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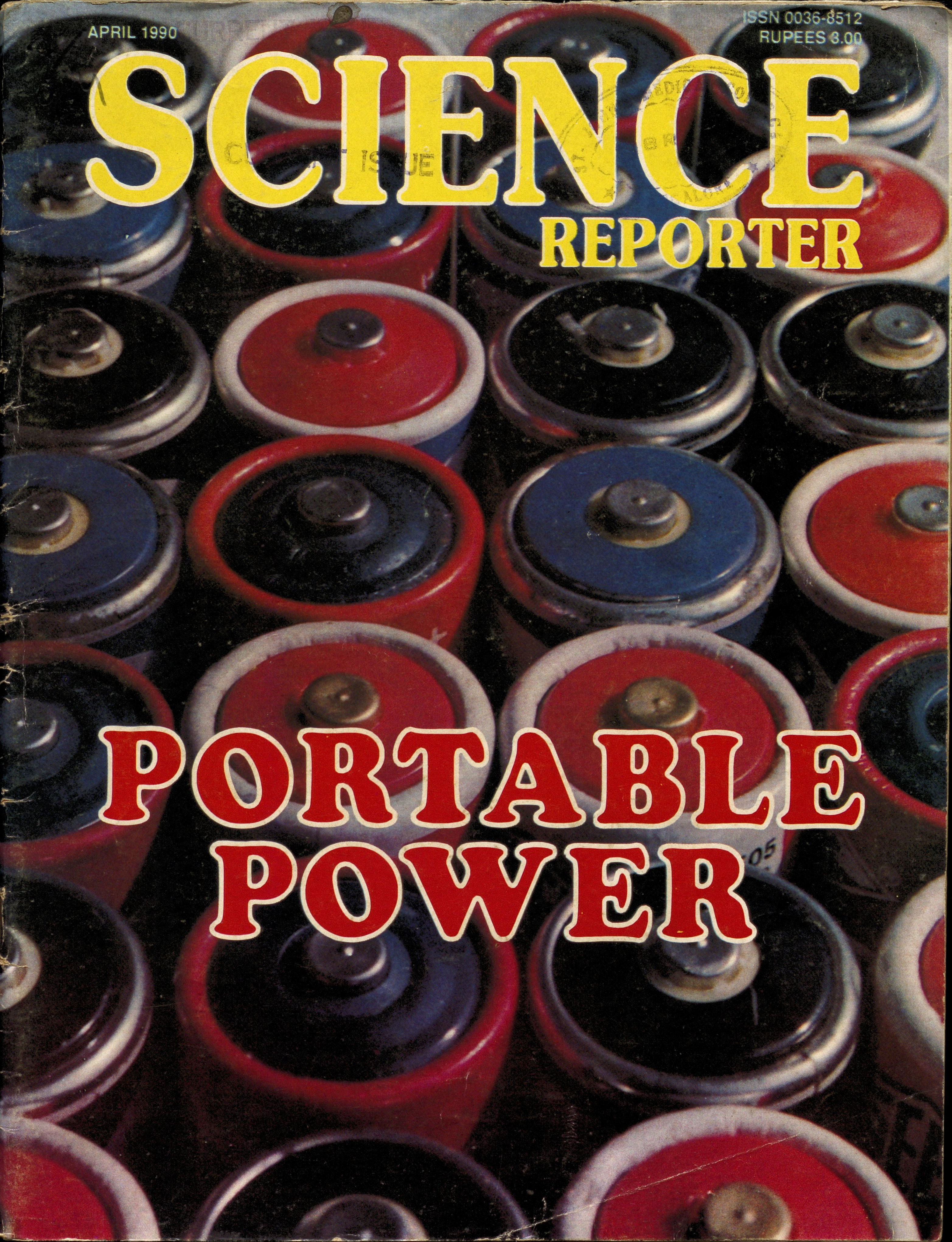

PORTABLE POWER

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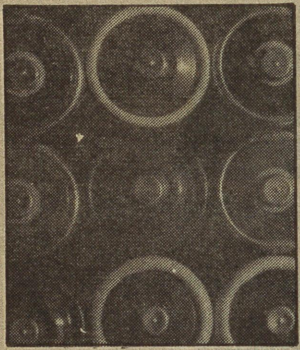
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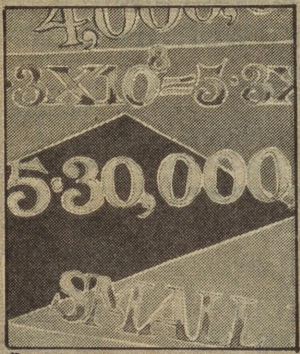

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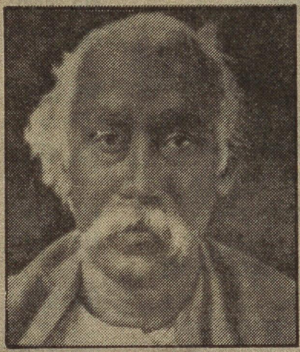
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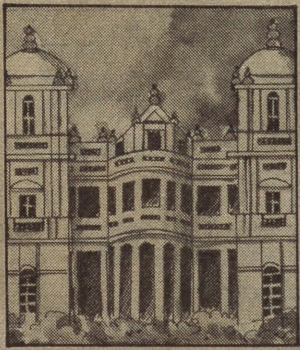
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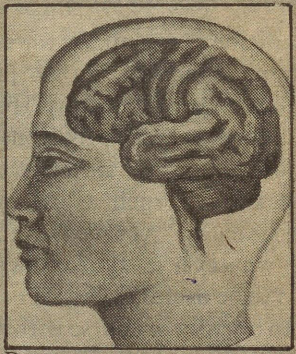
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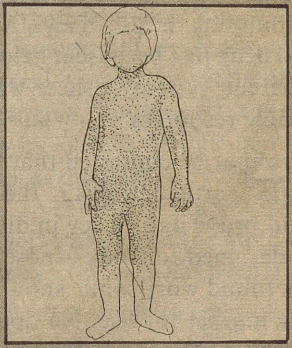
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A Unified System Of Medicine

Sir, The article **An Allovedic drug for Containing Cholesterol** (*S.R.* Feb 1990) was interesting. In this respect, I would like to make some observations regarding the ongoing debate concerning the acceptability of the various systems of medicine.

Today, the allopathic system of medicine is established as the leading system and follows a scientific approach to medical problems. However, all the systems of medicine have their own followers.

Medicine is essentially the science of curing ailments and their prevention to keep people healthy. How can such a concept accept divisions of the methodologies and means into different streams such as Allopathic, Homoeopathic, Ayurvedic, etc.? If a drug, whatever its source may be, is found to be useful, it should be available to doctors of course with proper authentication of its efficacy for use. Classification of a drug into systems and shunning the use of an otherwise useful drug just because it belongs to a different 'system' is sheer waste of available resources.

It cannot be contested that before using a particular drug, the same should prove its efficacy in different tests designed for the purpose. Only if it is found worthwhile should it be in the market for use. No doctor in his right mind would refuse to use a proven drug. However, the problem arises when drugs are used without any rational basis for their use. If a drug is found to be useful in some cases, it should be immediately brought to the notice of the medical community so that proper research could be carried out and full facts about it known. Such a procedure would also prevent fake claims. Also, a hitherto unknown but useful drug would not be missed due to neglect to any system, nor would blind use of any drug be resorted to.

