $h\upsilon$ is the energy of the photon absorbed and ϕ the energy of the potential barrier.

Photoelectric detectors designed on the above principle consist of a photoemissive cathode and a plate, both housed in an evacuated glass envelope. A positive voltage with respect to the cathode is applied to the plate. The cathode emits electrons due to the incidence of radiation on it. The plate attracts the electrons and current starts flowing in the circuit. The amount of current is directly proportional to the intensity of the incident radiation. The measure of the current is therefore a measure of the intensity of radiation. These photoemissive detectors operate in ultraviolet, visible and very near infrared region. This photoemissive effect is widely used in photomultiplier systems, image converters, sound film reproduction, television cameras, etc.

Semiconductor detector

The semiconductor material is a crystalline solid. The conductivity of the material depends upon its electronic configuration. The conductivity of semiconductors lie between that of metals and insulators, that is, between 10^{-3} ohm-cm and 10^{12} ohm-cm.

Semiconductor materials widely used in designing infrared detectors are pure crystals of silicon or germanium and compounds like PbS, PbSe, CdS, ZnS, CdSe, CdTe, GaAs, GaSb, HgTe, etc. The electrical conductivity of silicon or germanium can be further increased by adding a very minute quantity of impurity to it. Such semiconductors are called impurity-activated semiconductors. Impurity-activated semiconductors are of two types, one of them is called p-type, while the other one n-type. In p-type materials, the impurity creates vacant positions of electrons. The vacant positions in such materials are positively charged and are known as holes. Similarly, the impurity creates an excess of electrons in n-type materials. In p-type material, the current flows due to the movement of holes, while in n-type it is due to electrons. When p- and n- type materials are joined, a neutral layer is formed at their joint. The junction is called p-n junction. These semiconductor materials are commonly used in making photon detectors.

Photoconductive detectors

A pure or impurity-activated semiconductor material acts like a high resistance device when it is in an electronic circuit. On applying a voltage across it current flows through it in form of electrons and holes. When IR radiation falls on it, its conductivity is further increased. This increase in conductivity is the measure of the intensity of IR radiation.

Photovoltaic detector

A photovoltaic detector consists of a p-n junction formed in an intrinsic semiconductor. It does not require an external voltage supply because it itself generates a voltage due to the incident IR radiation. As a minimum amount of energy of the photon is required to produce an electron-hole pair, this type of detector cannot be used for the entire range of IR radiation. Practical and theoretical studies have shown that it can operate only upto 7 μm of IR radiation. Often, photovoltaic detectors are made of silicon, indium arsenide and indium antimonide.

Some intrinsic semiconductor detectors made of PbS and PbSe have been developed at BARC. Nowadays, some new type of materials like mercury cadmium teluride (MCT) and lead tin teludride (LTT) are being extensively used in infrared detectors. BARC scientists are also developing MCT and LTT crystals, which are often used in photoconductive detectors. MCT crystals can also be used in photovoltaic detectors. The type of the detector is selected on the basis of the requirement of an infrared system.

Nowadays, several countries are busy developing very high power IR lasers for use in defence and creating controlled fusion for generation of electricity on a commercial scale.

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DNA REPAIR MECHANISMS

Living cells possess several mechanisms by which they can repair radiation or chemical induced damage to the genetic material

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M.A. KHAN
SYED E. HUSNAIN

THE currently estimated antiquity of the earth is about 4800 million (4.8×10^9) years and the first life is believed to have originated in the "primeval soup", some 10 million years later amidst a plethora of injurious radiations. The perpetuation of such injurious components of the primitive environment ultimately led to the development of a heritable repair machinery within the living system to overcome the recurrent radiation damage. As life evolved from simple to complex, this repair machinery also became finer and complex, with attendant diversification.

The contemporary living world is also provided with definite heritable repair workshops within each cell that tend to offset the damaging effects of a variety of naturally occurring chemicals and radiations. The destructive radiations fall in a wavelength range below 340 nm (1 nannometer=10^{-7} cm) and photon energy above one eV (electron volt). They comprise a variety of radiations; such as ultraviolet rays(UV), X-rays, γ-rays, cosmic rays, alpha(α) and beta(β) particles, and neutrons etc. (Fig. 1).

Type of damage

Radiation-induced damage to living systems can be categorized into three broad types. Lethal damage (LD), characteristic of particulate radiations is too severe for the organism to escape death (Fig. 2). Potentially lethal damage (PLD), predominantly inflicted by low LET (linear energy transfer) radiations (X and γ) can also prove fatal under ordinary conditions. However, its severity can be modified by manipulating the pre- and/or post-irradiation environmental conditions. Sublethal damage (SLD), on the other hand, is a cumulative damage, and is caused by electromagnetic radiations (X and γ). Unless it reaches a certain threshold value, cells do not die. It is against these two categories of damage that repair is generally possible.

The aforesaid concepts of damage, which have mostly evolved from studies on the survival of single cells, are manifestations of the initial effects of radiation essentially at the molecular level. In a live cell, radiation damage to proteins, lipoproteins, DNA, carbohydrates, etc. is caused directly—by

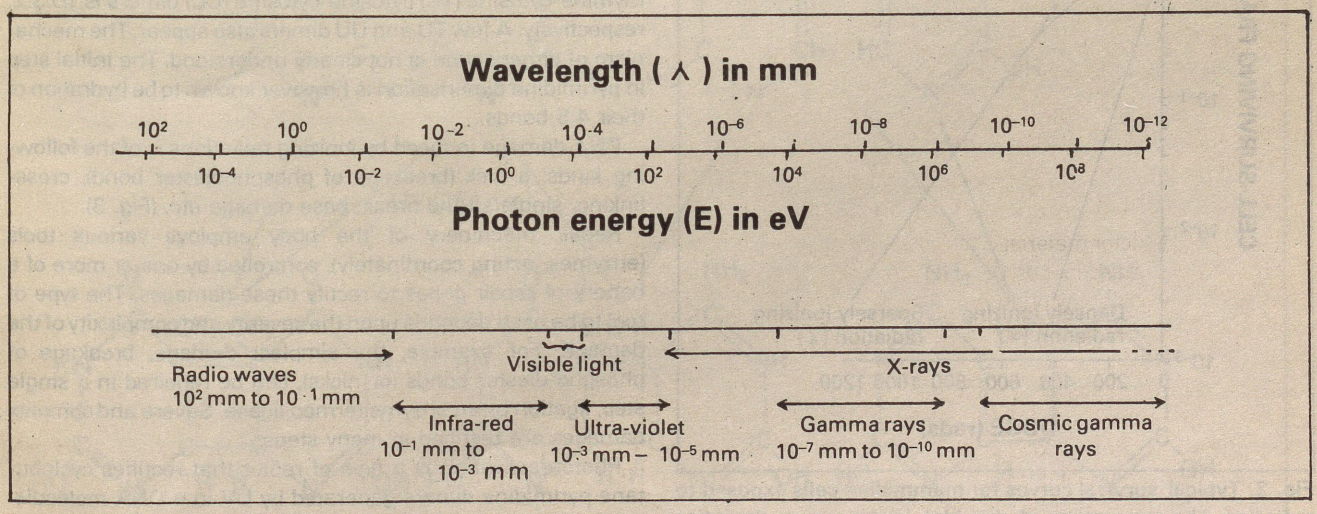

Fig. 1.a

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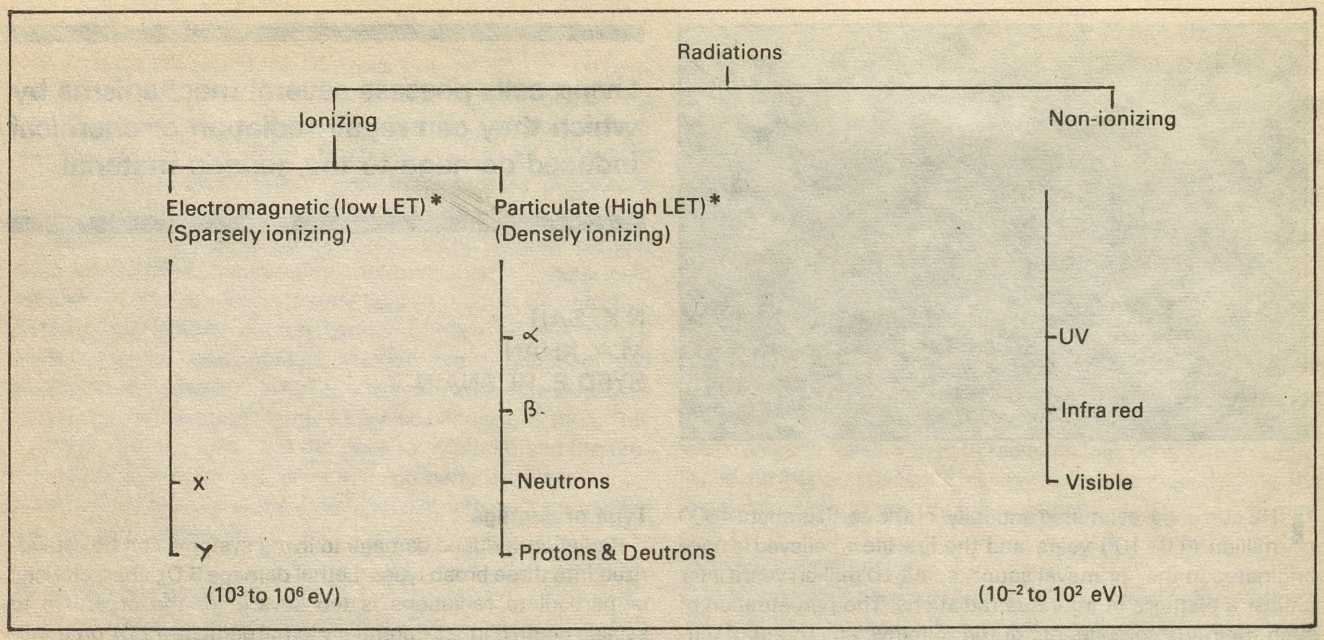

Fig. 1. b

way of ionization or excitation—or indirectly—through the highly reactive free radicals known to be produced predominantly by radiolysis of cellular water. DNA is the storehouse for genetic information, so a damage to it assumes great dimensions. It can perpetuate genetic defects and therefore the cellular repair machinery is largely devoted to its welfare.

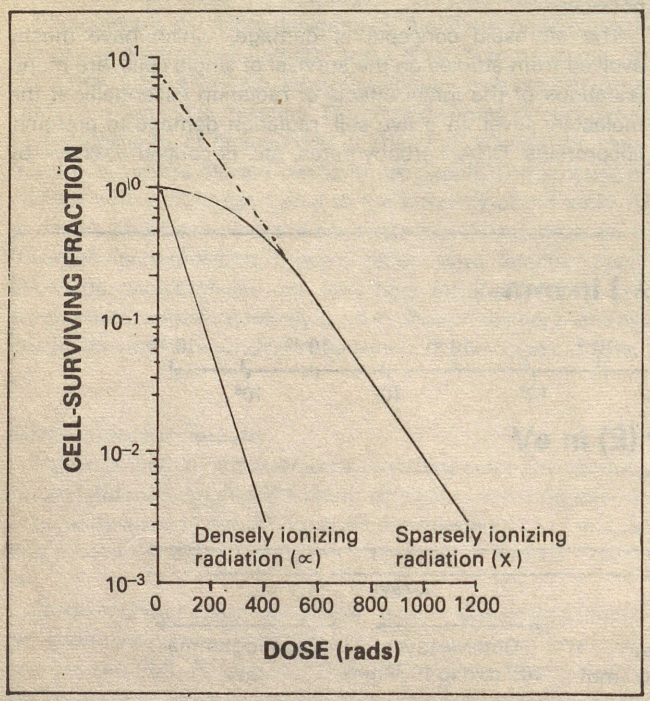

Fig. 2. Typical survival curves for mammalian cells exposed to radiation. The appearance of shoulder in the curves depicting the effect of sparsely ionising radiation points to the existence of sub lethal damage. On the other hand, the linear curve for densely ionizing radiation is indicative of lethal damage (Adapted from 'Radiobiology for the Radiologist' by E.J. Hall, 1978.)

Genetic damage by radiation

The DNA duplex is damaged by UV and ionizing radiations in different ways. Absorption of UV rays causes excitation of the macromolecules (Fig. 2) which leads to cross-linking, single strand breaks and base damage as minor lesions, and generation of nucleotide dimers as a major one. Purines are generally more radioresistant than pyrimidines. Of the latter, thymine is more reactive. Therefore, the ratio of thymine-thymine (TT) thymine-cytosine (TC) cytosine-cytosine (CC) dimers is 10:3:2, respectively. A few TU and UU dimers also appear. The mechanism of dimerisation is not clearly understood. The initial step in pyrimidine dimerisation is however known to be hydration of their 4:5 bonds.

DNA damage induced by ionizing radiations is of the following kinds: a nick (breakage of phosphodiester bond), cross-linking, single strand break, base damage etc. (Fig. 3).

Repair machinery of the body employs various tools (enzymes, acting coordinately), controlled by one or more of a bettery of repair genes to rectify these damages. The type of tool to be used depends upon the severity and complexity of the damage. For example, the simplest damage, breakage of phospho-diester bonds (or nicks), can be repaired in a single step, ligation by an enzyme termed ligase. Severe and complex damages are rectified in many steps.

Photoreactivation is a type of repair that rectifies cyclobutane pyrimidine dimers generated by UV in a DNA molecule. The term was coined by A. Kelner (1949) who stumbled upon the discovery that exposure to visible light (300-500 nm) of UV-irradiated bacteria tends to reverse the killing and mutagenic effects of the latter. The phenomenon, though not universal, is known to occur in colon bacterium, yeasts, and possibly

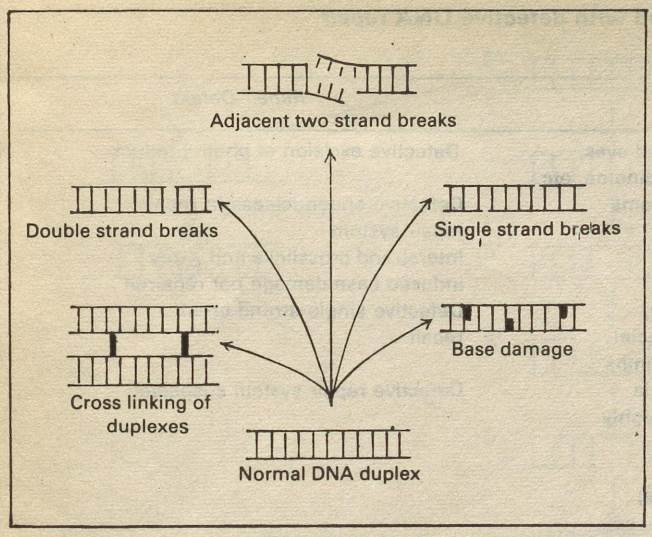

Fig. 3. Some types of DNA damage by ionizing radiation

higher animals and plants. An enzyme, named photoreactivating enzyme (PRE), has been shown to be involved in the process by C.S. Rupert (1962) of the University of Texas (USA). Recently the term photolyase has been used to designate it. This enzyme is species-unspecific, as is evident by the observations that organisms (like *Pneumococcus, Haemophilous,* etc.) incapable of photoreactivation-repair, can do so after being supplemented with an extract from photoreactivable *E. coli*. The enzyme, because of its occurrence in infinitesimal quantity, defied all attempts at purification for over a decade. C.O. Fuselier (1976) and his collaborators at the University of California, Irvine (USA) finally succeeded in doing so by developing a colon bacterium, lysogenic for λ transducing phage carrying *phr* gene (photoreactivating gene).

The enzyme is now known to consist of monomeric apoprotein (mol. wt. 35,200 daltons) with arginine at the amino terminal, and requires a cofactor, believed to carry an adenine moeity. This enzyme has reportedly been isolated from orchid seedlings, mammalian cells, human lymphocytes and fibroblast also.

Not much is known of the photoreactivation process (Fig. 5). The distortion (lesion) in DNA is said to be perceived by the enzyme while moving along the DNA duplex. The enzyme, photolyase, recognizes it and then binds to the damaged site of DNA in dark to form an enzyme-damaged DNA complex. Illumination with visible light splits the dimer *in situ* and the enzyme is released. Light apparently provides the energy-trigger for this split. In addition to restoration of the pyrimidine dimers (especially TT) to normal state, the enzyme also undoes UV-induced cross-linking of DNA duplexes. There are reports that it also repairs UV-induced damage to RNA in a hitherto unknown way.

The nature of Photolyase-substrate complex has not yet been resolved. Nucleotides, DNA-digest and synthetic poly

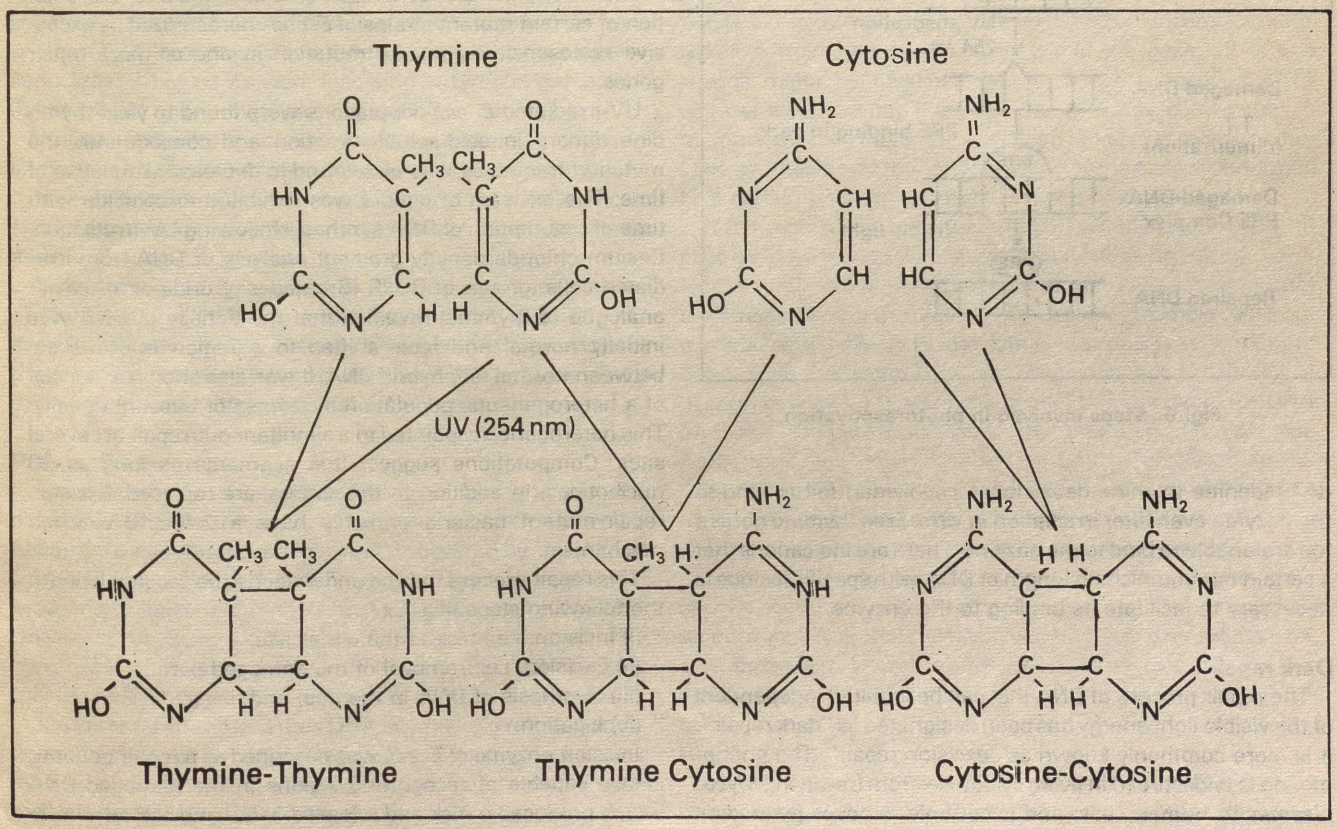

Fig. 4. Pyrimidine dimer induced by UV radiation

Some human diseases connected with defective DNA repair

Disease	*Symptoms*	*Repair Defect*
1. Xeroderma pigmentosum	Photosensitivity of skin and eyes; high incidence of skin carcinoma, etc.	Defective excision of photo product
2. Ataxia telangiectasia	Nervous and immune systems and skin affected	Defective endonuclease in repair repair system
3. Fanconi's anemia	Lethal aplastic anemia	Interstrand crosslinks and X-ray induced base damage not repaired
4. Hutchinson-Gilford progeria syndrome	Alopeica, premature aging, prominent eyes & craniofacial abnormalities, very short limbs	Defective single-strand break repair
5. Bloom's syndrome	Light-induced telangiectasia on face; stunted growth; highly infection-prone	Defective repair system suspected
6. Cockayne's syndrome	Premature aging, Type II lipoproteinemia; dwarfness; deafness; large ears and nose; sunken eyes & optic atrophy	"
7. Down's syndrome	Mentally & physically retarded; premature senescence; highly prone to leukemia, Trisonic 21st chromosome	"
8. Retinoblastoma	Malignant eye tumor, associated with deletion in chromosome 13	"

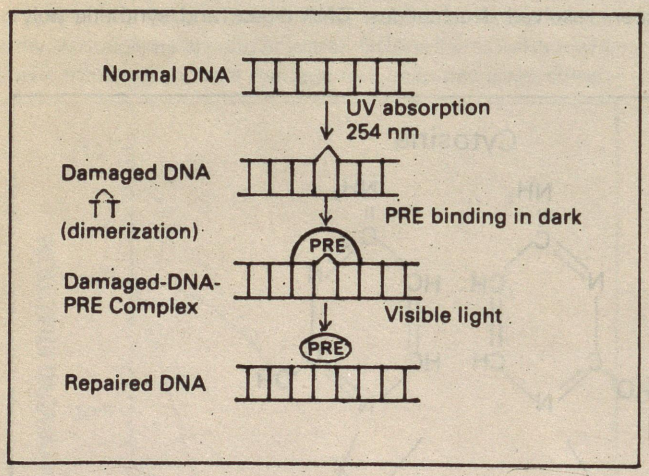

Fig. 5. Steps involved in photoreactivation

dAT (adenine-thymine deoxyribose copolymer) fail to bind to the enzyme even after irradiation *in vitro*. Free thymine dimers too are unable to bind to the enzyme. There are indications that a certain minimum chain length of DNA with specific lesions is necessary to facilitate its binding to the enzyme.

Dark repair

The repair process of DNA that can be initiated independent of the visible light energy has been designated as "dark repair" It is more commonly known as "excision repair". The phenomenon is widespread in living systems—from free living *Mycoplasmas* to human cells; and it not only removes pyrimidine dimers, but also corrects a variety of structural defects of the double helix e.g., cross linking, base damage, etc. Some chemically induced DNA damages can also be rectified by this process.

The mechanisms of dark repair was unveiled after the isolation of certain mutant strains of *E. coli* characterized by excessive radiosensitivity due to mutation in one or more repair genes.

UV-irradiated *E. coli* populations were found to yield thymidine dimers in acid-soluble fraction and consequently the mutation frequency was also found to decrease with lapse of time. The excision of dimers was exhibited to coincide with time of resumption of DNA synthesis following UV-irradiation. Cesium chloride density gradient analysis of DNA from irradiated cells, grown in BUdR (Bromodeoxy uridine, a heavier analogue of thymine) revealed that the density of DNA was initially normal and later shifted to a region intermediate between normal and hybrid DNA. It was also shown to consist of a heterogeneous population in respect of buoyant density. This heterogenecity pointed to a simultaneous repair at several sites. Computations suggest that segments as long as 20 nucleotides, in addition to the dimers, are replaced. Excision repair-mutant bacteria probably have a defective excision mechanism.

This repair process may be understood to be accomplished in the following steps (Fig. 6):

(i) Incision, i.e., nick at the dimer site;
(ii) Excision, i.e., removal of the damaged portion;
(iii) Synthesis of DNA in the gap; and
(iv) Ligation.

Incision enzyme of *E. coli* was described as a repair endonu clease capable of recognizing lesions in the damaged DNA which produced a nick and released 3' OH and 5' P termini. L. Grossman and his associates (1975) at Brandeis University, Massachusetts (USA) believe that it is a mixture of two

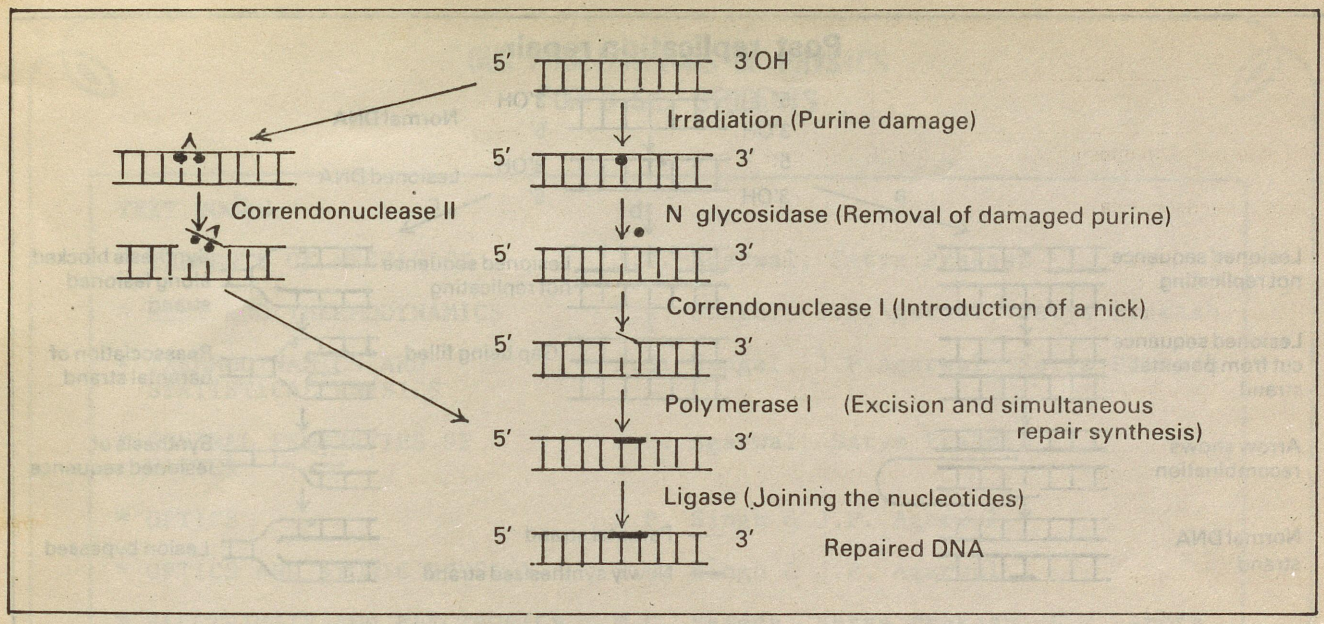

Fig. 6. Hypothetical model of excision repair of DNA

enzymes, viz., correndonuclease I and II. The former introduces a nick at the damaged-purine-depleted sites and UV-photoproducts other than pyrimidines (possibly cytosine photohydrates). The latter acts at UV-induced photodimer pyrimidine sites and cross-links caused by ionizing radiations or chemicals. In certain cases, it has been shown that correndonuclease I begins its work following enzymatic removal of the damaged purine by N-glycosidase from the DNA.

Nicking is followed by the excision of the lesioned DNA along with some adjacent undamaged portions of the defective strand in 5′ → 3′ direction. DNA polymerase I and II are involved here. The former can excise 7-8 oligonucleotides and the latter can do away with longer fragments.

The gap created by excision is filled up simultaneously by synthesis of fresh DNA by polymerase I and III in 5′ → 3′ direction. Finally, the gap between the nucleotide last added in the process of repair synthesis and the 5′ P terminus of the pre-existing nucleotide is levelled up by ligase.

Post-replication repair

The concept of recombination-like repair emerged from the decreased ability of the mutants for genes facilitating recombination to repair damages. This was discovered by W.D. Rupp and P. Howard-Flanders (1968) of Yale University School of Medicine in bacteria and then by A.R. Lehmann (1972) of the University of Sussex (England) in mammalian cells. The hypothesis of Rupp and Howard-Flanders (Fig. 7a) assumes that the replicating complex jumps over or bypasses the lesions in the parental strand and thus DNA synthesis is rather discontinuous with gaps as long as the lesions. These gaps are later filled by a recombination-like process. the undamaged complementary parental strand replicates normally. The newly synthesized DNA strand has the same polarity as the damaged parental strand. Then segment of the size of the lesion and bearing a similar number and a kind of bases in a similar array is excised and inserted into the gap left due to the lesion. The gap so created in the newly replicated DNA strand is later filled by the normal synthetic complex.

A.R. Lehman unable to observe the actual recombinational repair in mammalian cells, opined that the gaps left due to lesions might be filled afterwards by some unknown DNA polymerase randomly (Fig. 7b)., Later, it was shown that in mammalian cells there is a replication not connected to constitutive synthesis and the random filling of the gaps is performed by a certain enzyme, i.e., nucleotidy I transferase.

N.P. Higgins and coworkers (1976) of the University of Chicago (USA) came out with another proposition (Fig. 7c). According to their scheme, DNA replication always starts from undamaged end of the duplex. The replicating complex does not move beyond the lesion in the damaged strand, but continues to do so along the undamaged one. Later, due to the impossibility of further winding of the helix behind the stop point for DNA synthesis, the parent strands of DNA may start to reassociate. As a result, the newly synthesized DNA is displaced. In the region of displacement these new DNA chains are able to make a detour. This facilitates them to synthesize DNA again along alternate templates. After copying of the lesioned sequences, it is said, the block to replication is "switched off" and unwinding of DNA occurs, allowing synthesis to proceed without necessitating removal of the initial lesions. Electron microscopic studies, they claim, provide some corroborating evidence for this model.

Repair genes

At least eight genes are believed to be involved in the repair process of *E. coli*. Three of them, viz., Pol A, Pol C and Lig genes, are known to perform fast repair (excision repair) in non-dividing cells. Other five genes, viz., rec A, rec B, rec C, lex A and

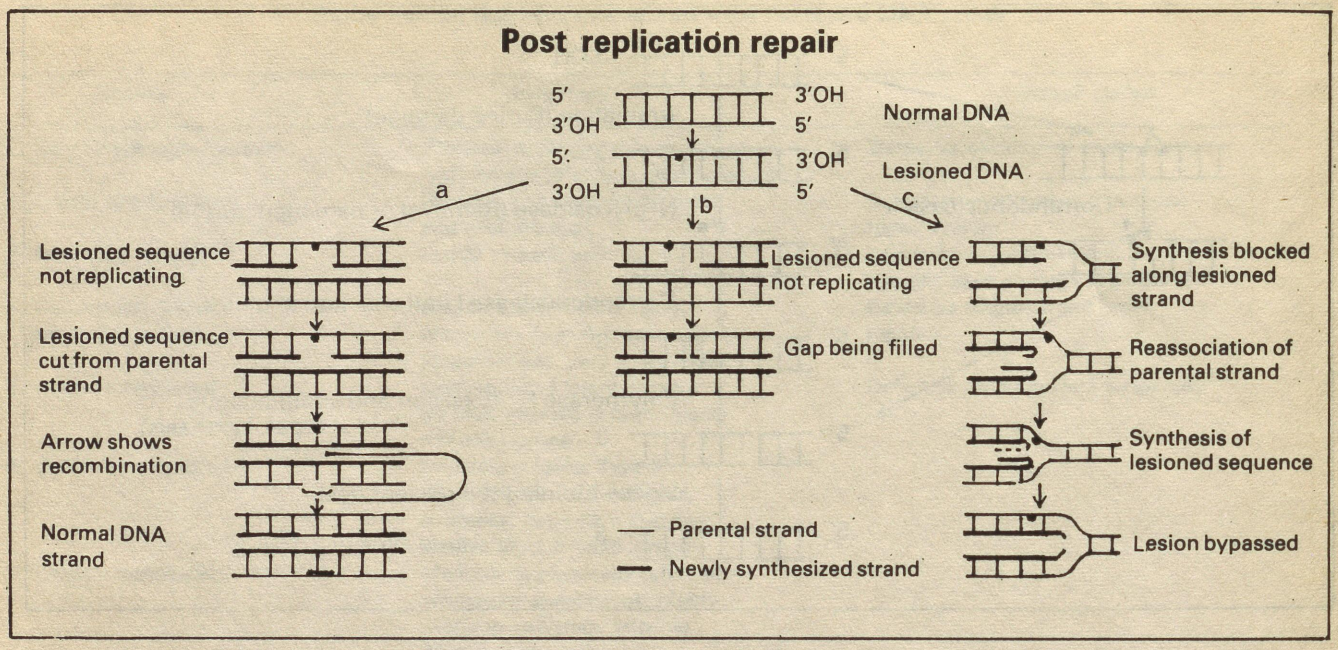

Fig. 7. Three hypothetical models of post replication repair (a) Recombination-like repair, (b) Random filling, (c) Repair replication according to Higgins *et al.* (1976). (Adapted from Valery N. Soyfer in Advances in Radiation Biology (1979) Vol. 8.

uvr D are supposed to mediate the slow repair (recombination-like or post-replication repair). These quin genes may also be controlling the capacity of the cell to synthesize new DNA upon irriadiation—may be what is commonly known as unscheduled DNA synthesis (UDS). It has been found that rec B and rec C genes together code for a nuclease which has a definite role to play in this repair. Genes rec A and lex A are known to be regulatory. The gene product of rec A is a protease which destroys certain proteins believed to keep the genes responsible for repair processes "switched off" after irradiation. However, under normal conditions, lex A gene product keeps the rec A "switched off". It is said that something following irradiation triggers "switching off" of the lex A gene (may be scanty amount of rec A product), and thus the rec A is "switched on" to function. This process of slow repair has been designated as "SOS" repair by M. Radman (1974) of Universite Libre de Bruxelles (Belgium). This is an error-prone repair. It has been evidenced by the observations that mutants for any of these repair gene result in a decreased frequency of mutations.

In yeast, at least thrity genes are believed to co-operate in the repair process. Their function is however inadequately understood.

Chemical inhibition of repair processes

Experimental results suggest that under certain conditions some chemicals, such as caffeine, N-ethylmaleimide, hydroxyurea, etc. inhibit one or more of a host of enzymes involved in the repair processes. This impairment of the repair-machinery is said to underpin the interpretation of potentiation of the radiation-induced damages by these chemicals.

Repair, mutation and evolution

Radiations, both ionizing and non-ionizing, have catalysed several chemical reactions, have also induced many new changes in the incipient macromolecules of genetic consequence. The production of such new changes viz. mutation provided raw material on which Darwinian natural selection could operate. The Dutch botanist Hugo de Vries (1848-1935) put forward the "mutation theory" of evolution in order to overcome some of the objections raised against Darwinism. However, one of its inadequacies again remained with regard to the explanation of how spontaneous mutation cropped up in biological systems. Discovery of the inherent repair processes, especially in the error-prone slow repair (SOS), has eased the understanding of the origin of spontaneous mutation.

According to the State University of New York medical scientist Evelyn Witkin (1969), who made a comparative study of UV-sensitive and normal strains of *E. coli*, mutations arise by strand mismatching or by copy-errors that occur during the molecular recombination process of the post-replication repair. She concludes that although unrepaired thymine dimer production is a potential mutagenic event, it becomes an actual mutagenic event only during the post-replication repair. Spontaneous mutation may arise during the process of repair of damage caused by natural radiations or environmental chemicals. The variants so produced undergo the process of natural selection where the fittest ones are allowed to survive, while others may perish in the long run.

Interstellar molecules

THE vast empty space between stars forms a unique laboratory where chemical reactions previously unknown on earth take place. Astronomers have known for decades that interstellar space contains dust particles and hydrogen gas in atomic form. The most abundant element present in the universe is hydrogen. The other elements present are in trace ammounts 10^{-4}-10^{-7} times of hydrogen) in the entire cosmos. These elements include mainly helium, oxygen, carbon, nitrogen, neon, iron, silicon, magnesium, sulphur, argon, aluminium, calcium, nickel, sodium, phosphorus, etc. These various elements combine in interstellar space due to ultraviolet and other radiations to produce various familiar and unfamiliar molecules. In the present article the outline of chemistry involved in the formation of various interstellar molecules is given.

Molecules in space

The first interstellar molecular species were CH, CH^+, and CN which were detected by optical telescopes in the early 40s. Later, radio telescopes identified OH radical. Thereafter followed a spate of discoveries of interstellar molecules of amazing varieties. Approximately 90 molecular species, including isotopic varieties, have been identified in the vast interstellar space to date. They include the simplest and familiar such as hydrogen (H_2), carbon mono-oxide (CO), ammonia (NH_3), water (H_2O), hydrogen cyanide (HCN), hydrogen sulphide (H_2S), methanol (CH_3OH), acetaldehyde (CH_3 CHO), etc. Some of the unfamiliar and unusual interstellar molecular species are as follows: Simple molecular ions (CH^+, HCO^+, N_2H, HCS^+, $HOCO^+$, etc.), radicals (OH, HC_4 SO, HC_3, CN, etc.) and cyanopolyynes (HC_3N, HC_5 N, ...HC_{11} N, etc.).

Reaction routes

Interstellar molecules are formed and destroyed in a galaxy through various alternate routes depending upon the drastically different physical conditions found between stars. Owing to very low temperature and densities of matter in the interstellar medium, the chemical reactions which produce these molecules are mainly the ones that produce heat (exothermic) and occur between two reacting species (bi-molecular). They have also relatively higher reaction rates.

Different reaction routes are given to explain various chemical reactions taking place in solid, liquid (solution) and gaseous phases. The interstellar chemical reactions follow reaction mechanisms which are generally operative when the reacting species are in gaseous form. Some of the reaction routes possible for the interstellar chemical reactions are as follows:

(a) In an ion (A^+) and neutral molecule (B) reaction mechanism, either an ion-molecule (AB^+) is formed or due to charge transfer the ion (A^+) is changed to neutral molecule (A) and the neutral molecule (B) to an ion (B^+) as follows:

$$A^+ + B \longrightarrow \begin{cases} AB^+ + h\upsilon \\ A + B^+ \end{cases}$$

(b) In an electron recombination reaction, an ion (A^+) is converted into neutral molecule (A) by combining with an electron (e-) as follows:

$$A^+ + e^- \longrightarrow A + h\upsilon$$

(c) An ion-molecule (AB^+) dissociates due to the absorption of a photon ($h\upsilon$) in a photo-chemical reaction as follows:

$$AB^+ + h\upsilon \longrightarrow A^+ + B$$

(d) An interaction between two neutral species produce either another neutral species or a charged species after ejecting an electron (e-) as follows:

$$AB + C \longrightarrow AC + B$$
$$A + B \longrightarrow AB^+ + e^-$$

(e) Ion (A^+)-ion (B^-) neutralisation reaction produces a neutral molecule as follows:

$$A^+ + B^- \longrightarrow AB$$

The distribution of interstellar matter is not uniform; most of the space is empty, and the matter is accumulated in the form of 'Clouds'. However, the cloud material is not uniformly distributed. It is composed of a solid fraction or 'cosmic dust'(grains)of uncertain composition (1%) and gas (99%). The grains in the matter absorb the reacting species over their surface where chemical reactions take place and the product molecules thus formed are ejected out from the surface. The observed abundance of hydrogen gas has been accounted for by the 'grain-catalysed' surface reaction between hydrogen atoms as follows:

$$H + H + \text{grain} \longrightarrow H_2 + \text{grain}$$

Formation mechanism

Amongst the various possible reaction routes mentioned above, the reaction between positive ion and neutral molecular species seems to be the most likely process of formation of most of the interstellar molecules. However, the chemistry of the formation of these molecules is controlled by entirely different processes in two different types of 'cosmic clouds', namely 'diffuse' or 'dense'. A 'diffuse cloud' has lower-density of interstellar material and a 'dense cloud' has higher density of the same.