It would be better if the medical world could unite in its approach to drugs and procedures to be used. There should be a single uniform system of medical studies in which all proven techniques of diagnosis and treatment should be taught so that the graduating doctor can use all available methods of treatment. What we need is a comprehensive system which is useful and not one divided into fighting factions.

Amit Chattopadhyay
New Delhi-110027

Chitosan and Chitin

Sir, The write-up **Crab Shells, A Billion Dollar Industry** (*S.R.* February, 1990) does not mention about the work done on chitin and chitosan in India.

Chitin and its derivative chitosan processed from the discarded shells of prawns, lobsters, shrimps and mushrooms, is effective in arresting haemorrhage and speeding up wound healing. It has been cleared for use on humans by the ethical committee of Trivandrum Medical College hospital following spectacular results in a series of animal experiments conducted during the last three years. The experiments have conclusively proved its haemostatic and wound healing properties.

It has also been established that chitin is bio-compatable and there are no adverse side-effects or reactions after its administration.

Following the clearance, chitosan was applied on to two patients who bled profusely after being involved in accidents. Gauze impregnated with chitosan was used as a dressing to cover ulcers which also healed rapidly.

Chitin is a promising product with many important uses: as a sizing agent in textile industry, in the clarification of water and wine, as adhesive and base for chromatography. Experiments conducted at Central Institute of Fisheries Technology (CIFT), Cochin in collaboration with the Textile Research Association (TRA), Bombay have shown that its use imparts stiffness, semi-transperancy, shine and hydrophobicity to fabrics. The chemical nature of chitin and cellulose are basically the same. It can do everything that cellulose can do.

Kerala State Fisheries Cooperative Federation has also set up a pilot plant for the manufacture of chitin and chitosan. The plant has a production capacity of 3000 kg/year and the technology has been supplied by CIFT. The plant is located at the coastal town of Needakara in Quilon district of Kerala.

G.V. Joshi
Yerwada, Pune 411 006

Love For Plants

Sir, Thanks to S.K. Jain for his article **Vanishing Plants** (*S.R.* January, 1990). It was informative, educative and inspirational.

Endangered plants such as Pitcher plant are rarely seen today in Garo Hills and some parts of Khasi Hills. These plants should be protected by all. Unless each and everyone of us takes interest in preserving them, no government will be able to contain their extinction.

Let us hope, publication of such articles will prompt people to understand the wonderful nature of plants and serve as an incentive to take care of them.

Olleyven T. Sangma
Shillong 793 001 (Assam)

Electromagnetic Fluids

Sir, I am a regular reader of *S.R.* since 1969. I am very much interested in electromagnetic fluids as well as their electrical conductivity. Kindly publish an article on it.

Ratnakar Pal
Berhampur-760 004 (Orissa)

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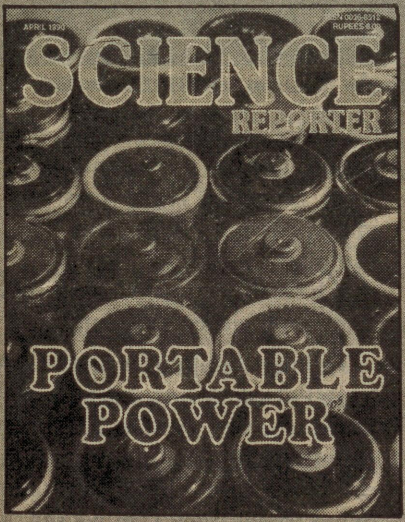

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Man Or Machine?

PUBLIC mistrust of new technology is perhaps as old as technology itself. Way back in the early days of 19th century, the world's first railway system had to face stiff opposition from the British Parliamentarians. The reason: The hon'ble Members of the House of Commons were firm in the belief that trains travelling at more than 19 km/hr would cause mental disorder and would expose passengers to the risk of being suffocated because the mindboggling speed would suck all the air out of their lungs. Needless to say, such fears proved to be no more than figments of a fertilie imagination gone berserk. Even so, it is now a part of recorded history that the inventor George Stephenson had to deliberately lie to a Parliamentary Enquiry Committee to get the project back on the rails.

The apprehension of today's flying public about the safety of the computerized fly-by-wire technology cannot, nonetheless, be ascribed to such weird fantasies; nor are they indications of any phobia. Within two years of its introduction in civil aviation two airbus A-320s equipped with the new technology have crashed under almost identical circumstances. In both cases, while the pilots castigated the new technology, the manufacturers laid the blame squarely at the footsteps of the pilots. In the recent crash at Bangalore, analysis of the digital flight data recorder and cockpit voice recorder data have pointed to the engine mal-functioning as a result of which the ill-fated plane could not develop enough power to keep it from dropping out of its flight path while approaching the runway for landing. It is not known, if it ever will be, why the engine behaved that way—whether it was due to any improper command from the onboard computers or some other inherent defect in the engine itself. So the real issue of the safety of the fly-by-wire technology still remains an enigma. Looking at it purely from the technological angle though, fly-by-wire is neither new nor untried. Modern supersonic jet fighters such as the F-16 use it regularly. If that should be considered irrelevant, F-16 being a military aircraft, the civil aviation industry has not kept itself away from the state-of-the-art technology either. The Anglo-French Concorde has been flying by wire for almost two decades now without a single failure.

Aviation experts have suggested computer bugs as being the culprit. Since the new system is fully computerised with no manual override, any mal-functioning due to software bug could lead to disaster. Unfortunately, as yet there is no way of spotting a bug until it shows up as a mal-functioning programme, and it takes years to produce a totally bug-free, reliable software. In today's industrial rat-race where technologies become obsolete even as they are introduced, that may not be always possible.

The next best alternative, at least in applications where safety of human lives is involved, would be to provide some manual back-up. That would at least give the pilot a chance, however slender, to save his machine and passengers. That brings one back to the age-old conundrum; who should be ultimately in charge : Man or Machine.