Galactic star light (1000Å -2000 Å) can penetrate through diffuse clouds. Reactions in this phase take place due to the absorption of ultraviolet and visible radiations. They form

mainly diatomic molecules such as H_2, HD, OH, CO, CH,CH^+ etc., due to ionisation and dissociation processes of atoms and molecules respectively. The accepted mechanisms of some of the molecular species forming in 'diffuse clouds' are shown in Fig 1. Dense clouds, on the other hand, are opaque to ultraviolet

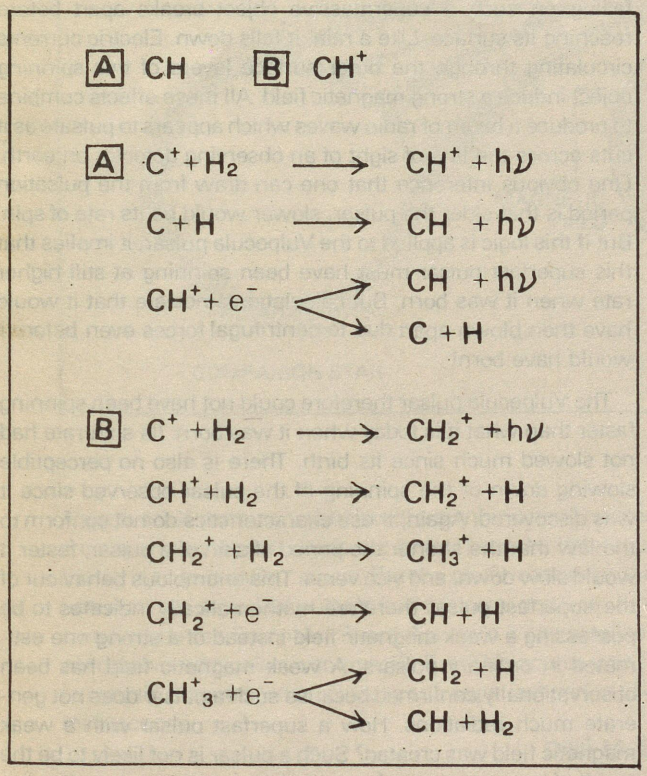

Fig. 1. Formation mechanism in diffuse interstellar clouds

starlight. Cosmic rays, that is, highly energetic nuclei of atoms or nucleons, however, can penetrate them and cause chemical reactions producing interstellar molecules. Hydrogen molecule is first ionised by these rays. It then reacts with other molecular species, including H_2, to produce highly reactive H_3^+ ion as follows:

$$H_2 \text{ Cosmic rays} \longrightarrow H_2^+ + e^-$$
$$H_2^+ + H_2 \longrightarrow H_3^+ + H$$

These H_3 ions react with other molecules to form different molecular species through the following reactions:

$$H_3^+ + CO \longrightarrow HCO^+ + H_2$$
$$H_3^+ + N_2 \longrightarrow N_2H^+ + H_2$$

Cosmic rays also produces energetic helium ion (He^+) which can dissociate other molecules such as CO, N_2, O_2, etc., producing ions like C^+, N^+, N_2^+, O^+, etc. The reaction with nitrogen molecule (N_2) is as follows:

$$He + \text{Cosmic rays} \longrightarrow He^+ + e^-$$
$$He^+ + N_2 \longrightarrow N_2^+ + He \text{ or } N^+ + N^+ + He$$

Formation mechanisms of some interstellar molecules are shown in Fig. 2. Cyanopolyynes such as $H-(C\equiv C)_n-CN$ are important compounds formed in dense clouds. Their formation mechanism is shown in Fig. 3.

Although the qualitative picture of formation of various molecules in interstellar space is clear to a reasonable extent, the

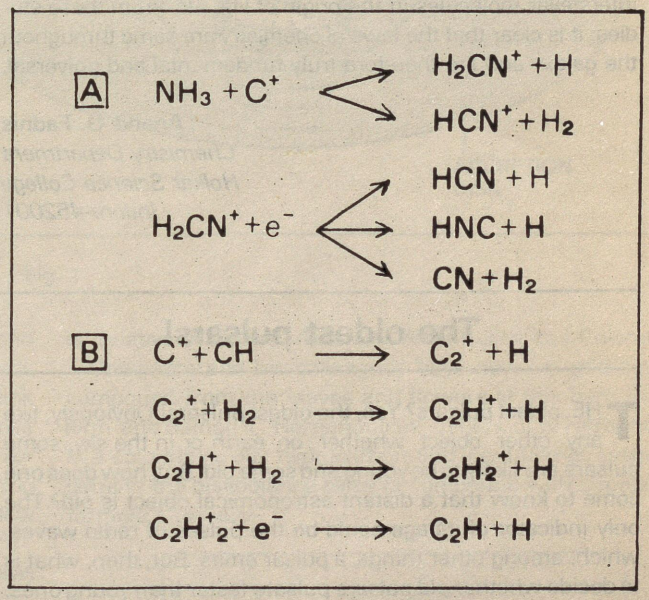

Fig. 2. Formation mechanism in dense interstellar clouds

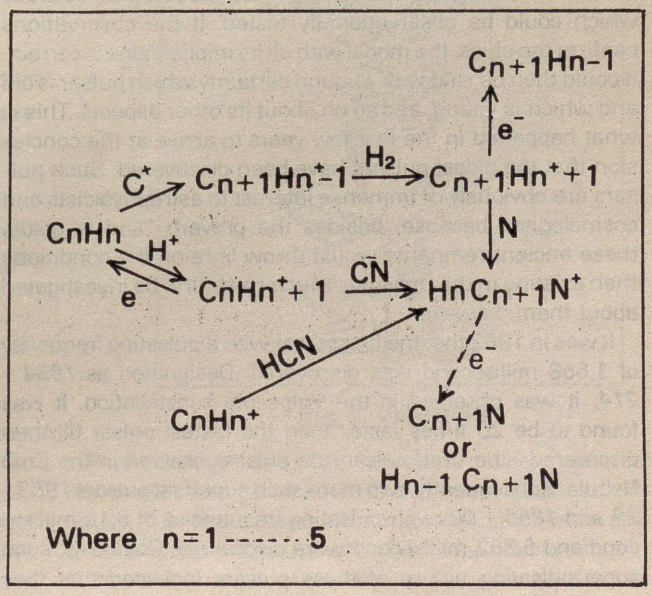

Fig. 3. Formation mechanism of cyanopoly-ynes H—(C ≡ C)n—CN

quantitative aspect of interstellar chemistry is still uncertain. Recently, some quantitative models have appeared but they differ in reacting species, number of reactions considered in a particular formation reaction of a molecular species, and also in the computation of values of rate constants.

So, interstellar chemistry, the youngest branch of chemistry, has made substantial contribution to the better understanding of different theoretical and experimental aspects of chemistry, such as reaction mechanism, surface chemistry, computation of rate constants, etc., and of astronomy, such as, distribution of matter in galaxy, origin of star and solar system, implications of interstellar molecules in the origin of life, etc. From these studies, it is clear that the laws of chemistry are same throughout the galaxy and are therefore truly fundamental and universal.

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The oldest pulsars!

THE oldest pulsars? Yes, the oldest pulsars! Obviously, like any other object whether on earth or in the sky, some pulsars are likely to be young and some old. But, how does one come to know that a distant astronomical object is old? The only indicator of its age could be the pulses of radio waves, which, among other things, a pulsar emits. But, then, what is to decide whether old pulsars pulsate faster than young ones, or vice versa? This is determined on the basis of mathematical models of pulsars. Examining those models provide clues which could be observationally tested. If the observations confirm the clues, the model with all its implications is correct. It could then be said with enough certainty which pulsar is old and which is young, and so on about its other aspects. This is what happened in the last few years to arrive at the conclusion that the oldest pulsars have been discovered. Such pulsars are obviously of immense interest to astrophysicists and cosmologists because, besides the proverb "Old is gold", these ancient remnants would throw light on the conditions then existing in the universe. Much has still to be investigated about them, however.

It was in 1982 that the first pulsar with a pulsating frequency of 1.558 millisecond was discovered. Designated as *1934 + 214,* it was observed in the Vulpecula constellation. It was found to be 20 times faster than the fastest pulsar till then discovered—the Crab pulsar, the pulsar observed in the Crab Nebula. Subsequently, two more such superfast pulsars *1953 + 29* and *1855 + 09,* with pulsating frequencies of 6.13 millisecond and 5.362 millisecond were discovered. Obviously, such super-pulsating nature of these pulsars indicated that they belonged to a class of their own. But, what they eventually turned out to be—the oldest class of these exotic objects—took a lot of mathematical ingenuity and observational evidence.

A pulsar is a neutron star spinning like a top. It has a mass equal to that of the sun but compressed to the size of an average city. Neutrons, elementary neutral particles having the mass of a proton, are apparently in abundance in the star. One brick of this star is 10 trillion times or so denser than a lead brick! Matter falling on such a supermassive object breaks apart before reaching its surface. Like a rain, it falls down. Electric currents circulating through the outer surface layers of this spinning object induce a strong magnetic field. All these effects combine to produce a beam of radio waves which appears to pulsate as it cuts across the line of sight of an observing detector on earth. One obvious inference that one can draw from the pulsation period is that older the pulsar, slower would be its rate of spin. But if this logic is applied to the Vulpecula pulsar, it implies that this superfast pulsar must have been spinning at still higher rate when it was born. But calculations indicate that it would have then blown apart due to centrifugal forces even before it would have born!

The Vulpecula pulsar therefore could not have been spinning faster than what it is today when it was born. Its spin rate had not slowed much since its birth. There is also no perceptible slowing down of the spinning of the pulsar observed since it was discovered. Again, these characteristics do not conform to the law that the shorter the period of spin of a pulsar, faster it would slow down, and vice versa. This anamolous behaviour of the superfast pulsar therefore mathematically indicates to be possessing a weak magnetic field instead of a strong one estimated in ordinary pulsars. A weak magnetic field has been observationally confirmed because such a pulsar does not generate much radiations. How a superfast pulsar with a weak magnetic field was created? Such a pulsar is not likely to be the result of a supernova explosion in that a massive star collapses, shedding matter into the surroundings, settling down to a spinning neutron star with a strong magnetic field, and so becoming an ordinary pulsar. Two alternative scenarios have been suggested for the creation of a superfast pulsar. In one scenario, an ordinary pulsar comes into being due to a supernova explosion and decays over 10 millions of years to assume a weak magnetic field. Its spinning rate is however whipped up by the matter swirling into it from a neighbouring star (Fig. 1). The latter may eventually self-immolate itself in the process. In the other scenario, a white-dwarf star, a star having the mass of a neutron star but with a radius 1000 times larger, collapses to form a slow-spinning pulsar which is, again, speeded up due to accretion of matter from a neighbouring star. In both the cases, the superfast pulsar eventually attains a stable yet fast spinning speed because the outgoing radiation balances the incoming accretion matter at some particular point.

Both the superfast pulsars, *1953 + 29* and *1855 + 09,* have been observed to have stars as their companions but the Vulpecula superfast pulsar has to date been observed to have none. It is quite likely that its companion star has immolated itself in the process of making a superfast pulsar out of it! In recent times, astronomers think that these superfast pulsars are the subsequent phase in the evolution of what are known as "compact x-ray binaries" *(Scientific American,* February 1987).

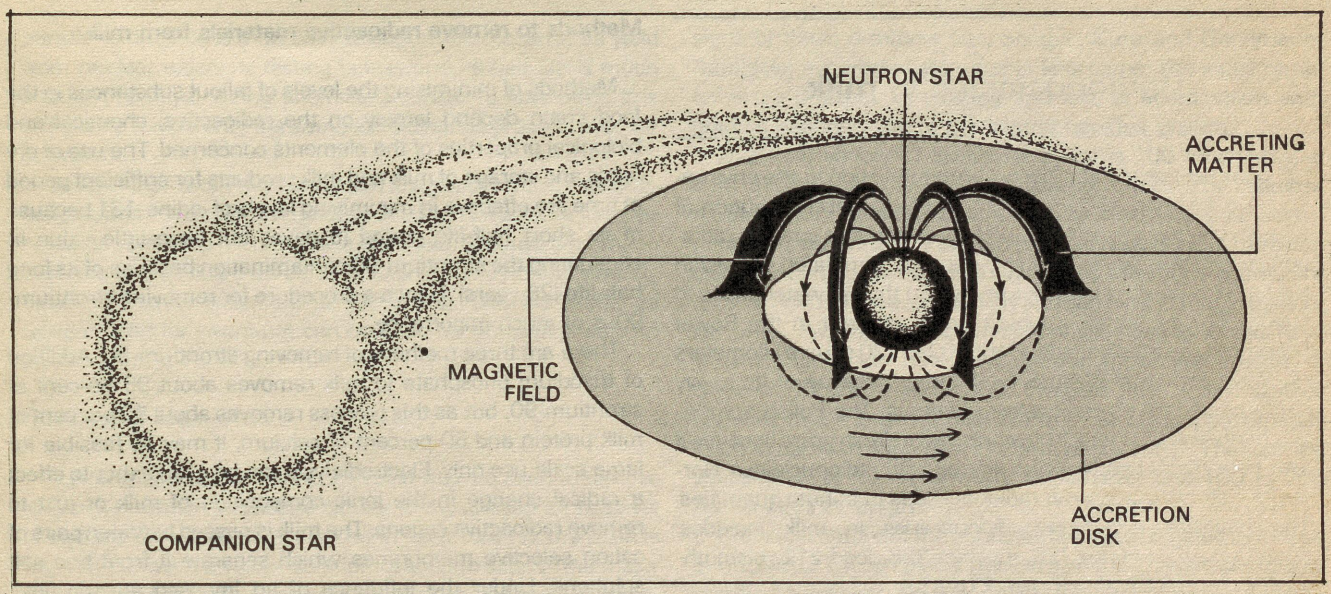

Fig. 1

A compact X-ray binary consists of a spinning neutron star and a companion star that swirls out matter from the latter towards the former generating x-rays. But the confirmation for the link between the superfast pulsars and the compact x-ray binaries came when the European Space Agency's x-ray satellite *Exosat* discovered a galactic source, GX5-1. This source was found to contain a neutron star spinning at a superfast period of a few milliseconds.

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Hernandulcin—a new sweetner

EVERYBODY likes sweets. The principal source of sweetness is sucrose, but its caloric value and cariogenic caries producing property do not permit its use beyond certain limits. As a substitute, synthetic substances such as saccharin, cyclamate and aspartame, have been in use in the western countries. In Japan naturally occurring sweet substances such as phyllodulcin, stevioside and glycyrrhizin are used. But none of these substances is an ideal substitute because they are unpleasant, or chemically unstable or unsafe, and above all costly.

While scanning old Mexican literature on science Cesar Compadre and his colleagues of the College of Pharmacy, Illinois University, U.S.A (*Science,* 1985, 227, 417) found to their surprise mention of a 'sweet herb' or 'honey herb'. It was reported by a Spanish physician Hernandez who had travelled the empire of Aztecs in Central Mexico and written a monograph on science "The Natural History of Spain". After careful screening the herb has been found to be *Lippia dulcis* Trev. of Verbenaceae family. It is shrubby, suffruticose, erect, up to 60 cm in height with green petiolate leaves and white flowers, It is a native of Central America, West Indies and Colombia.

Compadre and his colleagues have now isolated a sweet compound from the leaves and flowers of this herb in pure form and named it "Hernandulcin" in honour of Hernandez. It is a colourless, oily hydrocarbon and identified as sesquiterpene of the bisabolance class of compound with a molecular formula $C_{15}H_{24}O_2$.

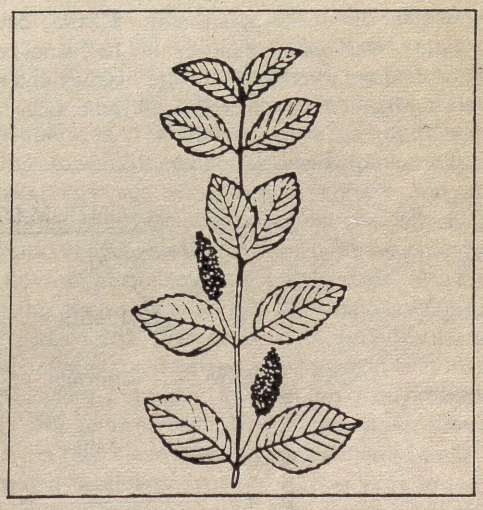

Fig. 1. Lippa dulcis

Preliminary studies with human taste panel have shown Hernandulcin to be 1000 times as sweet as sucrose. Unfortunately, it is less pleasant than sucrose and leaves a slightly bitter aftertaste. Two U.S. chemical firms are investigating this compound, possibly to sweeten toothpaste and mouthwash.

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Radionucleides in milk

THE presence of naturally occurring radiation in the environment has been known, but relatively recent contribution of man-made nuclear devices and knowledge that ionizing radiation causes damage to living tissues, has stimulated interest in the quantity of radionucleides present in the air, water and food supply. The recent Chernobyl reactor accident in the Soviet Union has reportedly made about 100 to 120 square kilometers of Soviet farmland useless for farming because of its heavy contamination with radioactive elements. The Polish authorities banned sale of milk from cows fed on fresh grass because it was considered highly contaminated with radionucleides. Normally, milk contains some radionucleides in minute quantities. The naturally occurring radionucleides in milk includes: potassium-40, radium-226, thorium-228, lead-212, bismuth-212, iodine-131 and actinium-228.

But following a nuclear fallout such as after a nuclear test or accident, many others appear in milk. They include strontium-89, strontium-90, yettrium-90, barium-140, lantanum-140, cesium-137, iodine-131, zirconium-95, niobium-95, and ruthanium-105. Of all these radionucleides, those generally of great concern to public health authorities are strontium-90, strontium-89, barium-140 and cesium-137.

Strontium follows much of the same biochemical pathways as calcium and is therefore deposited in bones from which it is removed very slowly by metabolic processes. The irradiation of bone tissues and marrow by strontium-90 may cause bone tumours and leukemia. Although cesium-137 is not bone seeking, it is distributed throughout the soft tissues and thus irradiates bones. The pathways of transfer of radionucleides to milk is given in Fig 1.

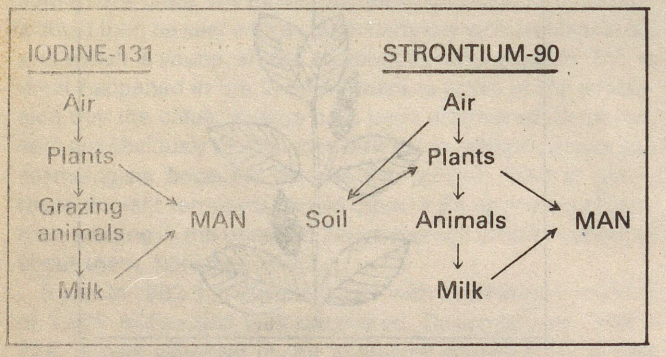

Fig. 1

Radionucleides are normally present in milk in extremely small quantities. Their concentrations are usually measured in picocuries (micromicro curies) per litre. One picocurie is equal to 10^{-14} gram of the nucleide in question (representing 2.22 radioactive decay per minute).

Methods to remove radioactive materials from milk

Methods of minimising the levels of fallout substances in the food chain depend largely on the radioactive, chemical and biological properties of the elements concerned. The use of dry feeds and storage of milk and milk products for sufficient period of time are effective in minimising levels of iodine-131 because of its short half-life period (8 days), but have little value in eliminating the strontium-90 contamination because of its long half-life (28 years). Hence a procedure for removing strontium-90 is of much importance.

There are three methods of removing strontium-90. Addition of trisodium phosphate to milk removes about 95 percent of strontium-90, but as this process removes about 30 per cent of milk protein and 50 percent of calcium, it may be feasible for large scale use only. Electrodialysis can be used either to effect a radical change in the ionic composition of milk or just to remove radioactive cations. The milk is passed between pairs of cation selective membranes which separate it from two salt solutions. Under the influence of an imposed electric field, cations from the milk pass into one salt solution and are replaced by cations from the other. For the removal of strontium-90, the milk must be acidified to a pH of 5.2 whereby an efficiency of removal of 90-99 percent of both strontium-90 and cesium-137 may be obtained. But this may not be practicable as at low pH milk may coagulate. The ion exchange process is based on the ion exchange principle. Milk contaminated with radioactive strontium is passed through a bed of synthetic resin charged with mixed metallic ions like calcium, potassium, sodium and magnesium which are present in milk. As the milk passes through the bed, strontium ions in milk are exchanged with metallic ions of the resin.

An important feature of the process is that the acidity of milk has to be adjusted. At the normal pH of milk (6.6-6.7) most of the strontium is bound by milk constituents and their removal is slow. When 25 resin bed volumes (rbv) of milk is passed through at normal pH, the column removes on an average less than 50 percent of its strontium. At lower pH, strontium is largely converted to a soluble and more readily exchangeable form.

The effluent milk from the ion exchange column is neutralised by continuous in-line addition of a mixed solution of sodium and potassium hydroxides, or a combination of sodium and calcium hydroxide solutions. After neutralisation the milk is pasturized and homogenised.

Regeneration of resin

After use the resin is cleared and regenerated with a salt solution of the same composition as that used for the initial preparation of resin. The chief purpose of this cycle is to remove the radioactive strontium from the resin. It also maintains the equilibrium with respect to minerals in milk.

Removal of barium-140 and cesium-137

The potential health hazard associated with radioactive

barium is much less than with strontium-90, because its yield from nuclear weapons testing is less and its half-life is much shorter (13 days). Being chemically similar to strontium, it is effectively removed by the same ion exchange process used for strontium.

Cesium-137 is chemically related to potassium and metabolically distributes itself throughout the body. However, a standby setup for removing it from milk is desirable, because it has been detected in significant amounts in milk and its half-life is nearly equal to that of strontium-90 (30 years). The ion exchange system used for strontium can be used for removal of cesium also.

Removal of Iodine-131

A strong base anion exchange resin may be used to remove iodine-131 under conditions similar to those used for removal of cationic radionucleides. For use in fixed column, the resin is regenerated with a mixed solution of sodium salts of the major milk anions like sodium chloride, di-sodium hydroxides, phosphate and sodium citrate. Laboratory studies have revealed that approximately 90 percent removal can be maintained for a quantity exeeding well over 150 rbv. It is not necessary to acidify the milk for this procedure.

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Do prions carry genetic material?

VARIOUS attempts were made by early molecular biologists to identify the physical and chemical nature of genetic materials or genes. The extensive experimental evidences on different organisms have revealed that genetic material contains nucleic acids (i.e., DNA or RNA) and by 1953 it was universally accepted that the DNA is the genetic material of all organisms except in some cases where the hereditary material is RNA. But this concept is threatened by discovery of an infectious puzzling protein-prion or Prp. The British investigators Tikvah Alper. MRC Experimental Radiopathology Research Unit. Hammersmith Hospital, London and David Haig and Michael Clarke of the ARC Institute for Research on Animal Diseases, Compton, Newbury, Berkshire, for the first time (1966) observed this protein as infectious agent in Scrapie—a disease which brings about a slow degeneration of the brain of sheep and goat. Prions are also known as the probable causative agents of two other human neurological disorders, viz., Kuru (found among some tribes of New guinea) and Gerstmann-Straussler syndrome. The clinical and pathological signs of these disorders (i.e., Scrapie, Kuru and Gerstmann-Straussler syndrome) are more or less same. The initial symptoms are difficulty in walking and loss of coordination with gradual degeneration of the central nervous system.

This new variety of infectious agent is 100 times smaller than a virus (size has been estimated at 27mμ by cellulose nitrate membrane filtration and 7mμ by X-ray target size determination), contains only protein and can reproduce in the living cell maintaining its own identity. These infectious agents are heterogenous in size and density and can exist in many molecular forms. Investigations by means of gel electrophoresis have shown that prion has an apparent molecular weight of between 27,000 and 30,000. Electron microscopic studies revealed that a large number of Prp molecules (approximately 1000 in number) aggregated to form prion "rods". The rods are typically 10 to 20 nanometers in diameter and 100 to 200 nanometers in length.

Chemical nature of the prion has been investigated by means of nucleases (which digest nucleic acids) and proteases (digest proteins) treatment. Nucleases have no effect on prion infectivity whereas proteases can drastically reduce prion infectivity. Prions are also highly resistant to ionizing and UV radiations which act mainly on nucleic acids. The experimental evidences gathered so far in this regard indicate that the prion has no nucleic acid at all. This leads to a number of questions. What is the nature of their genome? Do they violate the basic rules and regulations of central dogma? How can a protein enter a host cell and direct the process of replication?

A large number of hypotheses have been put forward regarding its activity and mode of replication. One of the plausible explanations is that the amino acid sequences in prion protein (Prp) somehow serve as a template during prion replication. Actually, this process takes place indirectly through the "reverse translation" of protein molecules into RNA or DNA. But such a process (i.e., protein directed protein synthesis) has never been observed. The most important and attractive hypothesis has been advanced by a group of scientists from the MRC Neuropathogenesis Unit at Edinburgh. According to them, the existence of a small piece of a 'DNA gene', also known as 'Prp gene', is necessary to encode the amino acid sequence of the prion protein. This 'DNA gene' is not carried by the prion but is a component of the host genome. Infection by prions would somehow initiate the transcription of Prp gene encoded in the host DNA. The prion serves as a promoter of Prp gene expression. But the hypotheses and theories gathered so far are not sufficient and need new thinking. Further work in the light of results obtained at molecular level by advanced methodology will no doubt provide some important clues regarding their exact nature, activity and mode of replication.

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Extrafloral nectar

CARL Linnaeus coined the word 'nectary' (nectarium) in 1735 to denote specialized glands in plants composed of small thin-walled secretory cells from which nectar is brought to the surface through modified stomata. Nectar was defined aptly by W. Trelease in 1879 as "a fluid, always sapid, usually sweet, often odourous, which is elaborated in any part of a plant, remaining where formed, or making its way to some other part, its reason for occurrence being the necessity for the removal of some useless or injurious substance or for some provision to attract nectar-loving animals to the plant for some definite purpose". The distinction between nectaries of flower (floral) and those in other parts (extrafloral) was made by M. Caspary in 1848. The mutual role of floral nectar in plant pollination and insect nutrition is well-known. Although extrafloral nectar has been the subject of curiosity and hypothesis for more than a century, only in recent years have we begun to understand its source, characteristics, functions and chemical ecology.

Source and characteristics

Extrafloral nectaries have been identified in about 300 species of plants in more than 40 families. They may be located on leaf laminae, petioles and rachids, bracts, stipules, pedicels, fruits, etc. Mostly extrafloral nectaries occur on the younger vegetative portion of a plant, and activity of the glands decreases proportionately with age. In some species, extrafloral nectaries function in a daily pattern while in other species there is no recognized pattern of gland activity. The quantity of nectar secreted by extrafloral nectaries also varies with species and glandular site, but ranges upto 3.8 ml/plant/day in *Gossypium barbadense* L. In *Impatiens sultani*, nectar secretion is more prevalent in dry environments where the quantity of its secretion is proportional to sunlight intensity, quantity of chlorophyll and soil water availability. Extrafloral nectaries seem to be supplied primarily by phloem tissues but in some taxa xylem tissue also contributes to the supply of nectar-rich fluid.

Composition of floral and extrafloral nectars from most species of plants differs widely. Composition of extrafloral nectar in *Ricinus communis*, for example, differs from both floral nectar and phloem exudate. Floral nectar from plants that rely on small insects for pollination, as do most Compositae, has hexose-rich sugar and is unattractive to most Lepidoptera. On the contrary, extrafloral nectars tend to be sucrose-rich, are less attractive to common Hymenoptera pollinators than are hexose-rich floral nectars, but tend to be highly attractive to adult Lepidoptera. For example, in the common annual sunflower, *Helianthus annuus* L., sugar composition of extrafloral nectar from leaf petioles is 79% sucrose, 0.09% glucose and 0.11% fructose by weight.

Although most extrafloral nectars are about 97% sugars, most have a full complement of 20 protein-building amino acids, plus a varying number of additional non-protein amino acids and fatty acids. The amino acid composition of extrafloral nectar does not change even during adverse environmental conditions. This may be the greatest asset of extrafloral nectar as a source of nutrition for insects when other food sources are either lacking or in short supply.

Function

The function of extrafloral nectar has been debated for more than a century. From the entomological view point, the role of extrafloral nectar has revolved around two theories dealing with protection of plants by ants and exploitation of ants by plants. Protectionists maintain that extrafloral nectar attracts ants, which protect nectar-bearing plants from herbivorous insects in return for their nutrition. The protectionist theory gets its support from such examples as (1) *Bixa orellana* plants with nectar-feeding ants produce more fruits and a greater number of seeds than other plants, (2) *Helianthella quinquenervis* plants having extrafloral nectaries with ants receive less oviposition in seeds by *Neotbepbritis finalis* lowe, a seed predator which results in richer harvest of seeds. This theory relies on coincident distributions of nectariferous plants and ants, the presence of aggressive ants, and active foraging for extrafloral nectar by ants. Some protectionists go even further to say that there has been a genetic selection to place extrafloral nectaries on the most vulnerable parts of a plant and that ants have played a major role in the selection process.

Exploitationists refute the protectionist theory and argue that 'plants have no more use for ants than dogs do for fleas' and that secretion of extrafloral nectar is merely a physiological process of the plant. According to them, protection of plants by ants could occur only if nectariferous plants were abundant where ants exist in abundance. In many instances, there is convincing evidence that mutual associations do exist between extrafloral nectar-bearing plants and ants. However, many claims in the literature regarding the function of those associations are highly speculative and remain unproven. Neither the protectionist theory nor the exploitationist theory explains the frequenting of extrafloral nectar by insects that offer no direct benefit to the plant or for which the plant has no direct need.

In fact, extrafloral nectar serves the plant in both secretory and excretory roles. In its secretory role, extrafloral nectar helps to maintain proper carbohydrate balance, regulate sugar and water balance, and secrete excess sugars while returning non-sugar compounds to the phloem and developing organs of the plant. In its excretory role, extrafloral nectar may transport metabolic wastes and toxic products from the plant. This was demonstrated by an American scientist D.L. Caldwell from Univ. of Missouri, Columbia, in 1981 in laboratory bioassays which indicated that aldicarb residues in extrafloral nectar of peach trees growing in soil treated with the insecticide was toxic to insects. This demonstration poses important questions about affects of other insecticides against non-target insects in

traditionally chemical-dependent pest management programs.

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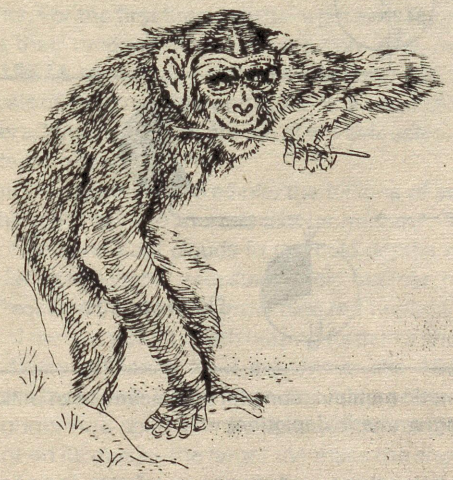
Social and sexual behaviour of chimpanzees

CHIMPANZEES are the closest living relatives of human beings. Chimps are at present confined to west and central equatorial Africa, from Sierra Leone to Congo, where they are abundant. Chimpanzees are expert climbers; they rest in sitting posture and sometimes stand or walk on hind limbs but run on all the four limbs. They are shy animals and avoid presence of human beings.

Jane Goodall and her colleagues of University of California, U.S.A. and Toshisada Nishida of University of Tokyo, Japan studied social behaviour of chimpanzees on eastern shore of Lake Tanganyika for about twenty years. Also, Michael P. Ghiglieri of University of California, U.S.A. studied their behaviour in natural conditions of Kibale Forest Reserve in Western Uganda. Their observations throw much light on the peculiar social behaviour of chimpanzees which is unparallelled in animal kingdom.



Chimpanzees generally live in groups and the males guard the territory. They do not allow males of other communities to enter their area. The community of chimpanzees always moves in search of food and often breaks into smaller parties, if food is scarce. In smaller groups each member searches its own food. The average feeding unit consists of 3-6 members, but the number is not uniform. The largest party may have as many as twentyfour members. The party size is proportional to the availability of food. When food in abundant, the smaller parties may join to form a larger community in which they enjoy life by eating, playing and taking rest. Anthropologists believe that this type of fission-fusion society resembles the human societies of hunting and gathering periods.

Exogamy in chimpanzees is interesting. When females attain sexual maturity, they migrate to other community. The males of other community welcome and mate with them. These females now become members of the new community in which they give birth to young ones after a gestation period of nine months. In contrast, the males devote their entire life in the community in which they are born. Hence the community has genetically different males and females. The males are genetically related as they carry paternal genes of the community whereas adult females may be genetically different. This genetical congregation of different males and females in a community is unique to animal kingdom.

Chimpanzees feed mainly on fruits of the genus Ficus. They also consume insects, mammals and a number of other plant products such as bark, pith, blossoms and young leaves. They often have to compete with fruit-eating birds and monkeys. The monkeys are larger in numbers than chimpanzees. On confrontation, chimpanzees frighten and displace all the monkeys except the red colobus, which, being more agile climbers than chimpanzees often chase the latter on the tree tops. The fight may result in death or serious injury to some chimpanzees due to fall from trees. But on ground, chimpanzees can kill red colobus like other monkeys.

Sexual tolerance

In most mammals, reproductive strategy of males is to defend their food and not to allow other males to approach their mature females. Chimpanzees do just the opposite. They display harmony both in feeding and mating. The most striking example of their co-operative behaviour is their vocal signal called pant-hoot. The pant-hoot is made by a lone male or by a party in chorus when they approach the source of food. The pant-hoots can be heard from a distance of two kilometers. These signals attract chimpanzees of both sexes and of other communities also to approach the tree for food. They, however, never pant-hoot when the tree is small and bears less fruit.

Their co-operation is also evident in mating behaviour. Unlike other mammals, chimpanzees never attempt to exclude others from mating opportunities. They generally ignore other males copulating at a distance. The females coming from other community often copulate with several members of the same community in quick succession. The males are not so tolerant all the times. They sometimes take a particular female on 'honeymoon' to avoid rivals and mate with her exclusively in seclusion. Usually a male dominates and does not allow others to mate with a particular female. However, if she presents herself to a subordinate male for mating, the dominant male does not interfere and walks away. If a female accidentally enters any other community with her infant, the males guarding the territory brutally kill the infant but spare the mother. After the infant's death, the female quickly offers herself to the territorial defenders.

Ghiglieri believes that such co-operation by males is in their own interest. By pant-hoots they invite other chimpanzees for feeding which may include estrous females of other community and hence get chance of mating with them. It was observed that most communities of chimpanzees have fifteen adult females and an equal number of males. The normal, adult female becomes sexually receptive every five years for only a few weeks. As such only three females become receptive every year in a colony and an equal number of males would succeed in mating with them produce offsprings. This indicates that reproductive opportunities for males of a group are rare. Therefore the sexual tolerance and feeding co-operation in chimpanzees are imperative for the survival of the species.

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'Frieswal' breed evolved by military farms

THE judicious use of genes to overcome perpetual milk shortages have been well illustrated by military farms by introducing in the indigenous cattle, the superior germplasm of exotic breeds. Indigenous cattle, though known for its resistance to tropical diseases, capacity to utilise coarse roughage, better resistance to heat stress, and suitability as draught animal, suffers from the drawbacks of low average milk production and poor reproduction efficiency. Selection through indigenous breeding for milk has been fairly effective, but such methods are too slow to bring about any substantial increase. The only rapid way to enhance milk production from such cattle is through cross breeding with superior exotic dairy breeds.

Due to their sustained efforts for almost a century military farms are today the proud possessors of elite crossbred cows like 'Radha' which yields as much as 49 kg of milk in a day. Radha is not an isolated example, many such cows have been bred in these farms which have won cattle shows.

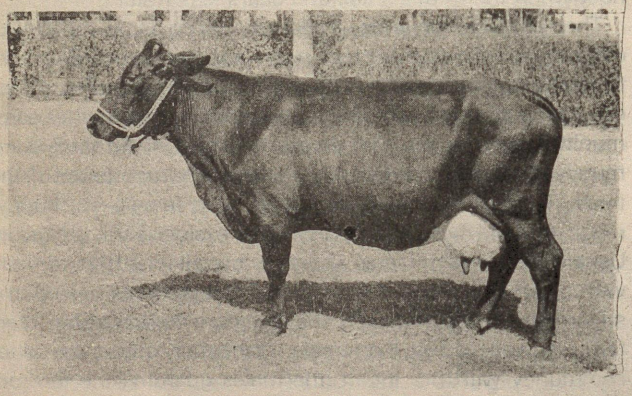


Fig. 1. Sahiwal cow

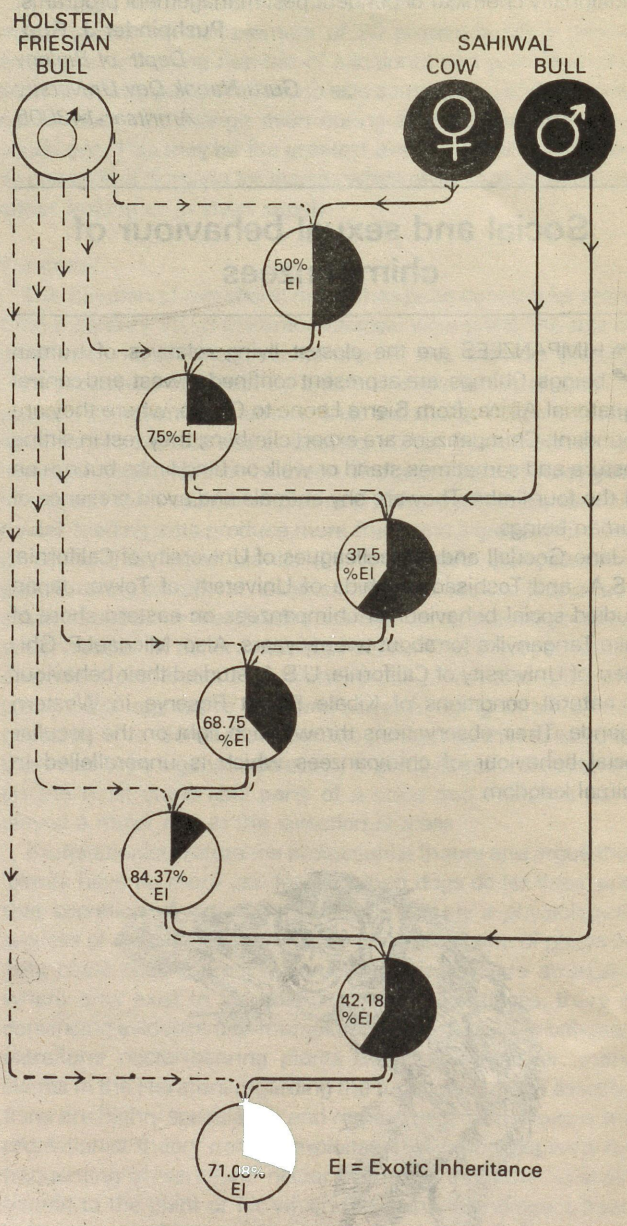


Fig. 2. Genetic manipulations for enhancement of milk military farms (Diagrammatic depiction)

To achieve such high levels of milk production, the indigenous dairy cow of Sahiwal breed is first inseminated with frozen semen of pedigreed bull of world's best Holstein-Friesian dairy breed. Their progeny acquires 50 percent of exotic inheritance. The females so obtained are again bred with the Holstein-Friesian semen. The second generation so produced has 75

(Continued on page 296)

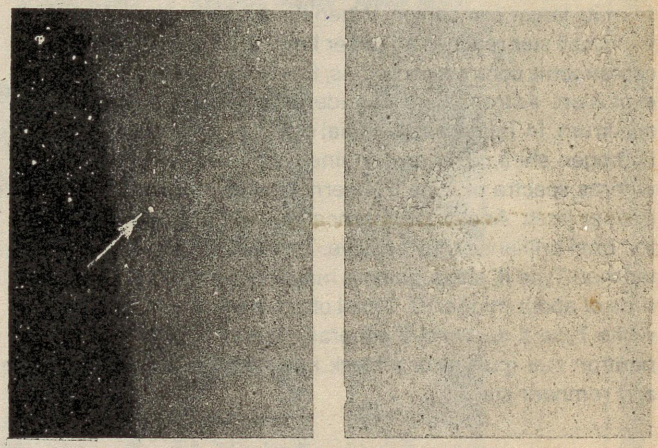
Supernova 1987A

COMING on the heels of the historic return of the Halley's comet last year, another celestial event early this year has created a stir in the astronomical world. But unlike Halley's return, the recent event—the sighting of the first naked-eye supernova in more than 300 years—was totally unexpected. Twentynine year-old Candian astronomer Ian Shelton working at the Las Campanas Observatory in Chile first spotted the new supernova on the night of 23 February during a routine session of photographing the Large Magellanic Cloud—a satellite galaxy of the Milky Way—seen as a hazy patch in the southern sky. It showed up as a bright spot on a photographic plate where none should have been. Skeptical, Shelton walked out into the open and saw it—there was indeed a new 'star' visible in Large Magellanic Cloud. At a distance of 170,000 light years, it could only be a supernova. Indeed it was—the first to be visible to the naked eye since the one seen by Kepler and Galileo in the constellation of Serpens in 1604. (A supernova seen in the Andromeda galaxy in 1885 was just a shade fainter than naked eye visibility and could be observed only through a telescope.)