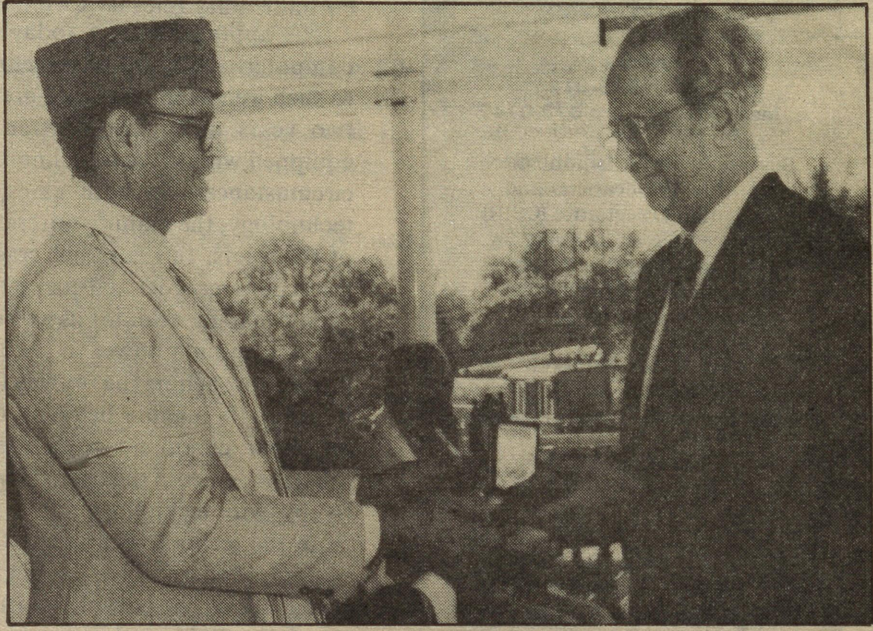
Indian Science Congress—1990

THE city of Cochin on the Malabar coast—known as the Queen of the Arabian Sea—was the venue of this year's Indian ScienceCongress Session, 77th in succession, from 4–9 February 1990. The beauty of this colourful city is enhanced manifold at dusk when one sees from a distance the dim silhouttes of huge merchant ships patiently awaiting their turn for a berth in the docks.

At the Cochin University of Science and Technology, gathered top scientists from all over India in as large a number as 5000 for multidisciplinary week-long deliberations. Established in 1971, the University was recognised and converted in 1986 into a full-fledged Science and Technology University of a unitary type (without any affiliating college) with emphasis on post-graduate studies and research in applied sciences, technology, industry and management. This year's focal theme of the congress was 'Science in Society' and its General President wasProf Yash Pal, Chairman of the University Grants Commission.

The session was inaugrated on 4th February 1990 by the Prime Minister Shri V.P. Singh who called upon the scientific community to develop alternate sources of energy which, while accelerating development, would also ensure the survival of man. Referring to the global warming due to indiscriminate burning of fossil fuels, which could upset climatic conditions in the future, Mr Singh remarked "What is sad today is that inspite of the knowledge that we have, we are confronted with the annihilation of man". Citing an example, he said, there is one soldier for every 250 persons while there is only one doctor for every 3,700 persons. We thus arrange more for death than for life. The Prime Minister was critical of the present educational system as it did not inculcate a spirit of enquiry in the youth which was so necessary for scientific progress. He said, science and society were inseparably linked with each other. Science and society are "parallel mirrors" that reflect each other. One of the advantages brought by scientific and technological progress was the "extension of the physical power of the human body". The mike is an extension of the human tongue, the radio, an extension of the ear, and the missile, an extension of the hand. While technology has enabled man to hear the voice half the world across, we have little time to hear the voice within ourselves. "Let us therefore devote our attention to nature's one masterpiece, that is man", the Prime Minister admonished.

Delivering the Presidential address Prof Yash Pal laid emphasis on being innovative in science and technology. For that purpose, he said, one must create some new products, goods and services which are better than or at least equal in quality to those which anybody else can produce. One cannot have a scientific and technological world or technological society which is dependent for everything it uses on innovations from abroad. Such a society may appear to be a very glittering one for a while, but it cannot be non-aligned or self-reliant and the glitter will not last. True development lies in the character of the processes which are operative in society and an important aspect of these processes is the existence of innovations. "Are the people equipped and trained enough and do they have the right kind of attitude to think on their feet?" he enquired.



The Prime Minister presenting the S. Ramanujan Award to Prof. B.V. Sreekanthan

Talking about ethics and law Prof Yash Pal asked, how can an industrialised country, where 20% of the people use 80% of the natural resources of the planet, be forced to start living frugal lives. Can we say "you shall not put 5 tonnes of carbon per person in the atmosphere". No, we cannot. So we need to create new laws and any new law which is created, of course, must have a relationship with a new ethic. Criticising the shifting away from the process patent system the country now used, Prof Yash Pal said, India and other developing countries had only a small fraction of the world patents now. Accepting product patenting would essentially mean that from now on any new products which one wants to produce in a country must necessarily be exactly those which have been invented outside and belong to outsiders. This would make nonsense of encouraging science and technology and innovation within the country. He also decried the tendency to go in for tie-ups with foreign collaborators enticed by the loan offered by them. This enables industrialists and middlemen to make easy money, but kills the spirit necessary to make science and technology of one's own, he said.

Delivering a talk on "Our planet in the universe", Dr Ponnamperuma, a noted exobiologist, expressed his optimism regarding the possibility of the existence of extra-terrestrial intelligence. The total number of stars in the universe is approximately 10^{23} and it is expected that there would be billions of stars having planetary systems like our sun. It is not unlikely that there are millions of planets having suitable atmospheric and chemical conditions for giving rise to and sustaining life form. Dr Ponnamperuma said that the survey of physical parameters of Mars had shown that though they are rigorous for the survival of higher organisms, some microorganisms could easily survive. Life on earth was not a unique phenomenon; nor has it happened by chance. "Life is an evitable consequence of the evolution of matter", he added.

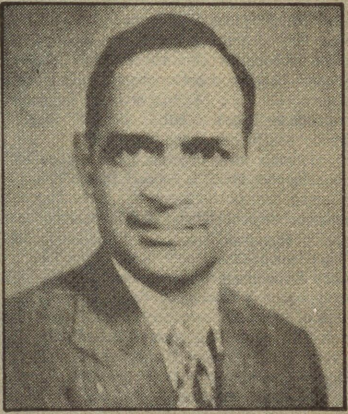
Speaking on the subject "Mobilising and challenging young scientists for extra-ordinary accomplishment", Dr A.P.J. Abdul Kalam said that India will have to break out of the "fifth country syndrome" in aerospace and come into its own. When the SLV-3 was launched, India was said to have been the fifth country to have developed the capability. When Prithvi was launched, India was still said to be fifth to have done so. After Agni was successfully launched, it was again said to have been the fifth. The hyperplane proposed by Indian scientists would help take the country to the fore—he believed. The crux of the space effort was to increase the payload which could be put into the orbit. The European HOTOL (horizontal take off and landing) project would try to put 5 per cent of the launch weight into orbit, and the American NASP aimed at 10 per cent. The proposed Indian hyperplane, which was only a concept at the moment, was intended to place half its launch weight into orbit. The hyperplane's system would collect and liquefy oxygen as it flew. This liquid oxygen along with the liquid hydrogen carried on board would propel the craft.

Dr J.C. Krupa, a nuclear physicist at the University of Paris and a visiting professor at the Bhabha Atomic Research Centre, Bombay, in a press conference said that cold fusion is perhaps possible in laboratory experiment, but the industry and other bulk consumers cannot be supplied with huge quantities of energy generated from this process. It remains to be seen whether the balance in energy, in connection with the amount of energy put in to generate the fusion and the amount of energy that one would get, can be achieved. French experiments in the field have not yielded neutrons or tritium which triggers off this process, he said. The detection of helium on the Moon will open up new vistas in nuclear power generation, since helium is non-radioactive.