The new supernova, named 1987A, has for the first time provided astronomers with a unique opportunity to study these celestial cataclysmic events with their sophisticated instruments. For the first time they have got a real opportunity to test out their theories of stellar evolution. And, not unexpectedly, 1987A has already sprung a few surprises. Preliminary analysis of spectroscopic and other data, according to the astronomers, "point to the existence of a previously unknown class of stellar explosion."

Although it may sound incredible, the billions of stars that light up the night sky are mortals like us humans. They are born out of gas and dust clouds in the cold depths of space when under gravitational pressure, their nuclear furnaces light up. Once born, stars also grow old, and finally they also die, many of them a violent death blazing forth in a short burst of extraordinary brilliance as a supernova like 1987A. Of course, stars live much longer than the three score and ten years of a human life-span. The life-span of a star depends to a large extent on its mass—the larger the mass the shorter will be its life-span. A star ten to twenty times as massive as our sun may live for only a few million years, while a smaller star, by using up its fuel at a much slower rate, may continue to shine for a few hundred billion years. It is the old, massive stars that end up as a supernova.

According to present theories of stellar evolution, a star is born when, under extreme gravitational contraction, the temperature inside a large cloud of interstellar dust and gas reaches around 10 million degrees Celsius, and nuclear fusion of hydrogen into helium begins. At this point the radiation pressure of the heat generated in the reaction prevents further contraction of the cloud and the new-born star begins steadily radiating energy.



The arrow (left) shows the star which became supernova 1987A (right)

Many millions of years may pass in this stage till all the hydrogen in the core of the star is used up. Then, as nuclear fusion of hydrogen into helium stops, the core shrinks and heats up ever more rapidly, while the outer layers expand and the star becomes a red giant. The core, now almost pure helium, is surrounded by a shell of fusing hydrogen.

With further contraction of the core and consequent rise in temperature, helium nuclei start fusing into carbon liberating energy in the process. For stars with mass up to 1.4 solar masses this state of affairs continues for thousands of years. Finally its outer layers drift away and a slowly cooling 'white dwarf' is left behind. If the mass of the star is more than ten solar masses, the events take a different course. In that case, the reactions at the core go on past the helium and carbon fusion stages, all the way to iron. Finally, according to theory, a stage comes when the inside of a star resembles a giant onion—with a core of iron surrounded by shells of silicon, sulphur, calcium, argon, chlorine, potassium, and so on with a final outer shell of fusing hydrogen. At this stage, since the fusion of iron nuclei absorbs energy rather than releasing it, the radiation pressure at the core suddenly disappears and in less than a second, gravity overwhelms the core, crushing it to a superdense nucleus that rebounds outward throwing off powerful shock waves. When these shock waves blast through the star's outer envelope, enormous heat is generated which finally leads to the gigantic explosion we see as a supernova. The explosion also leads to the creation of heavy elements which are scattered into the interstellar medium by the force of the blast. Astrophysicists believe that the heavy

elements that are found in the universe were all created in supernovas in the distant past.

The scenario described above is typical of a Type II supernova. There is another type which astronomers call Type I supernova. Here, the starting object is a double star—a close binary system one component of which is a white dwarf. The white dwarf, being highly compact and dense, can pull mass from its larger companion. When the accumulation of mass of the dwarf star reaches an upper limit (Chandrasekhar limit), a catastrophic contraction begins, finally leading to a supernova explosion. Astronomers can identify the two types by their spectrum. In Type I, as the initial star is a white dwarf with no hydrogen shell, no hydrogen lines are seen in the spectrum, wheras spectra of Type II supernova show distinct hydrogen Balmer lines. Another difference between the two types is in the final brilliance they achieve. Type I supernovas are brighter than Type II; although both may attain an absolute magnitude of about minus 18, Type I often reaches minus 20. Also, while Type II supernova generally leaves behind a spinning neutron star (pulsar) or a black hole, a Type I does not leave any remnant star.

Initial signs from 1987A did show it to be a supernova. Its brightness increased almost overnight, and the earliest readings showed material speeding away from it at a speed of more than 16,000 km per second, as would be expected in a supernova explosion. But later observations revealed several anomalies. From the distance of the Large Magellanic Cloud, 1987A at its peak brilliance should have had a magnitude of around 1 to 0; but its brightness rose to a magnitude of only 4.5, which is less than a hundredth of the expected brightness. The spectrum of 1987A had distinct hydrogen lines, showing it to be a Type II supernova, yet its ultraviolet spectrum resembled that of a Type I supernova. But initial doubts of astronomers that the new object may not be a supernova were dispelled by records of neutrino bursts received shortly before the sighting at various centres around the world.

Astronomers are still puzzled by the unusual behaviour of supernova 1987A. May be, the final analysis of the vast data will reveal some hitherto unknown facts about these spectacular cataclysms of nature.

Biman Basu

Conference on Surfactants, Emulsions and Biocolloids

THE third National Conference on Surfactants, Emulsions and Biocolloids will be held during December 28-30, 1987 at Aligarh. It will provide an opportunity to technologists and experts from academic and research institutions and industries to assemble on a common platform to exchange views and discuss latest findings with active researchers. The technical sessions will include invited lectures, presentation of papers (oral/poster) and symposia on the following : 1. Surfactant association: applications in analytical chemistry, industrial applications, enhanced oil recovery, etc., 2. Emulsions and micro-emulsions (including their industrial and technological applications); 3. Biological amphiphiles, biopolymers, polymers, surfaces and dispersions.

Enquiries should be addressed to : Dr H.N. Singh, Organising Secretary, 3rd National Conference on Surfactants, Emulsions and Biocolloids, Department of Chemistry, Aligarh Muslim University, Aligarh-202001.

SCIENCE SPECTRUM *(Continued from page 294)*

percent of exotic characters. The extensive data at military farms analysed by expert scientists has revealed that crossbred cattle with higher levels of exotic inheritance are more susceptible to diseases and are unable to withstand heat stress, while those having between 50 and 65 percent of exotic inheritance are superior in all the traits representing milk production, reproduction efficiency and longevity. Accordingly, the females of the second generation with 75 percent exotic inheritance are backcrossed with a high pedigreed Sahiwal bull. The third generation thus acquires 37.5 percent of genetic characters of Holstein-Friesian. The females of this generation are again forward crossed with Holstein-Friesian semen to obtain a progeny with 68.75 percent of desired inheritance and this is continued (Fig. 2).

Military farms have recently undertaken a project in collaboration with the Indian Council of Agricultural Research to evolve a new national breed of 'Frieswal' cattle which would give 4000 kg milk yield with 4 percent butter fat under good management conditions of the tropics.

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New concepts in transplantation

EVER since the advent of transplantation biology 35 years ago, doctors have been continually plagued by the trouble some rejection phenomenon, so much so that at one time tranplantation biology seemed to be a science of the past rather than of future. Attempts to alter donor tissues prior to transplantation, in order to minimize rejection, were made as early as 1907, when Carrel used refrigerated and frozen arterial vessels in various types of peripheral arterial reconstruction. However, no distinct improvement of the survival of preserved over fresh grafts was established in these experiments, which were designed merely to promote the convenience of vascular replacement by developing a ready supply of useable vessels. In 1934 Stone, Owings and Gey cultured donor parathyroid tissue in the serum of recipient before transplantation, in order to render them more acceptable. The work was followed up by Gaillard, but was abandoned later as it became clear that cultured cells generally retain their complement of histocompatibility antigens unless major genetic changes supervane. More recently attempts have been made towards lowering the immune responsiveness of recipients by giving them massive doses of corticosteroids. Besides producing a variety of undesirable metabolic consequences, this non-specific immunosuppression renders the recipient liable to multiple infections. To control these infections wide-spectrum antibiotics have to be administered which produce their own side effects.

Now attention has been focussed once again on the graft itself and in particular scientists have concentrated on two aspects. First, to alter the graft in such a way as to render it incapable of eliciting an immune response. Second, to use only that much part of the graft, that is really needed by the patient and reject the rest. This concept of selective treatment can be classified in three general groups.

1. Those designed to retain special mechanical properties in the donor tissue.
2. Those designed especially to retain particular metabolic properties in the donor tissue; and
3. Those performed primarily to alter the immunological properties of a donor organ or tissue.

Here are some of the examples of each:—

Transplants treated to retain mechanical properties

Efforts have been made to treat the graft in such a way as to free it entirely, or almost entirely, of living element. This results in a structure that provokes a less intense immune response and may be sufficiently well-tolerated to retain satisfactory functional characteristics for long periods without immunosuppressive treatment.

(i) *Heart Valves*. The function of heart valves requires the maintainence of demanding mechanical characteristics, which include flexibility alternating with tensile strength during each cardiac cycle. It has been seen that if one takes the valve from either allogeneic or xenogeneic sources, and fixes by an agent such as glutaraldehyde, the living cells present in the tissue are killed. What remains is the valve matrix composed mainly of collagen fibres, which is just what is required for retaining its mechanical properties. However not all antigenic determinants disappear. Some antigens persist on the surfaces of cell "ghosts" and elicit a low grade immune response, which may cause late shrinkage and stiffening of these valves, often with calcification. Fixation procedures that eliminate antigens more completely may improve the long term outcome of such procedures. Fixation thus selects in favour of mechanical properties and against antigenic properties in the transferred tissue.

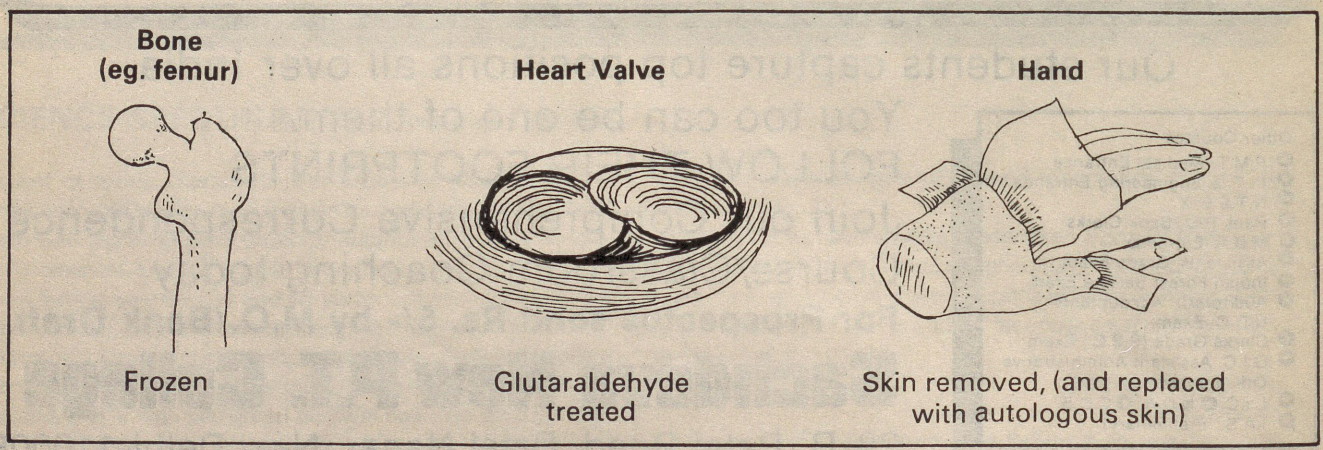

Fig. 1. Transplants selected for mechanical properties

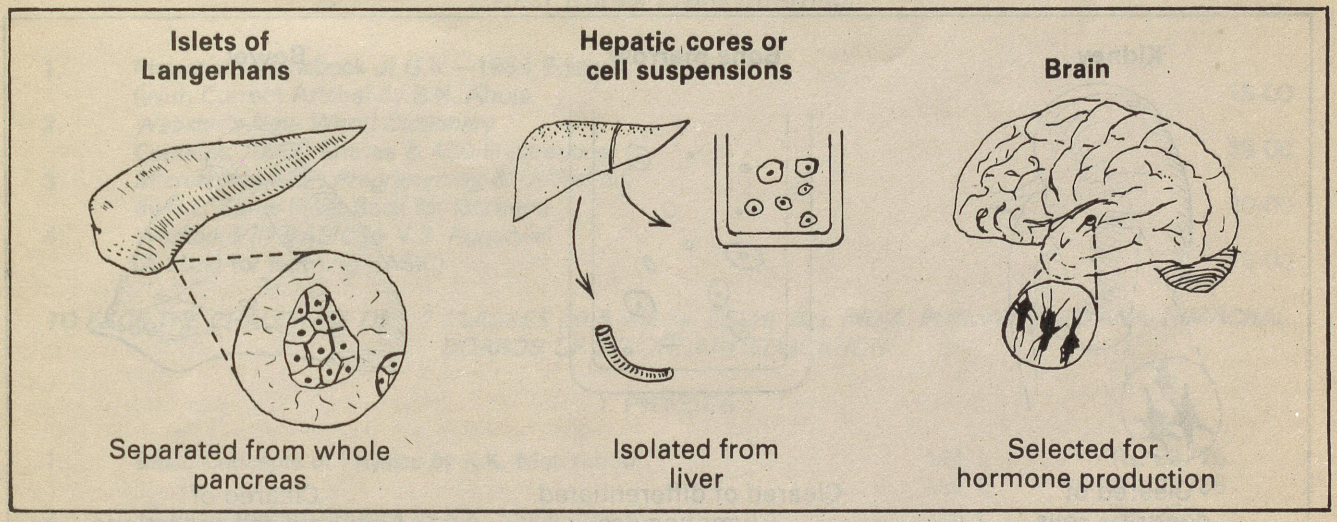

Fig. 2. Transplants selected for metabolic properties

(ii) *Bones.* Unlike living bone allografts, portion of bones which have been frozen for storage and thawed before use will elicit a much less vigorous immune response. As in the case of heart valves no immunesuppressive treatment is used.

(iii) *Cartilages.* Nasal cartilages are transplanted to reconstruct the nose. They are taken frum dead donors and may be treated in similar fashion for better retention.

(iv) *Extremities.* It has been shown that entire flexor tendor apparatus, freshly removed can be transplanted quite successfully. However when the question is of transplanting the whole extremity itself, problems creep in because it contains highly antigenic tissues like skin, vascular andothelium and intrinsic musculature of the hand. This problem may be overcome by removing the skin completely from the donor extremity before transplantation and freezing the remainder of the donor tissue to reduce antigenicity further. Discoveries of batter methods to reduce antigenicity more affectively shall no doubt improve the outcome of such transplantations.

Transplants selected for metabolic properties

To restore a desired metabolic function, it is not necessary to transplant the whole organ concerned. Transplantation of just those cells that are required would do equally well.

(i) *Pancreatic islets of Langerhans.* One of the recent developments in treatment of diabetes is the transplantation of pancreas itself.

It has been established that endocrine tissues can be transplanted successfully as free grafts provided the dimensions of each bit of tissue transferred are suitable to allow the establishment of vascular connections before central necrosis of the transferred tissue occurs. In the case of pancreas, the complications that arise in transplantation are traceable to the exocrine portion of the gland, the portion that is transplanted merely as a vehicle for the endocrine cells. What is now done is to dissociate the exocrine and connective tissue components of pancreas by enzyme disgestion and to "hand pick" the islets under the dissecting microscope. In the pancreata of mouse and rats it has been accomplished, but in man the islets tend to adhere more firmly and are difficult to separate. However more work in this direction is in progress and better results are likely to be achieved soon.

(ii) *Hepatic fragments or cells.* Liver cells may be transplanted as a source of enzymes that may be deficient in a recipient by reason of a genetic defect. Narrow cores from a genetically normal donor rat liver have been transplanted in the liver of a recipient genetically deficient in its ability to produce the enzyme bilirubin-uridine-diphosphate-glucuronyltransferase. Not only do the transplanted cells produce this enzyme, they somehow induce the liver cells around them to produce the enzyme on their own.

(iii) *Brain tissue.* Transplantation of whole brain itself presents several ethical and philosophical problems, one of which is the transference of consciousness itself of donor to the recipient. However, small sections of the brain tissue, e.g. substantia nigra have been transplanted to the proper sites in recipient's brain. These cells release the hormone dopamine which has become deficient in the recipient and given rise to symptoms of parkinsonism. Transplantation of these segments of brain provides lifelong the proper drug at the proper site.

Transplants of tissue selected with regard to immunological properties

It has been seen in recent times that migratory cells of lymphoid and bone marrow origin, which are found in vary-

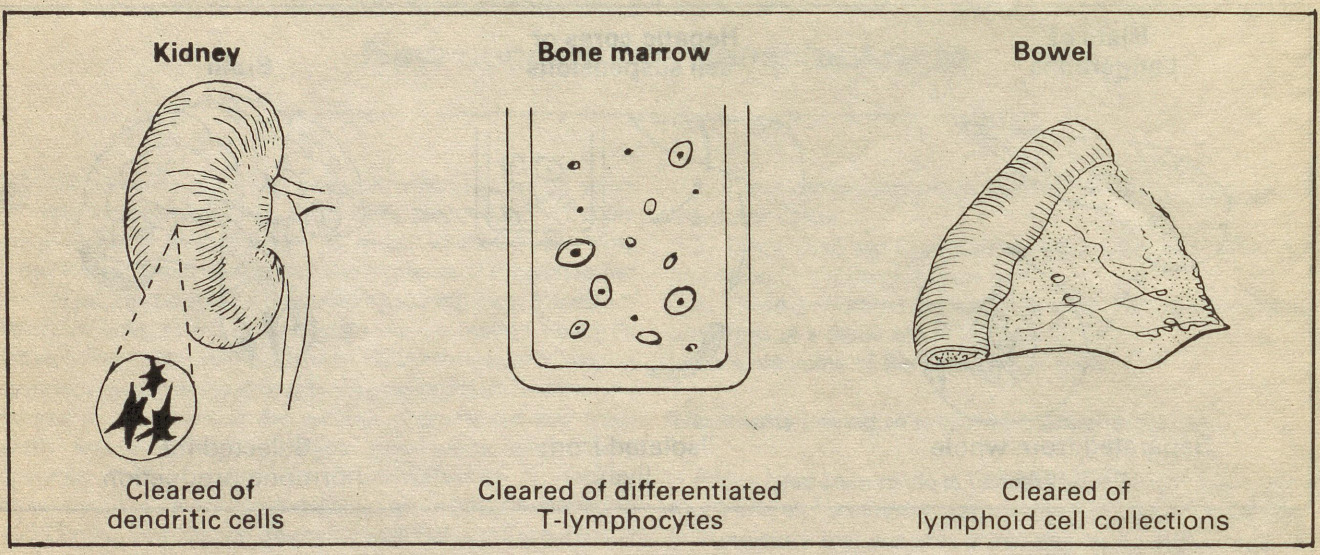

Fig. 3. Transplants selected for immunological properties

ing numbers in most normal tissues "passenger leukocytes" comprise a high proporton of the effective foreign antigens that stimulate rejection reactions. Certain of these cells contain class I histocompatibility antigens, while others contain class II histocompatibility antigens. Passenger leukocytes containing class II antigens "trigger" the first signal, initiating rejection. These cells are termed 'dendritic' cells because of their characteristic extended cytoplasmic processes. If somehow the donor tissues may be purged of these dendritic cells, the rejection reaction would not be triggerd in the first place and graft may be better tolerated. One way to kill these dendritic cells is by specific antibodies and the other by culturing them in high oxygen tension. This principle of dendritic cell elimination has not yet been applied to clinical transplantation, but following possiblities may become applicable in recent future.

(i) *Kidney.* In some dramatic experiements on rats, after the kidney was transplanted, the recipient was given several injections of an appropriate antiserum against donor antigens shortly after transplantation. Kidney transplants maintained for several weeks in this way survived well on secondary transplantation to other rats of the same foreign strain. The obvious conclusion was that the dendritic cells had been killed by the antiserum. On the other hand if as few as one million dendritic cells from original donors were injected at the time of secondary transplant, the kidney was promptly rejected. In human beings, the additional difficulty is that certain other cells such as endothelial cells also contain class II antigens and these cells are really difficult to eliminate

(ii) *Bone marrow.* Bone marrow transplantation is a standard method of treatment for certain aplastic states and leukemias. In this case, to avoid graft-versus-host reaction, which include chronic gastrointestinal and hepatic derangements as well as a scleroderma-like cutaneous disorder, mature T-lymphocytes are selected out and removed from the bone marrow *in vitro* before transplantation to the host. This maneuvre is designed to retain stem cells, which mature under the thymic influence of recipient and do not react against their host.

(iii) *Bowel.* Bowel contains liberal population of lymphoid cells in Peyer's patches contained in submucosal layers and in this way resemble bone marrow to some extent. Irradiation of the donor animal or the transplant with 700 rads is supposed to kill many such lymphocytes and consequently the graft may be better tolerated.

Thus the concept of removing certain cells from the graft, which are strongly immunogenic but which do not contribute to the physiological function of the transplant appears to be quite appealing. Transplantation surgery is expected to make rapid advances in near future, in light of these revolutionary developments.

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Eurocentricity in elements nomenclature

WHILE a small town in Sweden lends its name to as many as four elements, there is not even a single element which derives its name from any place or country on the continents of Asia, Africa or South America. The elements Erbium, Terbium, Yttrium and Ytterbium derive their names from Ytterby, a Swedish town. One can say that contemporary science is essentially "Eurocentric" or more correctly "Caucasiocentric" because even the continents of Europe and America lend their names to two elements namely, Europium and Americium.France alone lends its name to two elements : Francium is derived from the English name France and Gallium comes from its Latinized version Gallia. In addition, the element Lutetium derived its name from Lutetia, ancient name of Paris, the capital of France. Not only does Germany lend its name to Germanium but even one of its rivers, Rhine. The element Rhenium is named after it. Similarly, not only does the tiny state of California lend its name to an element (Californium), but even the place Berkeley, where its university is situated does so (Berkelium). The Caucasians have, in short, monopolised scientific nomenclature.

Incidentally, Sweden imprints its name on a fifth element as well—Holmium coming from Latin Holmia for Stockholm. Another Scandinavian country Denmark is also associated with an element Hafnium coming from Hafnia, the old name of Copenhagen. In fact, the Scandinavian region itself finds its name in Scandium.

Other major examples of elements getting their names from European places are Magnesium from Magnesia, a district in Thessaly; Ruthenium from Ruthenia, Ukraine; Strontium from Strontian, a town in Scotland and Thulium from Thule, the legendary land of far North which some people equate with Scandinavia. Even the small island of Cyprus, through its latinized version "Cuprum" gives its name to copper. (Table 1).

How interesting would it have been for the world in general and the Third World in particular if some elements had been reserved for such names as Africium, Asium, Sudanium (Sudan, Africa's largest country), Chineum (China, Asia's largest country), Gangium (Ganges, India's largest and holiest river) and Himaleum (Himalayas, world's largest mountain range)! Instead of distributing the names more evenly over the entire globe, the Europeans have gobbled up all elements for themselves and, in their greed to stamp their name on everything, have usurped not just one but multiple elements for a single place or country of their continent. Deriving multiple names from a single place not only gives undue and undeserved honour to that place, but makes it very easy to confuse one element for the other. Erbium could easily be confused for Terbium, as could Yttrium for Ytterbium. Unfortunately, the element Indium does not derive its name from India but from its indigo blue spectrum. The only consolation for us is that the element Gold might have derived its name from Sanskrit *Jval,* but there is difference of opinion among etymologists regarding it.

Table 1

	Place	*Element*
I	**Continents**	
	1. Europe	Europium
	2. America	Americium
II	**Countries**	
	1. Germany	Germanium
	2. France	Francium Gallium
	3. Poland	Polonium
	4. Cyprus	Copper
III	**Capitals**	
	1. Paris	Lutetium
	2. Stockholm	Holmium
	3. Copenhagen	Hafnium
IV	**Regions**	
	1. Scandinavia	Scandium
V	**Rivers**	
	1. Rhine	Rhenium
VI	**Places**	
	1. California	Californium
	2. Berkeley	Berkelium
	3. Magnesia	Magnesium
	4. Ruthenia	Ruthenium
	5. Strontian	Strontium
VII	**Legendary places**	
	1. Thule	Thulium

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An efficient executive

EVERY human being wishes to complete his job with minimum efforts. Mathematics has often helped in such endeavours. Even simple knowledge of school mathematics can enable one to do a job more systematically with minimum efforts. To illustrate this point, consider a common life situation where simple application of elementary mathematics helped a factory manager in reducing a lengthy task to an extremely simple and easy one.

Mr. Prasad is looking after the important task of management of a large factory, United Fertilizers. This factory produces a fertilizer called Sulpha. It is sold in three types of packs: (i) 10 kg pack, (ii) 12 kg pack, and (iii) 20 kg pack. Once it so happened that one pack of 12 kg got mixed in the heap of 10 kg packs. The total number of packs in the heap were found to be 729. The workers started the job of searching the 12 kg pack in a clumsy way. One of them suggested that each and every pack should be weighed. Everyone rejected this suggestion as

weighting 729 times is boring and tedious. Then another worker suggested that each pack should be examined for its size as the biggest-looking pack would certainly be the heaviest pack. But, then, every person picked up a new pack. In short, they were all confused and wasted considerable time.

On his morning round of the factory, Mr. Prasad saw the messy situation. He sorted the things out easily. He found the 12 kg pack in merely six weighings. The funny thing was, he did not even touch the weights which were kept there. How did he do it?

Mr. Prasad distributed those 729 packs, equally, into three heaps. So, each heap contained 729/3=243 packs. Then he put one of the heaps in the right pan of the balance and the other heap (both selected at random) in the left pan. He found that both the selected heaps were equal in weight. So, he concluded that the heap left behind contained the 12 kg pack. (Even if the two selected heaps happen to be unequal in weight, the heavier heap obviously contains the 12 kg pack.) So, in one weighing Prasad got rid of 729–243=486 packs. (Fig. 1)

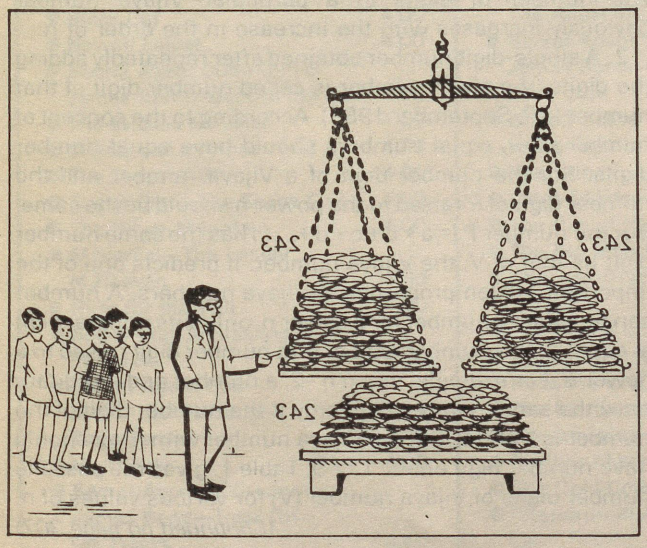

Fig. 1

Then he took the heaviest heap (containing 243 packs, of which one is the 12 kg pack) and broke this heap again into heaps, each containing 243/3=81 packs. As before he put one heap in the left pan and another heap in the right pan of the balance. He found the heap in the left pan heavier. So, he concluded that the heap in the left pan contained the needed pack Thus after the second weighing he found a heap of 81 packs which contained the 12 kg pack. Again, he broke the heap of 81 packs into three heaps and repeating the same trick found a heap of 27 packs which contained the 12 kg pack. In this way, in the fourth weighing, he found a heap of 9 packs which contained the 12 kg pack. Again, he distributed the nine packs in three heaps, put one of them in the right pan and another in the left and found heap of three packs which contained the 12 kg pack. Finally, he took two packs from that heap and put one of them in the left pan and another in the right pan and then weighed for the sixth time. So, he obtained the heaviest, 12 kg pack.

Using this technique, one can successfully detect the heaviest pack if the total number of packs happen to be one from the set 3,9,27,81,243..... Table 1 will further clarify this point.

Similarly, if the original number of packs happens to be one from the set 2,4,8,16,32, 64..... then similar technique will be of help. The only difference in this case is that one has to distribute the packs in two heaps rather than three. So, if there are in all four packs, they are first split into two heaps, each containing two packs. By comparing their weights, the heavy heap, which contains the pack, can be found. As this heap contains two packs in the second weighing, the needed pack can easily be found. Table 2 sums up the matter.

Table 1

Original number of packs	*Minimum number of weighings necessary*
$3 = 3^1$	1
$9 = 3^2$	2
$27 = 3^3$	3
$81 = 3^4$	4
.	.
.	.
.	.
$x = 3^n$	n

Table 2

No. of packs	*Minimum number of weighings necessary*
$2 = 2^1$	1
$4 = 2^2$	2
$8 = 2^3$	3
$16 = 2^4$	4
.	.
.	.
.	.
$x = 2^n$	n

Remember that only powers of 2 and 3 have this special advantage. If the number of packs happen to be $25=5^2$, then dividing the packs in five equal heaps continuously will not help one in finding the heaviest pack in two weighings. The powers of 2 and 3 possess this speciality basically because out of two as well as three heaps one can find the heaviest heap in only one weighing.

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Science Quiz (Know the 'Cultures')

1. The cultivation of grapes is....
2. The science or art of cultivating plants, especially for ornamental use is....
3. The cultivation of fresh-water and marine species is....
4. The branch of biology in which tissues or cells of higher animals and plants are grown artificially in a controlled environment is....
5. The production of raw silk and the raising of silk worms is....
6. The breeding, hatching, and rearing of fish under controlled conditions is....
7. The management and maintenance of colonies of honeybees for the production of honey is....
8. The cultivation of trees for the study of or the production of timber is....
9. The practice of controlling the astablishment, composition, and growth of forest trees is....
10. The science, art and business of cultivating soil is....

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Some Properties of Vijaya Numbers

A number may be equal to the n^{th} power of the sum of its digits. It is mathematically expressed as:

$V = abcd..... = (a + b + c + d + ...)^n = P^n$

where P stands for the sum of the digits of the (Vijaya) number V and n=1,2,3,4.... Numbers having this specific property were termed "Vijaya numbers" by the late mathematician D.R. Kaprekar. From the above mathematical expression for Vijaya numbers, one can easily predict that all single-digit numbers from 1 to 9 are Vijaya numbers for n = 1, as

$1 = 1^1$

$2 = 2^1$ and so on.

Also, number 1 is a Vijaya number for all values of n, as

$1 = 1^n$ (n = 2,3,4,.....)

Vijaya numbers with two or more digits are found to have many peculiar properties. A few of them are illustrated below:

1. Numbers having more than a single digit are never Vijaya numbers for n = 1. The smallest double-digit Vijaya number is 81, which is obtained for n = 2.

$81 = (8 + 1)^2 = 9^2$

With n = 3, five Vijaya numbers are possible. They are as follows:

$512 = (5 + 1 + 2)^3 = 8^3$
$4913 = (4 + 9 + 1 + 3)^3 = 17^3$
$5832 = (5 + 8 + 3 + 2)^3 = 18^3$
$17576 = (1 + 7 + 5 + 7 + 6)^3 = 26^3$
$19683 = (1 + 9 + 6 + 8 + 3)^3 = 27^3$

The Vijaya numbers possible with n = 4 are again five.

$2401 = 7^4$
$234256 = 22^4$
$390625 = 25^4$
$614656 = 28^4$
$1679616 = 36^4$

With n = 5 and n = 6, four Vijaya numbers are possible in each case.

$17210368 = 28^5$
$52521875 = 35^5$
$60466176 = 36^5$
$205962976 = 46^5$
$34012224 = 18^6$
$8303765625 = 45^6$
$24794911296 = 54^6$
$68719476736 = 64^6$

The number of digits in a particular Vijaya number obviously increases with the increase in the order of n.

2. A single-digit number obtained after repeatedly adding the digits of a given number is called number digit of that number (*SR*, September 1985). According to the concept of number digit, equal numbers should have equal number digits. So, the number digit of a Vijaya number and the number digit of P raised to the power n should be the same. But the number P (= a + b + c + d +.....) has the same number digit as that of V, the Vijaya number. It predicts one of the important hidden properties of Vijaya numbers. A number can be a Vijaya number for a power n, only if its number digit is equal to the number digit of that number digit raised to a power n. For example, when n =2, a number and its square have the same number digit only if the number digit of the number is 1 and 9. So, the Vijaya number with n = 2 should have number digit either 1 or 9, Table 1. gives the possible number digits of Vijaya number (V) for various values of n.

(*Continued on page 307*)

Table 1

n	*Set of possible number digits of Vijaya number*
2	1,9
3	1,8,9
4	1,4,7,9
5	1,8,9
6	1,9
7	1,2,4,5,7,8,9
8	1,9
9	1,8,9
10	1,4,7,9

Pregnancy and multiple risk factors

THE possibility of having an abnormal child occurs to most women during pregnancy. Some give it a passing thought, others worry about it. But however much a mother worries about her unborn child, she is never prepared for the tremendous shock of having a malformed baby. The congenital or birth defects have terrified and fascinated man since the begining of history. Stone-age drawings of Siamese twins have been found in caves in Australia. In Mesopotemia, malformation in babies was recorded in detail and used to predict the future of the king and his kingdom. In India, birth defects were attributed to Karma, in other cultures to the anger and punishment of the Gods. Let us see what are the factors which lead to these unpleasant eventualities.

The process of cell division follows just after the formation of the fetus. During the first trimester (12 weeks), each developing cell of the fetus is assigned a specific function through the complex process of organogenesis (formation of organs). The alteration of this mechanism by intrusion of any factor produces gross changes in the fetal physiology. Most congenital malformations take place in the first 10 weeks of fetal life. The structures commonly affected are eyes, ear, heart, bones and muscles. Damage to genital organs and nervous system may occur upto as many as 20 weeks after conception.

Drugs

Use of tetracyclines for the treatment of pyelonephritis (of relatively common occurrence) during pregnancy may cause hepatic injury. Jaundice may first appear and then progress to azotaemia (a clinical syndrome due to renal failure), acidosis and terminal shock. Both renal and hepatic abnormalities may be associated with pregnancy, but the problem aggrevates when tetracycline is administered parenterally or in a dose of 2 mg or more. Kidney infections may lead to decreased renal function and reduced excretion of the drug, resulting in accumulation of toxic concentrations. Tetracyclines enter fetal circulation and amniotic fluid after crossing over the placenta. Treatment of pregnant patients with tetracyclines may produce discoloration of the teeth in offspring. The early characteristic of this defect is a yellow fluorescence of the dental pigment, which has an U-V spectrum with absorption peak at 270m micron. Gradually it is replaced by a non-fluorescent, brown colour. This is an oxidation product of the antibiotic and its formation is hastened by light. The discoloration is permanent and is directly related with the dose of the drug. The period of severe danger is from mid-pregnancy to about 4 to 6 months of the post-natal period for deciduous anterior teeth and from 6 months to 5 years for permanent anterior teeth. The deposition of the drug in the skeleton is probably due to its chelating property and the formation of a tetracycline-calcium orthophosphate complex.

The treatment of morning sickness includes antinauseants of the Phenothiazine class, especially chlorpromiazine, which may cause cleft palate or neurological problem in the growing fetus. Anticoagulant drugs (e.g., dicumarol, tromaxan, etc.) taken by pregnant mother may interrupt the fetal life due to bleeding in the womb. The common antibiotics like streptomycin, kenamycin, etc., have great value in the therapy of severe infection by gram-negative bacteria. The drugs can produce deafness in the baby. The anti-diabetic drugs such as tolbutamide and chlorpropamide may lower blood glucose level resulting in severe brain damage of the fetus. The use of drugs as late as the time of delivery may affect infant's immature systems. Pain-killers (e.g., veganin, cincophen, etc.) used as general anaesthetics to relieve pain during labor may cause depression of fetal respiration which may be irreversible and lead to death. Treatment with drugs to reduce hypertension (e.g., adelphane, M-dopa, etc.) in pregnancy may affect the nervous system of the child. Mothers taking diphenylhydantoin for epilepsy, or adrenal steroids for chronic disorders have been known to give birth to babies with cleft lips and palates.

A women who has missed her periods often takes drugs to test whether she is pregnant. If the drug (ususally a mixture of estrogen and progesterone) fails to induce menstrual flow, it is assumed that she is pregnant. Various research studies have shown that these drugs are not only ineffective but also can produce deformed babies. Several western countries have now banned these tests but in India doctors continue to prescribe them. As such, the best advice to a pregnant woman would be to avoid all drugs in the first 12 weeks of pregnancy unless absolutely necesary.

X-ray

X-rays are used to detect multiple pregnancies (twins), fetal deformity or confirmation of pregnancy. Gamma and X-rays freely penetrate all the growing cells of the body causing alterations in the chromosomal pattern. The effects may be disastrous causing abnormality of almost any system in the infant. X-ray examination should therefore be avoided before the 20th week of gestation. It should be done cautiously if at all required.

Smoking

The association between smoking during pregnancy and reduced fetal size is universally acknowledged. Tobacco smoke usually contains tar substance (may induce cancer), irritants (may produce bronchitis), carbon monoxide (interferes with oxygen transport in blood) and nicotine. Nicotine produces constriction of blood vessels thus reducing the supply of vital nutrients and oxygen to the placenta and fetus. The weight of the newborn is reduced by atleast 200g (perhaps more) due to retarded intra-uterine growth in smokers as

opposed to non-smokers. Such reduction in growth is proportional to the amount of smoking. Every additional cigarette smoked over 15 per day brings about a further reduction in birth weight of the order of 20g.

Paan chewing (betel-leaf)

Anorexia (loss of appetite for food) and giddiness are the commonest symptoms during pregnancy. Paan with tobacco exerts harmful effects of nicotine. Calcium intake is supplemented by lime (chunna) with paan during pregnancy. The average total weight gain during pregnancy is about 10kg. The reduced appetite and food intake, common in smokers and paan chewers, leads to a caloric deficit and poor nutrition of the baby. As a result, the weight gain (about half a kg per week) may go down to about one third of a kg per week during later stages of pregnancy.

Drinking (alcohol)

Alcohol is habit forming and it is difficult for a woman to overcome the temptation of drinking even during pregnancy. On drinking, the concentration of alcohol in the fetal blood becomes equal to that of the mother. This condition is highly injurious to the growing fetus. An adult liver can metabolise upto 28ml of alcohol in an hour. The under-developed liver of the fetus can work only slowly and hence most of the alcohol reaching it is diffused across the placenta. The mother can lower it back only when her own blood alcohol level goes down. So, if the mother drinks more than 28ml of alcohol at one time, the fetus has to retain it for long. Babies born to mothers who consume between one to two ounces of pure alcohol a day (one ounce of pure alcohol is equal to 2 ounces of whisky, 10 ounces of wine and 24 ounces of beer) may develop growth abnormalities and congenital malformations. It has also been noted that woman who drink an ounce or less of alcohol a day have higher rate of still-births and their babies also weigh less.

Present knowledge is still inadequate to say precisely at what stage in pregnancy the risk from alcohol is highest. Nevertheless, it can be suggested that for a normal healthy baby the mothers should stay away from alcohol.

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SCIENCE FOR THE YOUNG (*Continued from page 304*)

The possible set of number digits of Vijaya numbers for different n is repeated in a cyclic order. So, the Vijaya number with n and n + 6 have the same set of possible number digits. Accordingly, the Vijaya numbers with n=2,8,14,20,26..... will have number digit either 1 or 9. For example,

$$\cdot\cdot 72,301,961,339,136 = 54^{8}$$

$$20,864,448,472,975,628,947,226,005,981,267,194,447,042,584,001 = 207^{20}.$$

3. According to the number digit property of Vijaya numbers, a number with a given number digit can be a Vijaya number only for certain values of n. A number with number digit 1 can be a Vijaya number for any n, but a number with number digit 2 can be a Vijaya number only for n=1,7,13,19.,.... Table 2. gives the possible values of n for a given number digit of Vijaya numbers. It is found that no Vijaya numbers for any n (other than 1) have number digits 3 and 6. With the help of Tables 1 and 2, the search on Vijaya numbers becomes much simpler.