C.B. Sharma

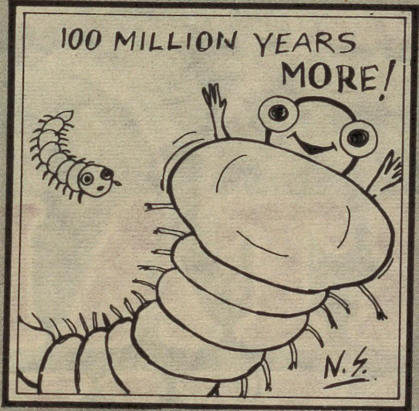
Prof. M.M. Sharma is FRS

Prof. M.M. Sharma, President of the Indian National Science Academy has been elected Fellow of Royal Society, London. A Ph.D. from Cambridge (1964) and winner of several distinctions and honours, Prof. Sharma is currently Professor of Chemical Engineering in the department of Chemical Technology, University of Bombay. He is the first chemical engineer to be appointed a UGC National Lecturer in Engineering and Technology. He is also a recipient of the Shanti Swarup Bhatnagar Prize for Engineering and Technology of CSIR (1973), the FICCI Award (1981), and the Vishwakarma Medal of INSA (1985). Prof. Sharma's significant research contributions are in the area of gas-liquid, liquid-liquid, and gas-liquid-solid reactions; fast liquid-liquid reactions; and recovery of chemicals from liquid waste streams.



Age Of Centipedes Pushed Back By 100 m.y.

THE ancestry of centipedes, millipedes and other insects has been pushed back by 100 million years by Richard A. Robinson's discovery of a fossil in Millard County, USA. This fossil, estimated to be about 500 million years old, updates the earlier estimate of 400 million years in the evolution of animals with jointed legs (Arthropods). This animal has been named *Cambropodus gracilis* refering to the Cambrian age, arthropodan affinity and its long slender legs.



The fossil shows that this 2-cm long, animal had about 15 pairs of legs. Of these, the last nine pairs are not as well formed as the pairs nearest the head. The legs were designed for short quick movements. The fossil, formed in limestone, also exposes a part of the internal anatomy of the pre-historic animal (*Nature,* **343** p. 163 (1990).

K.P. Madhu

How Did Our Oceans Form?

ONE of the main theories of the evolution of oceans on earth suggests that nearly half of our ocean mass was formed when the earth was subjected to a heavy bombardment of comets and asteroids some 4.5 to 3.5 billion years ago.

A major objection to this hypothesis is that large impacts can erode as much of the atmospheric gases as they deliver. Now, Christopher F. Chyba of Cornell University presents arguments to show that it is indeed possible for the earth to have oceans and for Mars, Venus and the Moon to be without much water with the same mechanism of cometary and asteroid impacts (*Nature,* **343** p. 131-133 (1990).

Comets have 50% water ice. Among asteroids, a water content of 10.20% is not uncommon. Indeed, at the time of planetary formation, most asteroids were of the water-containing type. If the impact velocities are high and the air mass above the planet is small, then the impact causes erosion. Otherwise, the water is captured and a bit of the planetary volatiles (like nitrogen, carbon dioxide, noble gases) are removed. removed.

Fortunately for us on earth, the latter is what seems to have happened.

K.P. Madhu

Compounds Toxic To Some Tumours

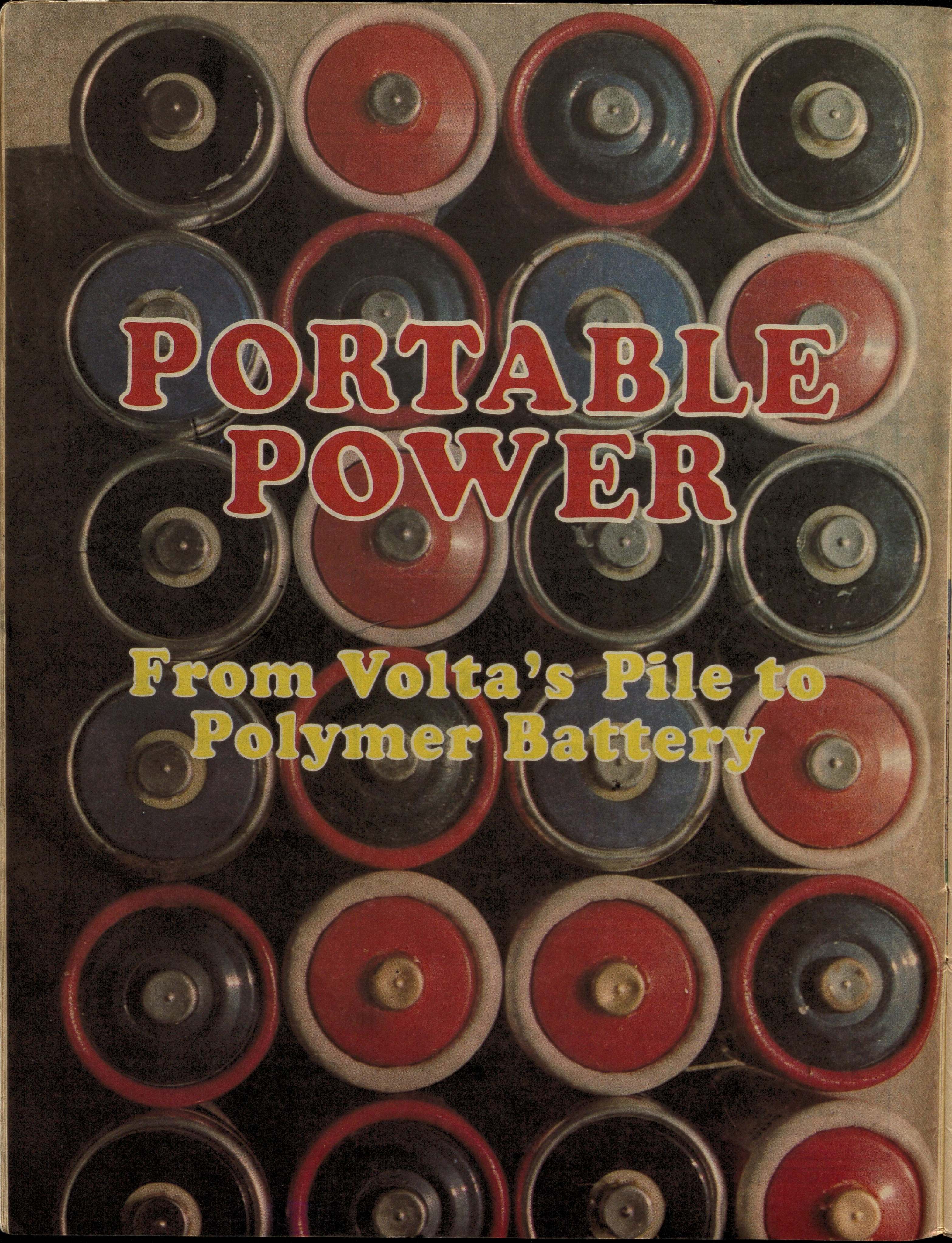
RESEARCHERS at the University of Queensland have isolated new classes of biological compounds from two species of ascidians, or sea squirts, with considerable potential in treating some cancers. They have isolated a large molecule, called polyether macrolyde, which stop human leukemia cells from dividing and change them into non-cancerous cells.