Table 2

Number digit N	*Power n*
1	1,2,3,4,5 .....
2	1,7,13,19 .....
3	1
4	1,4,7,10,13 .....
5	1,7,13,19 .....
6	1
7	1,4,7,10,13 .....
8	1,3,5,7,9,11 .....
9	1,2,3,4,5,6

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Answers to Science Quiz

1. Viticulture 2. Horticulture 3. Aquaculture 4. Tissue culture5. Sericulture 6. Pisciculture 7. Apiculture 8. Arboriculture 9. Silviculture 10. Agriculture.

Amla pricking machine

AMLAS (Indian gooseberries, *Emblic myrobalan*) are often used to prepare delicious jams and pickles. For making jams, the fruits of amlas have to be properly pricked. Traditionally this is manually done using nails or fork. This method is irk-some and slow, and the nails often injure the fingers. The pricking of amlas for this purpose can be hazardous in the absence of a convenient tool. This problem has now been solved with the invention of an amla pricking machine, which is developed by the author. The machine described below works efficiently to prick amlas on a large scale.

Construction

The machine consists of four movable plates and a perforated cyclinder with a thick lining. The plates, fitted with needles of definite dimension, are placed around the cylinder. Every plate is connected with a separate crank which has a pinion on its shaft. A chain connects all the four pinions (Fig. 2) thus connecting the four crank-shafts with each other. If one crank-shaft is rotated with the help of a handle, all four rotate simultaneously. The whole assembly is housed in a box.

How it works

The machine is placed on an inclined surface. The cranks are rotated using the handle and the gooseberries are dropped simultaneously from the top of the cylinder (Fig. 1). The plates begin to move to and fro. The needles penetrate through the holes in the cylinder and prick gooseberries passing through them.

The needles are constructed in such a way that when they are inside the cylinder there is a gap of the size of an average gooseberry nut between them. And when they are completely out of the inner surface of the cylinder, their tips continue to remain inserted in the thick wall of the cylinder.

Advantages

The machine offers following advantages over conventional methods.

It can prick about 100 gooseberries in the same time (three minutes) that it takes to prick a gooseberry manually. During manual pricking there are chances that the juice spatters to

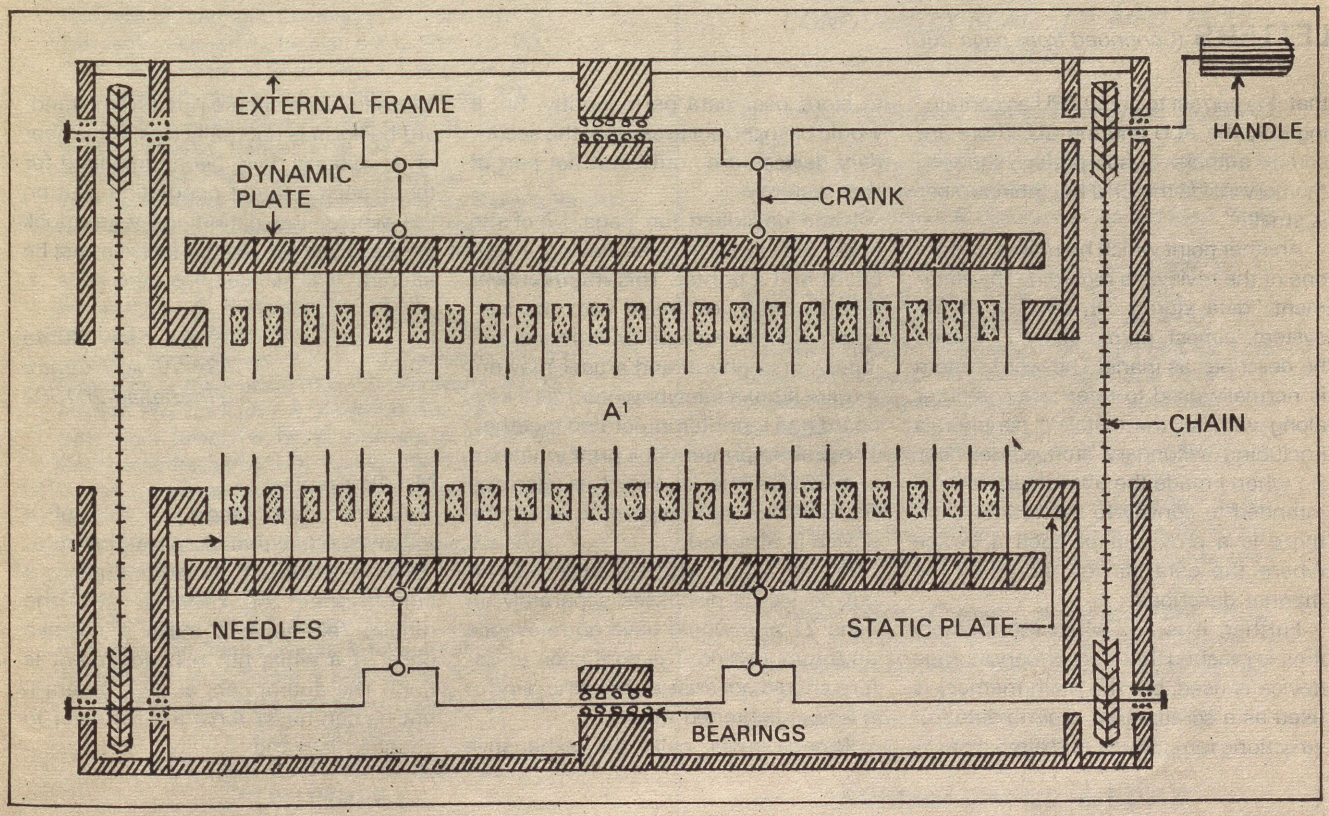

Fig. 1. Internal structure

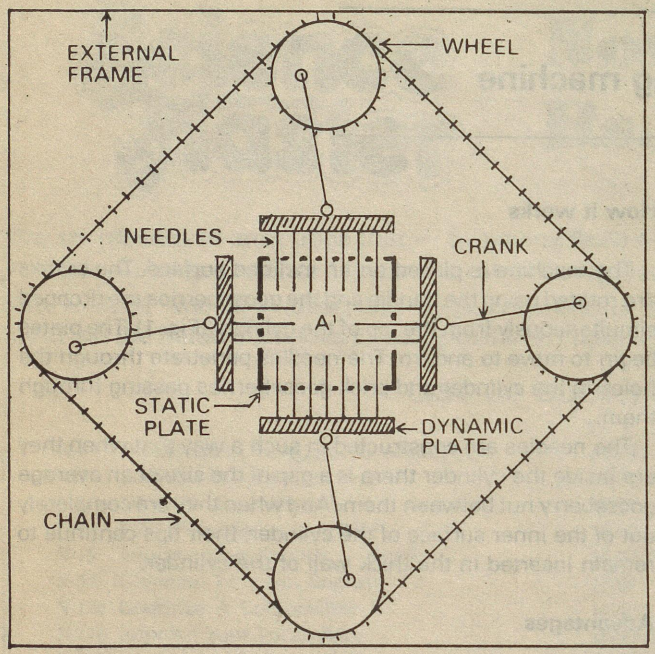

Fig. 2. Side structure

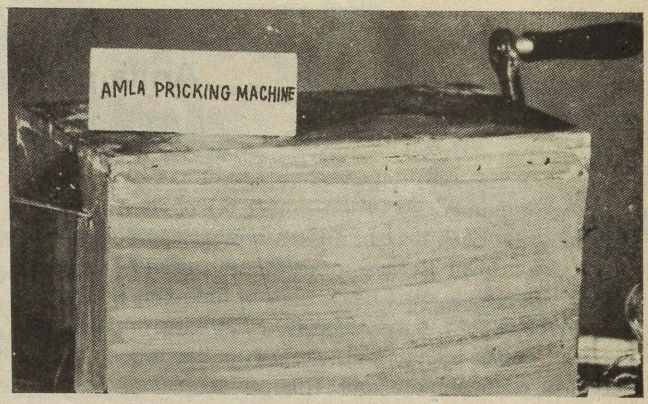

Fig. 3. Amla pricking machine

the eyes and causes irritation. The machine solves this problems as it is covered from all sides. The possibility of injuring oneself with knives, forks or needles used for manual pricking is also eliminated.

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LETTERS (*Continued from page 260*)

that it is correct to show CPU as containing only the ALU and the CU. There are some authors who prefer showing memory inside the CPU but their number is small.

Another point which he makes (in para one of the review) is regarding my statement "data stored can be held in the system, almost permanently...." which he describes as inane! The word system is normally used to refer to a computer along with all the installed peripherals (including secondary storage devices). So when I made the above statement, I intended to convey to the reader that there is a provision of such a device where the data can be stored in the manner described.

Further, it is not when the memory limit is reached that a secondary storage device is used, but the main memory is used as a scratch pad, storing data/instructions temporarily and almost never to store user data permanently. So, it would be incorrect to say that the secondary devices are "out" and not part of the 'system'.

I had described (on page 17 of the book) teletypewriters as having a keyboard and a printer. This, the reviewer has, probably, confused with the keyboard of a microcomputer. Printer is definitely a peripheral and a user may not require it but a teletypewriter has a keyboard and a printer integrated together. The built-in printer does print whatever is typed on the keyboard as also the responses of the computer to which the device is attached.

Printer alone, which is solely an output device, is discussed separately on page 21 and would have no relevence on the input side. The confusion therefore should not arise even in the mind of a less enlightened reader.

The reviewer calls the exhaustive 'glossary' as a simple ripoff from standard books. It is not really that. A number of definitions have been simplified for the expected target population. But on the whole, the definitions would look similar anywhere as the facts cannot be altered.

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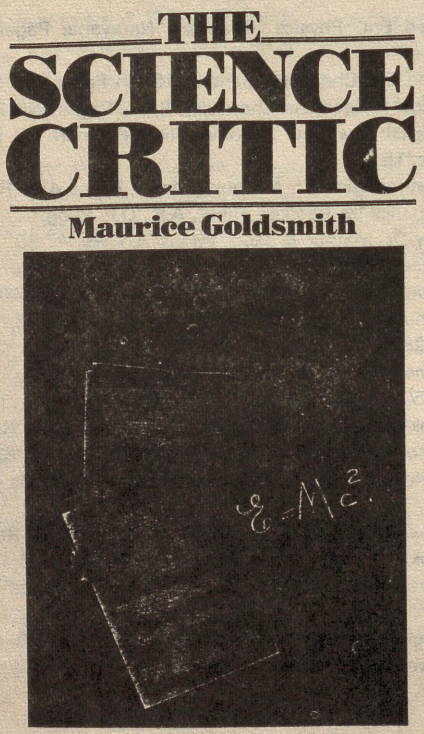
Mr. Nag replies:

To my knowledge, the role of a reviewer is like that of an umpire/referee in any sport. To take the analogy a little further, the reviewer (like the umpire/referee) can make a mistake once in a while but his judgement is final. The author can, at best, resent it but he can never *force* the reviewer to change his stand.

THE SCIENCE CRITIC: A Critical Analysis of the Popular Presentation of Science *by* Maurice Goldsmith, *Routledge & Kegan Paul,* London and New York, pp. 217, £ 15.95, ISBN 0 7102 0467 1

IF the quality of science journalism is to continue to improve, then the education of science journalists must be a matter of highest priority, says Eugene Garfield, the veteran impresario of information science, in a recent issue of *Current Contents* (23 March 1987). "Training for science journalism has become too important for a hit-and-miss educational approach," said the well-known journalism professor Killier Kreighbaum in his classic *Science and the Mass Media,* published in 1967. Why is it that so much importance is being given to the public understanding of science? Is it because it now enjoys the kind of esteem normally accorded to the institution of marriage, or to motherhood before that went out of fashion, as a *Nature* editorial affirmed not so long ago (30 August 1984)? Perhaps, the importance of public understanding of science will cease to be underscored when what we now designate as science has been fully assimilated into our culture. But until then books like *The Science Critic* will pour forth.

The author of this title is the well-known science policy expert (whose hobbyhorse is science popularisation), who learnt his trade with the left scientists, like J.D. Bernal, of the 1930s. The central message of the book is that we should create a new genre of science writers. Whether they will have functions analogous to those of literary and art critics in society, however, is not clear. Why Goldsmith prefers the new breed of animal is perhaps due to his aversion to the expression 'popularisation of science', which he has said on several occasions has connotations of scientists having to condescend to address the man in the street. "To popularise is to sin," as he puts it in this book. It is not without reason that Goldsmith has developed such an attitude. For, even great science popularisers like Jeans, Haldane, Bronowski and Mead found themselves discredited by highbrow scientists. Popularisation may also have an undertone of 'cheapening' science for the sake of arousing public taste. Science critic is thus Goldsmith's new nomenclature for a profession whose origins in the Western world could be traced to Bernard le Bovier Fontenelle in France towards the last quarter of the seventeenth century.



Who is a science critic? Goldsmith defines him as "a public policy journalist alerting us to the growing pains of future worlds through the day-to-day discoveries of the present". Who is best qualified to be called science critic? Not the scientist, says the author. Not the information officer or PRO, either. Not even the science writer or communicator. Only a new curriculum could produce the species Goldsmith has conceived. The curriculum might include a course in general science which imparts an understanding of the linking concepts now being formulated, a course in the history and philosophy of science and technology, a course in the meaning and significance of the arts, a course in the psychology of communication and the nature of creativity, and a course in the techniques of communication. The science critic should also be his own creator so that he can bring forth life itself in all its truth.

What are the functions of the science critic? Let Goldsmith convey his flavour: "To see the whole picture; to see the future because of what he knows of the past; to uphold the integrity of science, so that people understand its poetry and cease to have fear of it."

The Science Critic spreads over six chapters. In the first chapter, 'The proper public for science', Goldsmith stresses the obvious: Science is a part of the process of social and cultural evolution. So the proper public for science will vary from period to period depending on what is the meaning and purpose of science. In Chapter 2, Goldsmith looks at the way science is presented through the various media, namely newspapers, magazines, books, radio, films, television and museums, all in relation to the Western world. The role of science fiction is examined in the next chapter, SF writers being held out as the 'historians of the future'—a view of SF that is contested by many, for science itself is so very interesting and calls for far greater leaps of imagination. Chapter 4 looks at the school science education, mostly in Britain. The title 'The educational system no-go' is sufficient indication of the author's disenchantment with the nursery for science. "Schools have largely failed to inspire in students an understanding of science and mathematics." Chapter 5 considers the special problems of presenting science and technolgy in

the Third World, the subtitle of this chapter 'The third world: illiteracy and community' holding cue to the content. The meat of the book, however, lies in the quintessentially brief (4½ pages) last chapter 'The science critic: A case for new creation'.

More than half of the book, re-assembled as it appears, spills over appendices, two in all. The first gives information on associations of science writers and awards for popularisation of science, national and international. Despite the author's long acquaintance with India there is no mention of the Indian Science Writers Association or India's fairly satisfactory track record in science popularisation. An instance of the First World scientists' amnesia to TW science and scientists? Another appendix comprises examples of science writing, which are excellent models of expository writing and lucidity and hence of immense educational value. But are they the type of material the new profession of science critic is expected to put out? Of the 11 examples included, five are the author's own writings. The Foreword too is by his son, television director David Goldsmith.

Spanning as it does so many topics, each one of which needs an in-depth treatment, this analytic work lacks the synthetic cohesion. Nonetheless, it is a good bedside read, enjoyable and informative.

Being well informed about science is not necessarily the same thing as understanding science. Would Goldsmith's 'science critic' so function as to fill the void?

P.S. Shankar

FAR TRAVELERS : THE EXPLORING MACHINES *by* Oran W. Nicks, *National Aeronautics and Space Administration* (Available from : Superintendent of Documents, U.S. Government Printing Office, Washington D.C. 20402, U.S.A. Please quote Stock No. 003-000-00957-7), Pp. 255, $ 17.00

WHEN the unmanned craft *Voyager 2* set out on its long voyage across the Solar System in August 1977, its mission was only to explore Jupiter and Saturn. The 900-kg spacecraft was designed to last only long enough to do that. Yet, eight-and-a-half years later, and four-and-a-half years after its rendezvous with Saturn, *Voyager 2* was still in good shape. On January 24 last year it sent back volumes of scientific data and the first ever close-up pictures of Uranus and its moons. It was a tremendous feat, made possible by the dedicated efforts of hundreds of scientists and engineers who designed, built and guided the tiny spacecraft throughout its long voyage.

Voyage 2 was just one of the couple of dozen or so unmanned space probes sent by NASA to explore the Moon and the planets. Many, like *Voyager 2* and the two *Viking* spacecraft, were remarkable successes; several others failed at various stages. *Far Travelers* is the story of these remarkable exploring machines, told by one who has been intimately associated with them. The author Oran Nicks joined NASA in 1960 as Head of Lunar Flight Systems and later became a Program Manager at NASA's Washington headquarters. Under his stewardship more than 30 U.S. spacecraft were launched toward the Moon and the planets. Nicks tells us all about them—both successes and failures.

In the early 1960s, interplanetary space exploration was still unknown. The designing and launching of a spacecraft on a planetary mission and then guiding it to its distant goal presented many unknown and complex problems, and failures were common. The first U.S. attempt at interplanetary flight, that of *Mariner 1* to Venus, failed "for want of a hyphen". Of the nine *Ranger* missions to the Moon as many as six failed, as did the first *Mariner* mission to Mars. There were also remarkable successes. Of the seven *Surveyor* probes sent to the Moon six successfully completed their mission and all the five *Lunar Orbiter* missions, which together photographed 99 per cent of the lunar suface, were successful. The 70s saw the opening up of the outer planets to space probes. Two *Viking* landers soft landed on Mars in 1976 and sent back the first panoramic colour pictures of the planet's boulder strewn red surface. *Pioneer 10* flew through the asteroid belt to send back breathtaking closeups of Jupiter and its moons. *Pioneer 11*, which reached Jupiter a year later, went on to visit Saturn and sent back remarkable pictures of its moons and ring system. Then followed the two *Voyagers* which blazed a new trail in planetary exploration.

Nicks describes these incredible machines in considerable detail—how they were conceived, designed and finally put together and set out on the various missions. He takes pains to explain many of the complex principles and engineering problems associated with designing and launching of a rocket, guiding tiny space probes across millions of kilometers of space using only a few tens of watts of power, and in maintaining round-the-clock radio link with them through the Deep Space Instrumentation Facility. He also talks about his colleagues and others at NASA whose dedication and loyalty made the missions possible. Recalling one incident he writes, "The three of us were together...some of the time with our backs to the wall defending our project against hardware failures, against scientific critics, against adversary review boards, and sometimes against political committees and administrative fault-finders...I kept trying to do the things I thought should be done, and with the help of these gifted friends, things worked out".

His experience with the bureaucracy, however, doesn't seem to have been a happy one. "For NASA Headquarters managers", he writes, "a recurrent headache was the need to synchronize mission planning with congressional budget cycles: a desirable condition that seemed rarely to happen. Neither the actions of Congress nor the movements of the planets could be made to accommodate the other, and it was our task to do all the adapting that was needed".

The book is well illustrated with a selection of black-and-white and colour photographs spanning two decades of space

exploration, and several line drawings. Among them is the historic first close-up of Mars in colour made by hand using crayons on paper tape as the picture was being radioed to Earth by Mariner-4 in July 1965. But the absence of an index will certainly reduce the reference value of this otherwise informative and highly readable volume.

Biman Basu

WEAPONS AND HOPE *by* Freeman Dyson, *Allied Publishers Pvt. Ltd.,* 13/14, Asaf Ali Road, New Delhi-110002, Pp. 340, Rs. 80.00 (Hardbound)

NO sooner a reader comes to know that the book under review is on nuclear disarmament issue than he or she would lose interest in it because every body feels that nuclear weapons have come to stay, nothing could be done about them, and nuclear disarmament is a futile issue to keep some thinkers occupied for earning their living! But that is what the purpose of writing the book under review is: to remove such misconceptions from a reader's mind and force him or her to think along fresh avenues yet untapped in the pursuit of nuclear disarmament. Indeed, as the author contends in the Preface, the book is aimed at opening a dialogue between the victims, the masses at large, and defense personnel and politicians who are responsible for the deployment of nuclear weapons. He has tried to open this dialogue by giving both sides of the story by relating instances from his own life spent in army service during the World War II, his family members' behaviour during the war, his analysis of historic moments that led to the building and deployment of nuclear weapons, the reasons for the present stalemate in disarmament issue, various myths circulating about nuclear war, and his personal views on the future of nuclear weapons. But despite all his story-telling and technical descriptions of sophisticated nuclear weaponry, there is a strong undercurrent that advocates every one not to lose hope because it is necessary for the survival of mankind.