In another set of experiments, Prof. Cliff Hawkins and Prof. Martin Lavin, of Queensland Institute of Medical Research, have isolated from an ascidian a new type of protein called "ferreascidin", a highly aromatic, iron-binding protein with commercial potential as a dental adhesive and as an under water glue.

Hasan Jawaid Khan

PORTABLE POWER

From Volta's Pile to Polymer Battery



New innovations in battery technology have revolutionised the concept of portable electricity. In this article *AKHEEL AHMED SYED* traces the developments from Volta's pile to the polymer battery

The first Volta's pile

THE demand for portable electricity has increased immensely during last few decades. The growing popularity of portable electrical products—from digital watches to audio and video recorders to cordless power drills—as well as the increasingly specialized needs of the semiconductor industry, the military, and the world's energy suppliers have made the battery the object of fierce competition among manufacturers and a topic of serious research. Today smaller, lighter, more powerful, and cheaper batteries, some based on entirely new chemical systems, are being developed for applications that did not even exist a decade ago. Polymer batteries promise structural changes in major industries such as transportation and power, with concomitant improvement in air quality and environmental pollution.

Alessandro Volta, Professor of Physics, at Pavia University, Italy was the first to present the modern world with an electrochemical battery in 1800. The battery named after him—Volta's Pile—was a pile of discs alternately made of copper and zinc interleaved with a separator soaked in an electrolyte. Volta later improved the system with a multicell battery and called it 'Couronne de tasses'. Since then, several other electrochemical phenomena have been discovered and concepts developed for generation of electricity.

Button cells come in various sizes

Reports of the usage of batteries by early civilizations have been proposed by archaelogists. Mysterious earthenware vessels have been found in Mesopotamian sites which might have been electrochemical power sources. These vessels have a copper tube along with a central iron rod, the latter being cemented in position with asphalt (a black semi-solid mainly consisting of complex hydrocarbons). An electrolyte such as an organic acid would certainly convert that vessel into a battery.

The use of batteries as portable electrical power source has increased tremendously in recent years. To some extent technology has not been able to keep pace with the demands for such power sources. Electric vehicles demand longer lifetime and higher volumetric energy densities. Computers and other electrical and electronic gadgets demand higher

Breakthrough in Rechargeable Batteries

A radically new generation of all solid state rechargeable batteries has been developed by scientists at the Lawrence Berkeley Laboratory in California, USA. The new batteries can provide more power, store more energy and have longer shelf life than any commercial battery available now or known to be under development.

Beyond energy and endurance advantages, the new light weight batteries promise to be cheaper than current state of the art batteries as they use less expensive materials. Also, existing industrial processes can be used in their manufacture, easing the passage from the laboratory to the consumer.

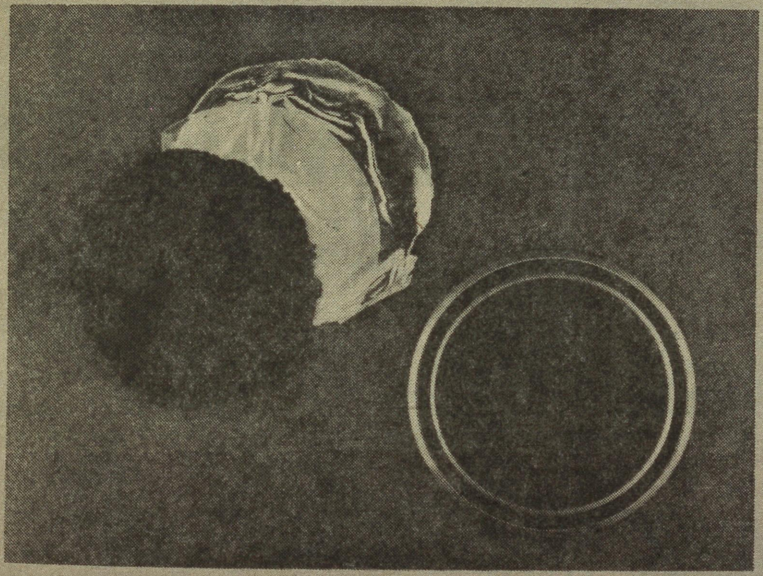
Invented by materials scientists Steven Visco and Lutgard De Jonghe with the assistance of graduate student Meilin Liu and visiting scientist Michel B Armond of France, the new battery can be made for all types of uses, from the sustained low power demands of a watch to the high power demands of electrically driven motor cars.

The heart of the new batteries is the radically new positive electrode, called the 'solid redox polymerization electrode' (SRPE). This novel class of solid state organic polymer electrode, developed at the Lawrence Berkeley Laboratory, not only operates on an entirely new principle of energy storage, but has demonstrated performances far exceeding those for intercalation and conductive polymer electrodes used currently in solid state lithium and sodium batteries.

Dr. Visco and colleagues found that the polymerization of organic polydisulphides is completely reversible and therefore could be used as positive electrodes in batteries for energy storage. When the disulphide bonds are broken, energy is released in the form of electric current and the polymer is depolymerised into a salt. When the current is reversed—during recharging—the disulphide bonds are formed again. Although the breaking and making of sulphur-sulphur bonds in polysulphides is used for the first time for storing energy in batteries, it is well known in many life forms, especially in folding together of chains of aminoacids into proteins.

Visco's group has tried a number of organic polydisulphide polymers—some linear, some ladder and others crosslinked—based on several monomers, both linear and cyclic. The linear polymers were found to perform better than ladder and cross-linked polymers.

To complete the cell, the Lawrence Berkeley researchers used a metallic electrode such as lithium, and a gel made of solid polyethylene oxide and a metallic salt such as $LiN(SO_2CF_3)_2$ as the electrolyte. Although in principle, a broad spectrum of solid state batteries having various metal anodes can be constructed if the appropriate solid electrolytes are available, the California scientists have so far tested only lithium and sodium anodes.



Solid-State Battery—**Lawrence Berkeley Laboratory's new class of batteries is energized by a three-layered sandwich of materials *(left)*. The dark top layer is a disulfide polymer acting as the positive electrode. The middle layer is the separator, composed of polythylene oxide. The shiny bottom layer is lithium. These materials can be fabricated into coin cells such as the prototype battery at right, or much larger and more powerful battery sizes for varied applications**

The new cells can be likened to a sandwich. They consist of layers of thin films enclosed in an inert battery case. In a coin cell, layers are laid out flat; in a cylindrical cell, they are rolled in 'jelly-roll' fashion.

UNLIKE batteries with an aqueous electrolyte, solid state batteries cannot leak and damage the devices they are powering. Combined with their energy, endurance, and cost advantages, this may make possible new uses for batteries, such as components for computer memory backup.

Coin cells for use in watches, calculators and cameras are likely to be commercially available in early 1992, while cylindrical cells for use in torchlights, power tools and autofocus cameras could be expected to hit the market by late 1993 or early 1994.

Vasco and colleagues have also tested some versions of batteries at 80°C–100°C. These provide substantially more energy and power than the room temperature versions, and could be used to power pollution-free motor cars. For adequate acceleration of an electric car, a battery should have a power-to-weight ratio of 100 watts per kilogram and an energy storage capacity of about 200 watt-hours per kilogram. The new battery meets both these requirements.

What is more, all the new batteries tested retain their staying power, performing like new with virtually no loss of energy even after 100 cycles of discharging and recharging. Some batteries have been put through more than 350 deep cycles!

Development work is continuing in the laboratory and the scientists have received many commercial inquiries already.

Subbiah Arunachalam

safety and shelf life, while space station applications require enormous amounts of power storage capacity in a small volume and weight. The defence industries require extreme battery performance. Many of today's batteries meet these requirements.

A BATTERY is an electrochemical cell which can supply energy at any time one wishes to use it. There are two types of cells, namely, primary cell and secondary cell (electrochemical converters such as fuel cell is beyond the scope of this article). Both convert chemical energy to electrical energy.

In a primary cell, chemical change takes place during energy production and the original chemical state of the cell cannot be brought back by passing electrical energy through the cell from an external source. That is, primary cells cannot be recharged electrically; once discharged, they have no further use. A familiar example is the dry cells used in flashlights. A dry cell consists of a zinc container, the anode, which is filled with a paste of ammonium chloride, zinc chloride, water and an inert filler as asbestos. This medium acts as a salt bridge. The central electrode, the cathode is made of a carbon rod surrounded by a mixture of carbon powder and manganese dioxide, MnO_2. The chemical reactions taking place in this cell depend on the amount of electric current drawn.

A secondary cell may be discharged like a primary cell, but its original chemical state may be brought back by passing through the cell an amount of electricity at least equal to that withdrawn during the discharge period. That is, the chemical reactions occurring in a secondary cell are reversible and the same cell can be used for storing or delivering electrical energy over and over again. Because it stores electrical energy a secondary cell is also known as an accumulator.

The most widely used design of lead-acid accumulator incorporates plates of sponge lead as anode and lead grids filled with lead dioxide as cathode. Dilute sulphuric acid is used as electrolyte and an inert porous insulator as separator between each pair of electrodes. The rectangular plates and separators are immersed in the acid in a suitable container fitted with a closure and terminal posts.

The consistent growth in the battery market throughout the world—by a factor greater than 20 since the end of World War II—is a result of commercial demand arising from new applications and concurrent advances in battery technology. For more than a century commercial battery production has been dominated by two types of battery—the Leclanche or zinc-manganese dioxide primary cell and its variants (which include so-called carbon-zinc and alkaline dry cells), and the lead-acid secondary battery. The popularity of the former is due largely to cheap raw materials and ease of manufacture.

LITHIUM primary batteries have been one of the bright spots of battery development in this century. With the advent of better materials and good understanding of the electrochemistry of lithium in organic electrolytes, a number of successful lithium based primary batteries are now in commercial production.

The first commercial rechargeable lithium battery was a button cell

(continued on page 21)

People's facility with numbers ranges widely which often comes in the way of proper understanding and appreciation of things around them, as *JOHN ALLEN PAULOS* tells us in this delightful piece from his book

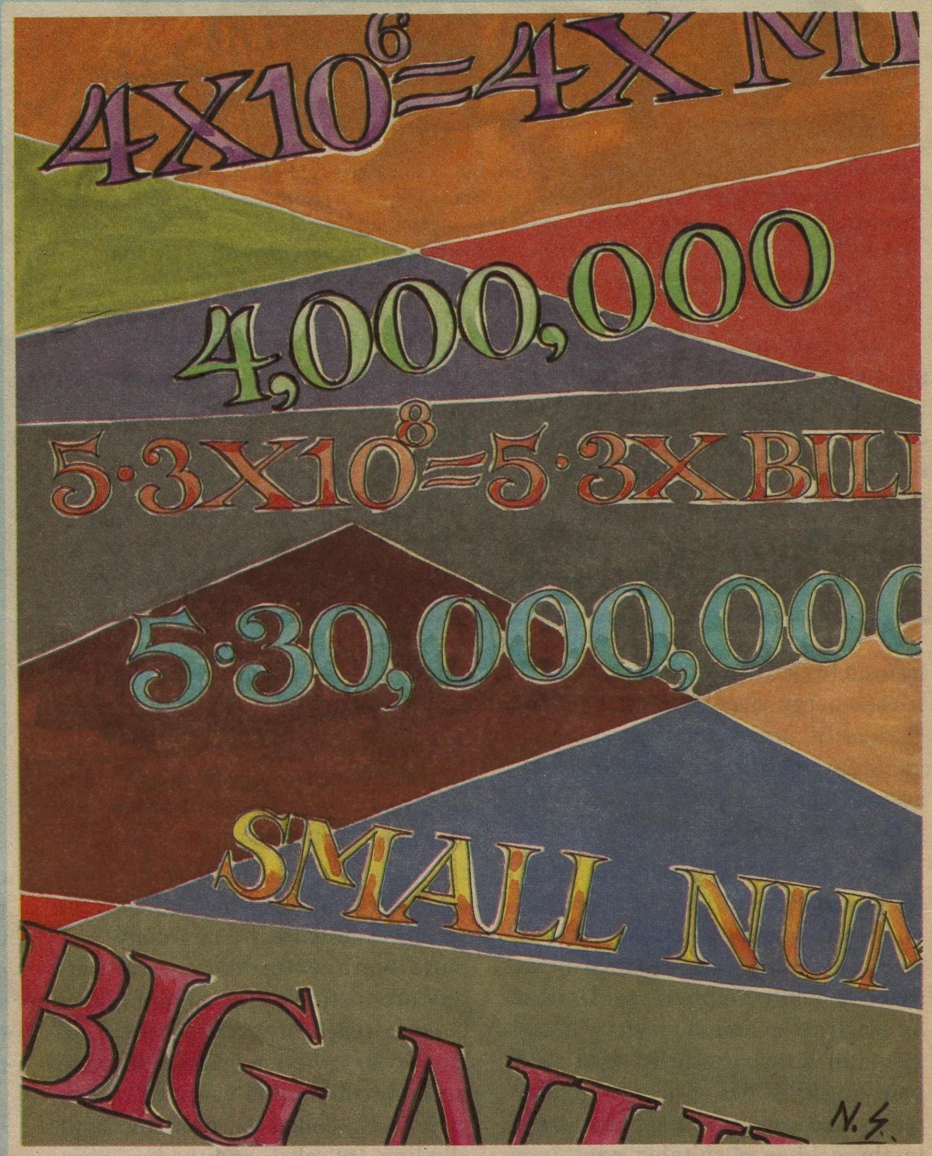
PERILS OF INNUMERACY

JOHN ALLEN PAULOS

TWO aristocrats are out horseback riding and one challenges the other to see which can come up with the larger number. The second agrees to the contest, concentrates for a few minutes, and proudly announces, "Three." The proposer of the game is quiet for half an hour, then finally shrugs and concedes defeat.

A summer visitor enters a hardware store in Maine and buys a large number of expensive items. The skeptical, reticent owner doesn't say a word as he adds the bill on the cash register. When he's finished, he points to the total and watches as the man counts out $1,528.47. He then methodically recounts the money once, twice, three times. The visitor finally asks if he's given him the right amount of money, to which the Mainer grudgingly responds, "Just barely".