The author thinks that no person in his right mind would commit certain atrocities upon another person unless he is a part of a gang or organisation. For instance, no single German would have thought of putting Jews into gas chambers unless abetted by the Gestapo. Similar is the case of the military leaders of the U.S.A. and the U.S.S.R.—or for that matter, of defence personnel or politicians—who make strategies to destroy not only the enemy country but also the entire world several times over. Not a single army personnel or military leader or politician would ever think of committing such a heinous crime unless he is abetted by his government and military establishment. Moreover, often, it is the rivalry among the Army, Air-Force and Navy, each trying to grab a bigger chunk of defense budget and extend its political influence, solely responsible for arms race rather than the rivalry between two nations. He therefore thinks that more efforts should be made to educate soldiers and Generals about the follies of deploying nuclear weapons rather than the masses at large because it is after all they who have to resist deployment of nuclear weapons. It should not be out of fear of nuclear holocaust that they should be urged to do so but for their military honour and self-respect because their very presence is redundant if nuclear weapons could do everything, he adds.

That, in short, is the arguments the author gives on the side of the military personnel. Now, the victims, the public at large. He thinks that the public too has an unconscious desire for war as is evident from the popularity of movies like *Star-Wars*. Even though his uncle had suffered miserably during the World War I, he adds, he (his uncle) was prepared to teach Hitler how to behave by joining the army! Taking the example of the abolition of slavery, the author claims that it has parallels in nuclear disarmament issue. In fact, he urges the public to follow the same strategy which was adopted in fighting slavery. Those, who fought slavery, first attacked politically the slave trade and left to the next generation the target of achieving absolute abolition of slavery. It requires people with moral conviction, patience and willingness to compromise to achieve nuclear disarmament, he says. The author has specifically expressed strong hope in "non-violent resistance" principles of Mahatma Gandhi. Giving the case of the French village of Le Chambon sur Lignon, where the villagers did not hand over Jews to German S.S. guards during World War II by adopting non-violent resistance tactics, he thinks that this Gandhian principle could be employed to achieve nuclear disarmament.

This U.S. National Critic Circle Award winning book contains much more than all this. Though certainly a serious reading, it is fully supplemented with interesting anecdotes, fascinating insights into the future of nuclear weaponry, men and moments of nuclear weapon history.

Dilip M. Salwi

CAPTIVE UNIVERSE *by* Harry Harrison, *Grafton books* (Available from: *Rupa & Co,* 3831, Pataudi House Road, Daryaganj, New Delhi-110002) Pp. 206, Rs. 55.00

HAVE you ever wondered whether the earth is a trap for the entire mankind and that some higher civilization is watching our activities? If you have ever wondered along these lines, which have been the favourite pastime of not only Science Fiction fans but also exobiologists, you are bound to be in for a pleasent surprise. The novel under review would satisfy that wondering mind of yours, keeping your attention spellbound from the moment you read the first few pages till the moment you finish it. It is an exhilerating journey which raises several serious questions in the end without providing clear answers.

Has the author; a renowned name in Science Fiction genre, tried to raise those puzzling questions to which no exobiologist has any answer? one wonders. For instance, if our earth is a trap and superior aliens are watching our progress, why have they not yet shown their presence? what could be their motives in watching us?

The novel is centered on Chimal, an inhabitant of a small valley containing only two villages, one river, a lot of snakes and scorpions, a temple and priests. People are highly superstitious and believe in evil gods and goddesses. But there is no way out of the valley. Chimal, who has no desire to lead a conventional life in the valley, is keen to see what is beyond the high cliffs that surround it. He is intelligent and sharp but more than these qualities he has guts and a curious mind. Eventually, owing to a chain of circumstances, Chimal is forced to leave the valley. It is in the process of escaping it that he reaches the other world, the technologically advanced world which is keeping a watch on the valley and its inhabitants. In fact, that entire world, including the valley, is an artificially created one, a huge spaceship heading towards the planets that circle Proxima Centauri. Chimal is completely boggled by what he sees there but manages to learn the ropes of that highly advanced society. And when he begins to see critically what is happening there he realises its follies and new "superstitions". The society has become a totalitarian system and men and women have been shred of their basic desires and urges. Specialisation has reached such a stage that no individual can handle another individual's work ! It is when he tries to set that world in order that the trouble starts.

If this novel is any guide to the dilemma the exobiologists are in today, nothing much could be expected of that higher civilization, if any, watching us for reasons best known to it. But, then, as somebody has contended that such a civilization would show itself and interfare in the present world affairs if and only if earth is threatened with extinction. Should we, then, wait till the moment the nuclear war starts? If the higher civilization is as passive and decadent as shown in the novel, it is better we sort out our affairs ourselves and let not the nuclear war engulf and destroy us!

Dilip M. Salwi

NUCLEAR RADIATION DETECTORS *by* S.S. Kapoor and V.S. Ramamurthy, *John Wiley & Sons,* (Available from *Wiley Eastern Ltd,* Ansari Road, Daryaganj, New Delhi-110002), Pp. 236, Rs. 35.00

WITHIN less than ninety years of the modern history of atomic and nuclear physics, the subject of detection, interaction and characterization of various kinds of radiations/particles emitted in a multitude of atomic and nuclear processes has grown enormously. The ever increasing use of atomic and nuclear radiations in science, industry, agriculture, medicine and defence have put several newer demands on the requirements of not only the radiation sources in various energy ranges but also their detection, safe handling and disposal. All these require proper and efficient detectors for accurate dosimetric and analytical measurements and monitoring. In most branches of science, nuclear, isotopic and atomic radiation techniques are being incorporated in one way or the other. Descriptions and use of these radiations in various applications have already moved from research journals and laboratories to standard text-books and regular curriculum courses in universities and research institutions. It is in this context the present book brought out by the Indian Physics Association for the benefit of post-graduate students and beginners is a welcome monograph. Keeping this objective in view, the scope of the book has therefore been rightly restricted to the detectors that are commonly used in low and medium energy ranges in nuclear physics researches and their applications in industry and agriculture. A major emphasis on the description of the general principles of working and operation of these commonly used detectors in the light of important technological developments in recent years has been given throughout the book. Starting with a chapter on general introduction, the other seven chapters devoted individually to various other kinds of detectors such as the gas-filled ionisation, semiconductor, scintillation, neutron and the track etch, have been thoughtfully planned in their contents and presentation. The inclusion of important references at the end of each chapter is a thoughtful gesture. However, as the book is primarily aimed at students and beginners, it would have been desirable had the authors at least included photographs of various detectors in use instead of leaving them completely to the imagination. Also, a brief directory of the principal international manufacturers and suppliers of various detectors would have been desirable.

Although the detectors used in more specialized areas of high energy physics and cosmic rays and also the applications of miniaturized detectors, which have become inseparable parts of most modern sophisticated research and analytical instruments, have not been discussed in the present book, the fundamental principles underlying the construction of these detectors have been adequately given in respective chapters. However, at least a brief introductory chapter on their applications would have satisfied the curiosity of serious and enthusiastic students, who would be using these sophisticated instruments in course of their post-graduate research and studies. Like-wise, an annexure containing the glossary of important terminology and physical processes would have further improved the utility of the book.

On the whole, the book is a welcome addition. It makes available all the necessary information on nuclear radiation detectors to student community under one cover. The moderate price of this excellent monograph should tempt all those users of nuclear radiation detectors to possess a copy of this book for their personal collection.

A.V. Moharir

BOOK REVIEWS

JANA SWASTHYA ANDOLANER RUPREKHA *by* Kalidas Samajdar, Pp. 14, Re. 1.00; **PETER ASUKH** *by* Tapas Sen, Pp. 16, Re. 1.00; **APUSTI** *by* Gopal Das, Pp. 20, Re. 1.00; **ROG PRATIRODHE TEEKA** *by* Samir Kundu, Pp. 19, Re. 1.00; **ESAB OSHUDH KHABENNA** *by* Sukhamay Bhattacharya, Pp. 19, Re 1.00; **PEOPLE'S HEALTH MOVEMENT: A MANIFESTO** (English rendering of the first title) Pp. 13, Rs. 2.00. All published by *Norman Bethune Jana Swasthya Andolan,* C-7/4, Labony Estate, Salt Lake City, Calcutta-700064.

BASIC needs of humans may be listed as clean air, potable water, nutritious food, shelter, clothing, health and hygiene. It is no surprise therefore that the organisers of Norman Bethune Jana Swasthya Andolan or People's Health Movement have chosen as their motto the couplet from Rabindranath Tagore's poem (Ebar Phirao More) : "want food, want light and fresh air; want strength, health and a joyful life-span". These six booklets in Bengali not only bring out this message clearly, they also tell us how to achieve a reasonably healthy life.

The booklet *Esab Oshudh Khaben Na* by S. Bhattacharya is probably the most important of all the six under review. Some statistics given may be revealing. In 1947 medicines worth Rs. 10 crores were sold in India; in 1985 the figure had reached a formidable Rs. 2,000 crores. Allowing for both population growth and devaluation of the rupee, this 200-fold increase is spectacular. Yet, in India only 5% of the population can afford to buy medicine, 20% can afford with difficulty, and the rest 75% gets along without buying any medicine at all! There are 400 primary formulation of drugs. According to the Hathi Committee (1975) report only 117 primary drugs may be sufficient to cope with almost all the diseases in India. Yet there are about 45,000 listed medicines in Indian market, many of them without having any medicinal value at all. The author says that our medical practitioners are prescribing and we are taking in name of medicine materials which are not only ineffective but also harmful. A number of wasteful medicines have been mentioned.

The booklet *Rog Pratirodhe Teeka* is about vaccines and toxoids and their uses. The author, S. Kundu points to a paradoxical situation in our health education and extension programmes. He questions the utility of charts, posters, prescriptions and other audiovisual materials made in English where more than 60% of the population is illiterate, He also tells us that in India about one crore children either die or become physically or mentally disabled from diphtheria, tetanus, polio, measles, whooping cough and T.B. while only Rs. 50 per child can protect from these six deadly diseases.

The booklet entitled *Apusti,* which means malnutrition, tells us that protein foods are not so much necessary for adults as they are for growing children and adolescents. Most of our protein needs can be received from 'grains'. According to the author G. Das, food with sufficient calories fulfills the protein needs also. He also provides tips on how to get nutritious food, without spending much.

The booklet *Janaswasthya Andolaner Ruprekha* by T. Sen is about enteric diseases and their prevention and care. It tells us that a 'Diarrhoea mixture' can be prepared with one litre of clean water (better if boiled), ½ tea-spoonful of baking soda, 1 spoonful of salt, a lump of gur or eight spoonfuls of sugar (about 25 gm). Even starch water from boiled rice (called *fan* or *maarh* in many Indian languages) with salt and 'gur' can be useful. Such mextures can prevent dehydration and can provide primary treatment for many enteric diseases including cholera.

The booklets have been written in lucid language by professional doctors and medical academics. They are informative and useful. But the emphatic overtones about social ills and class differentiations inter-sparsed throughout the booklets could have been avoided.

This review cannot be complete unless a few words are added about Norman Bethune (b. 4 march 1890 in Canada; d. 12 November 1939 in China) whose name the series and the organisation bear. Bethune received his medical education in Canada and England. Then he travelled throughout the world with medical missions. He was a surgeon of very high calibre. But he was better known for his views and activities for social hygiene and public health for all. He died while working in the Chinese war front in 1939.

Subir K. Sen

TATA McGRAW-HILL'S STUDY PACKAGE FOR MEDICAL COLLEGE ENTRANCE EXAMINATIONS, *Tata Mcgraw-Hill Publishing Company Limited,* 12/4 Asaf Ali Road, New Delhi 110002, Pp. 412, Rs. 54.00

A career in medicine is considered one of the best, and in this age of competition only the best informed students can take it up as a career. Good books do help students to prepare well, for competitive examinations.

The book under review is one such book. It is divided into six sections : physics, chemistry, botany, zoology, mental ability and general knowledge. Each section begins with a comprehensive synopsis of formulae, definitions and laws for quick recapitulation and revision of basic principles. The book contains about 4000 questions in all; they include multiple choice thought type, assertion-reason, true-false, fill in the blanks, match the column, etc. Answers to all questions are given. Emphasis is on multiple choice objective testing. Two model test papers on each subject are given. A glossary of important terms and definitions is also provided.

Various sections of the book are well prepared. Variety of questions are formulated and answered, and high degree of accuracy has been maintained. More illustrations should have been given under botany and zoology. The book will be very useful to those who wish to prepare for different medical entrance examinations. Considering the amount of information given, the price of the book is not high.

N.R. Mankad

BOOK REVIEWS

AN INTRODUCTION TO NUCLEAR PHYSICS *by* W.N. Cottingham and D.A. Greenwood, *Cambridge University Press*, 139, Munirka Enclave, New Delhi-110067 Pp. xv + 210, £ 5.25

NUCLEAR physics grew at a tremendous pace for about four decades after the discovery of the neutron in 1932. The seventies and eighties saw a fast decline in interest in nuclear physics. During the period of feverish activity in nuclear physics, almost half the Noble Prizes in Physics went to this branch and a large number of books were written on the subject by eminent scientists around the world. The last decade has seen a shift in interest from the earlier (now called the "classical" or "conventional") nuclear physics to the one intimately related with particle physics. Nuclear probes have changed, the energies of projectile particles drastically enhanced, and attempts have been made to understand nuclear interactions in terms of some basic force fields among particles. So, a book on nuclear physics at the introductory level which keeps the modern developments in view is welcome.

The book under review written by two physicists of the Bristol University, U.K., is intended for use as an introductory course on nuclear physics at the undegraduate level. Spread over 13 chapters, it starts with nuclear physics set in the context of elementary particle physics and goes on to discuss other conventional aspects like the understanding of nuclear properties both in the ground and excited states with the use of some simple models like the shell model. It discusses both nuclear fission and fusion as well as controlled production of energy in nuclear power reactors. As a welcome departure from conventional books on nuclear physics, it also gives an outline of the energy production and nucleosynthesis in starts, which is a direct application of nuclear concepts in astrophysics.

The book, available in a paperback edition, is very well brought out. It has four appendices on specialised topics like cross-sections in nuclear reactions and the theory of angular momentum. Each chapter has some problems at the end, for which answers and hints are provided. For the reader a basic knowledge of quantum mechanics and the special theory of relativity is necessary. This, makes it unusable at the undergraduate level in most universities of India. At the honours and the post-graduage levels, it can serve as a good text for both students and teachers of physics.

As a vast subject like nuclear physics cannot be easily condensed in a small volume like the present one, the authors have omitted many important branches, and have tried to discuss only the important features of some particular topics. In general, more emphasis has been laid on theoretical discussion of experimental results rather than the discussion of actual experiments themselves. Further, excitation energies and nuclear reactions considered are all below 10 MeV. It thus essentially considers low-energy nuclear physics. All these make it truly an introductory book, but, in the Indian context, it cannot serve as the only book for a course on nuclear physics in any university.

Naresh Kumar

ENVIRONMENTAL CONTROL OF CIRCADIAN RHYTHMS IN PLANTS *by* K.S. Sundararajan, *Agro Botanical Publishers* (India), Old Ginani, Bikaner-334001 (Rajasthan), Pp. 120, Rs. 120.00

THE book is the second in the Plant Growth and Development Monograph Series. The title is ambitious but after a third reading of the book, it can be written off as a superficial overall view of a fascinating aspect of plants—the circadian rhythm. Contrary to the claims made both in the dust jacket as well as in the Foreward, this reviewer failed to find any authoritative treatment of the subject. There is no definitive cohesive treatment or rigorous proof for the tall claims made in the book. Mere seeking refuge in a large disjointed survey of the literature on the subject cannot salvage a monograph.

There are many disturbing features of this monograph—too many to be listed here. The use of convoluted language, deletion of words, tenses of verbs changed in the middle and sentences and parenthesis forgotten either by the editor or by the press has resulted in a half-baked book. More often, entire passages often constituting more than half the page from German researches have been reproduced in the book. Also this reviewer did not find in the acknowledgement any permission to reproduce so many diagrams from other publications. The middle three chapters are absorbing. The ones in the beginning and the last one are more of a potpourri. The treatment of many fascinating case studies has been perfunctory. There appears to have been too much pressure for quick publication. The unintentional or intentional omission of references to classical works such as Daphne Vince Pince Prue's *Photoperiodism in Plants,* Evan's *Case Histories of Flowering,* elegant reviews of Hamner and Takimoto and more recent definite treatment of Satter on growth movements in the *New Series of Plant Physiology Encyclopedia,* make the author's credibility questionable.

In the book, the figures reproduced range from passable to worse, some with crowded lines which serve no useful purpose. The photograph of the set-up to study leaf movements as well the accompanying description of the recording unit are amateurish. Unacceptable number of typographical errors-/misprints from the jacket to the references section makes a sad reading. It is hoped that in the next edition the author makes up for these omissions and includes a good account of more recent works on the use of many chemical probes to study rhythms, study of isolated protoplasts of extensor cells, K + channels, phosphotidalinositol turn over, etc.

Vatsala

BOOK REVIEWS

HANDBOOK OF FOOD ANALYSIS *by* S.N. Mahindru, *Swan Publishers,* New Delhi-110008, Pp. 608, Rs. 550, $ 80.00, £65.0

AS one who has been associated for the last two decades with the Quality Testing Laboratory of Lady Irwin College, which controls the quality of foodstuffs sold in Delhi's Super Bazars, this reviewer has keenly felt the need for a precise and concise compilation of all the testing procedures relevant to food quality control in India today. The official brochure on food testing procedures is more than a decade old. However, the PFA (Preventation of Food Adulteration) Act 1954 and its rules have been amended several times after the publication of the official brochure. The Indian Standards Institution has also been publishing standards for most consumer commodities, but there is hardly an I.S.I. publication without cross references to other standards or books.

The available literature on the subject of food analysis at present is scattered and, besides, none explains in full the fundamental principles involved in the various processes of testing. The author has given ample thought to this aspect of the problem and the handbook gives detailed mechanisms of the chemical reactions involved. The book also explains probable causes manual as well as technical of variation in results. Upto-date Indian Standards have also been laboriously collated and compiled.

The book thus satisfies a long-felt need of food analysts, food producers, manufacturers, processors and technologists, and also of advocates and judiciary handling food quality disputes in India and elsewhere. It is an invaluable addition to the literature available in the area of food research and analysis.

The text has been divided into seven chapters, viz; Butter and ghee and other milk products; Vegetable oils, natural essential oils; Spices and condiments, cereals, meat extracts; Honey; Jams, jellies, marmalades, fruits and preservatives; Beverages, powders; and Colouring matter, aflatoxins and pesticide residues in foods.

The author is at present Chief Chemist of the Agmark Laboratories of the Government of India. He has been actively engaged in the analysis and inspection of foods since 1954 and his long experience is amply reflected in the handbook. He has two other books to his credit; *Spices in Indian Life* and *Milk Nutrients,* as well as several published papers and articles.

The cost of the book, however, is exorbitant, which puts it out of reach of individuals and small laboratories. There is also scope for substantial improvement in the quality of the production.

Thankamma Jacob

MINDSWAP *by* Robert Sheckley, *Grafton Books* (Available with: *Rupa & Co.,* 3831, Pataudi House Road, Daryaganj, New Delhi-110002) Pp. 191, £1.95

THE Science Fiction (SF) under review centres round Marvin Flynn who has an intense desire to become an extraterrestrial. On seeing an advertisement in a local daily he decides to exchange his body with a Martian, Ze Kraggash. Through a process called *"Mindswapping",* Marvin is transported to Mars in the body of Ze Kraggash. Incidentally, Marvin feels cheated and goes to seek the help of detective Undorf. The detective is a strange person who has to his misfortune a disastrous run of 158 unsolved cases!

Meanwhile, Marvin Flynn is forced to take a contract to collect ganzer eggs on Melde II from where he manages to flee to Celsus V. A mysterious sequence of events follows and the detective Undorf ultimately succeeds in tracing the absconding Martian criminal Ze Kraggash. But before Kraggash is captured, it mysteriously disappears to the so-called Twisted World. Finally, Marvin succeeds in recovering his body.

With his powerful imagination and unmatched vocabulary, the author is able to keep readers engrossed and spell bound. But the SF is absolutely devoid of any science. It is full of queer and fanciful ideas. To enjoy the S.F. one must not try to find science in it and must read it with an open mind. Nevertheless, the S.F. is packed with surrealist humour.

P.K. Mukherjee

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