The mathematician G.H. Hardy was visiting his protege, the Indian mathematician Ramanujan, in the hospital. To make small talk, he remarked that 1729, the number of the taxi which had brought him was a rather dull number, to which Ramanujan replied immediately, "No Hardy! It is a very interesting number. It is the smallest number expressible as the sum of two cubes in two different ways."



Big Numbers, Small Probabilities

People's facility with numbers ranges from the aristocratic to the Ramanujanian, but it's an unfortunate fact that most are on the aristocrates' side of our old Mainer. I'm always amazed and depressed when I encounter students who have no idea what the population of the United States is, or the approximate distance from coast to coast, or roughly what percentage of the world is Chinese. I sometimes ask them as an exercise to estimate how fast human hair grows in miles per hour, or approximately how many people die on earth each day, or how many cigarettes are smoked annually in this country. Despite some initial reluctance one student maintained that hair just doesn't grow in miles per hour), they often improve their feeling for numbers dramatically.

Without some appreciation of common large numbers, it's impossible to react with the proper skepticism to terrifying reports that more than a million American kids are kidnapped each year, or with the proper sobriety to a warhead carrying a megaton of explosive power—the equivalent of a million tons (or two billion pounds) of TNT.

And if you don't have some feeling for probabilities, automobile accidents might seem a relatively minor problem of local travel, whereas being killed by terrorists might seem to be a major risk when going overseas. As often observed, however, the 45,000 people killed annually on American roads are approximately equal in number to all American dead in the Vietnam War. On the other hand, the seventeen Americans killed by terrorists in 1985 were among the 28 million of us who travelled abroad that year—that's one chance in 1.6 million of becoming a victim. Compare that with these annual rates in the United States: one chance in 68,000 of choking to death; one chance in 75,000 of dying in a bicycle crash; one chance in 20,000 of drowning; and one chance in only 5,300 of dying in a car crash.

CONFRONTED with these large numbers and with the correspondingly small probabilities associated with them, the innumerate will inevitably respond with the non sequitur, "Yes, but what if you're that one," and then nod knowingly, as if they've demolished your argument the their penetrating insight. This tendency to personalize is, as we'll see, a characteristic of many people who suffer from innumeracy. Equally typical is a tendency to equate the risk from some obscure and exotic malady with the chances of suffering from heart and circulatory disease, from which about 12,000 Americans die each week.

There's a joke I like that's marginally relevant. An old married couple in their nineties contact a divorce lawyer, who pleads with them to stay together. "Why get divorced now after seventy years of marriage? Why not last it out? Why now?" The little old lady finally pipes up in a creaky voice: "We wanted to wait until the children were dead."

A feeling for what quantities or time spans are appropriate in various contexts is essential to getting the joke. Slipping between millions and billions or between billions and trillions should in this sense be equally funny, but it isn't, because we too often lack an intuitive feeling for these numbers. Many educated people have little grasp for these numbers and are even unaware that a million is 1,000,000; a billion is 1,000,000,000; and a trillion, 1,000,000,000,000.

A recent study by Drs. Kronlund and Phillips of the University of Washington showed that most doctor's assessments of the risks of various operations, procedures, and medications (even in their own specialities) were way off the mark, often by several orders of magnitude. I once had a conversation with a doctor who, within approximately twenty minutes, stated that a certain procedure he was contemplating (a) had a one-chance-in-a-million risk associated with it; (b) was 99 percent safe; and (c) usually went quite well. Given the fact that so many doctors seem to believe that there must be at least eleven people in the waiting room if they're to avoid being idle, I'm not surprised at this new evidence of their innumeracy.

For very big or very small numbers, so-called scientific notation is often clearer and easier to work with than standard notation and I'll therefore sometimes use it. There's nothing very tricky about it: 10^N is 1 with N zeroes following it, so 10^4 is 10,000 and 10^9 is a billion. 10^{-N} is 1 divided by 10^N, so 10^{-4} is 1 divided by 10,000 or .0001, and 10^{-2} is one hundredth. 4×10^6 is $4 \times 1,000,000$ or 4,000,000; 5.3×10^8 is $5.3 \times 100,000,000$ or 530,000,000; 2×10^{-3} is $2 \times 1/1,000$ or .002; 3.4×10^{-7} is $3.4 \times 1/10,000,000$ or .00000034.

Why don't news magazines and newspapers make appropriate use of scientific notation in their stories? The notation is not nearly as arcane as many of the topics discussed in these media, and it's considerably more useful than the abortive switch to the metric system about which so many boring articles were written. The expression 7.39842×10^{10} is more comprehensible and legible than seventy-three billion nine hundred and eighty-four million and two hundred thousand.

Expressed in scientific notation, the answers to the questions posed earlier are: human hair grows at a rate of roughly 10^{-8} miles per hour; approximately 2.5×10^5 people die each day on earth; and approximately 5×10^{11} cigarettes are smoked each year in the United States. Standard notation for these numbers is: .00000001 miles per hour; about 250,000 people; approximately 500,000,000,000 cigarettes.

Blood, Mountains, and Burgers

In a *Scientific American* column on innumeracy, the computer scientist Douglas Hofstadter cites the case of the Ideal Toy Company, which stated on the package of the original Rubik cube that there were more than three billion possible states the cube could attain. Calculations show that there are more than 4×10^{19} possible states, 4 with 19 zeroes after it. What the package says isn't wrong; there are more than three billion possible states. The understatement, however, is symptomatic of a pervasive innumeracy which ill suits a technologically based society. It's analogous to a sign at the entrance to the Lincoln Tunnel stating: New York, population more than 6; or McDonald's proudly announcing that they've sold more than 120 hamburgers.

The number 4×10^{19} is not exactly commonplace, but numbers like ten thousand, one million, and a trillion are. Examples of collections each having a million elements, a billion elements, and so on, should be at hand for quick comparison. For example, knowing that it takes only about eleven and a half days for a million seconds to tick away, whereas almost thirty-two years are required for a billion seconds to pass, gives one a better grasp of the relative magnitudes of these two common numbers. What about trillions? Modern Homo sapiens is probably less than 10 trillion seconds old; and the subsequent complete disappearance of the Neanderthal version of early Homo sapiens occurred only a trillion or so seconds ago. Agriculture's been here for approximately

300 billion seconds (ten thousand years), writing for about 150 billion seconds, and rock music has been around for only about one billion seconds.

More common sources of such large numbers are the trillion dollar federal budget and our burgeoning weapons stockpiles. Given a U.S. population of about 250 million people, every billion dollars in the federal budget translates into $4 for every American. Thus, an annual Defense Department budget of almost a third of a trillion dollars amounts to approximately $5,000 per year for a family of four. What have all these expenditures (ours and theirs) brought over the years? The TNT equivalent of all the nuclear weapons in the world amounts to 25,000 megatons, or 50 trillion pounds, or 10,000 pounds for every man, woman, and child or earth. (One pound in a car, incidentally, demolishes the car and kills everyone in it.) The nuclear weapons on board just one of our Trident submarines contain eight times the firepower expended in all of World War II.

To cite some happier illustrations for smaller numbers, the standard I use for the lowly thousand is a section of Veterans Stadium in Philadelphia which I know contains 1,008 seats and which is easy to picture. The north wall of a garage near my house contains almost exactly ten thousand narrow bricks. For one hundred thousand. I generally think of the number of words in a good-sized novel.

To get a handle on big numbers, it's useful to come up with one or two collections such as the above corresponding to each power of ten, up to may be 13 or 14. The more personal you can make these collections, the better. It's also good practice to estimate whatever quantity piques your curiosity: How many pizzas are consumed each year in the United States? How many words have you spoken in your life? How many different people's names appear in *The New York Times* each year? How many watermelons would fit inside the U.S. Capitol building?

Compute roughly how many acts of sexual intercourse occur each day in the world. Does the number vary much from day to day? Estimate the number of potential human beings, given all the human ova and sperm there have ever been, and you find that the ones who make it to actuality are *ipso facto* incredibly, improbably fortunate.

These estimations are generally quite easy and often suggestive. For example, what is the volume of all the human blood in the world? The average adult male has about six quarts of blood, adult women slightly less, children considerably less. Thus, if we estimate that on average each of the approximately 5 billion people in the world has about one gallon of blood, we get about 5 billion (5×10^9) gallons of blood in the world. Since there are about 7.5 gallons per cubic foot, there are approximately 6.7×10^8 cubic feet of blood. The cube root of 6.7×10^8 is 870. Thus, all the blood in the world would fit into a cube 870 feet on a side, less than 1/200th of a cubic mile!

Central Park in New York has an area of 840 acres, or about 1.3 square miles. If walls were built about it, all the blood in the world would cover the park to a depth of something under 20 feet. The Dead Sea on the Israel-Jordan border has an area of 390 square miles. If all the world's blood were put ino the Dead Sea, it would add only three-fourths of an inch to its depth.

SWITCHING dimensions for a moment, consider the ratio of the speed of the supersonic Concorde, which travels about 2,000 miles per hour, to that of a snail, which moves 25 feet per hour, a pace equivalent to about .005 miles per hour. The Concorde's velocity is 400,000 times that of the snail. An even more impressive ratio is that between the speed with which an average computer adds ten-digit numbers and the rate at which human calculators do so. Computers perform this task more than a million times faster than we do with our snail-like scratchings, and for supercomputers the ratio is over a billion to one.

One last earthly calculation that a scientific consultant from M.I.T. uses to weed out prospective employees during job interviews: How long, he asks, would it take dump trucks to cart away an isolated mountain, say Japan's Mount Fuji, to ground level? Assume trucks come every fifteen minutes, twenty-four hours a day, are instantaneously filled with mountain dirt and rock, and leave without getting in each other's way. The answer's a little surprising and will be given later.

A man who travels a lot was concerned about the possibility of a bomb on board his plane. He determined the probability of this, found it to be low but not low enough for him, so, now he always travels with a bomb in his suitcase. He reasons that the probability of two bombs being on board would be infinitesimal

Some Birthday vs. a Particular Birthday

Sigmund Freud once remarked that there was no such thing as a coincidence. Carl Jung talked about the mysteries of synchronicity. People in general prattle ceaselessly about ironies here and ironies there. Whether we call them coincidences, synchronicities, or ironies, however, these occurrences are much more common than most people realize.

Some representative examples: 'Oh, my brother-in-law went to school there, too, and my friend's son cuts the principal's lawn, and my neighbour's daughter knows a girl who once was a cheerleader for the school." — "There've been five instances of the fish idea since this morning when she told me of her fears about his fishing on the open lake. Fish for lunch, the fish motif on Caroline's dress the..."—Christopher Columbus discovered the New World in 1492 and his fellow Italian Enrico Fermi discovered the new world of the atom in 1942.—"You said you wanted to keep up with him, but later you said you wanted to keep abreast of her. It's clear what's on your mind."—The ratio of the height of the Sears Building in Chicago to the height of the Woolworth Building in New York is the same to four significant digits (1.816 vs. 1816) as the ratio of the mass of a proton to the mass of an electron—The Reagan-Gorbachev INF treaty was signed on December 8, 1987, exactly seven years after John Lennon was killed.

A tendency to drastically underestimate the frequency of coincidences is a prime characteristic of innumerates, who generally accord great significance to correspondences of all sorts while attributing too little significance to quite conclusive but less flashy statistical evidence. If they anticipate someone else's thought, or have a dream that seems to come true, or read that, say, President Kennedy's secretary was named Lincoln while President Lincoln secretary was named Kennedy, this is considered proof of some wondrous but mysterious harmony that somehow holds in their personal universe. Few experiences are more dispiriting to me than meeting someone who seems intelligent and open to the worl dbut who immediately inquires abot my zodiac sign and then begins to note characteristics of my personality consistent with that sign (whatever sign I give them).

The surprising likelihood of coincidence is illustrated by the following well-known result in probability. Since a year has 366 days (if you count February 29), there would have to be 367 people gathered together in order for us to be absolutely certain that at least two people in the group have the same birthday. Why?

Now, what if we were content to be just 50 percent certain of this? How many people would there have to be in a group in order for the probability to be half that at least two people in it have the same birthday? An initial guess might be 183, about half of 365. The surprising answer is that there need be only twenty-three. stated differently, fully half of the time that twenty-three randomly selected people are gathered together, two or more of them will share a birthday.

For readers unwilling to accept this on faith, here is a brief derivation. By the multiplication principle, the number of ways in which five dates can be chosen (allowing for repetitions) is $(365 \times 365 \times 365 \times 365 \times 365)$. Of all these 365^5 ways, however, only $(365 \times 364 \times 363 \times 362 \times 361)$ are such that no two of the dates are the same; any of the 365 days can be chosen first, any of the remaining 364 can be chosen second, and so on. Thus, by dividing this latter product $(365 \times 364 \times 363 \times 362 \times 361)$ by 365^5, we get the probability that five people chosen at random will have no birthday in common. Now, if we subtract this probability from 1 (or from 100 percent if we're dealing in percentages), we get the complementary probability that at least two of the five people do have a birthday in common. A similar calculation using 23 rather than 5 yields 1/2, or 50 percent, as the probability that at least two of twenty-three people will have a common birthday.

A couple of years ago, someone on the Johnny Carson show was trying to explain this. Johnny Carson didn't believe it, noted that there were about 120 people in the studio audience, and asked how many of them shared his birthday of, say, March 19. No one did, and the guest, who wasn't a mathematician, said something incomprehensible in his defense. What he should have said is that it takes twenty-three people to be 50 percent certain that there is some birthday in common, not any particular birthday such as March 19. It requires a large number of people, 253 to be exact, to be 50 percent certain that someone in the group has March 19 as his or her birthday.

A brief derivation of the last fact: Since the probability of someone's birthday not being March 19 is 364/365, and since birthdays are independent, the probability of two people not having March 19 as a birthday is $364/365 \times 364/365$. Thus, the probability of N people not having March 19 as a birthday is $(364/365)^N$, which, when N=253, is approximately 1/2. Hence, the complementary probability that at least one of these 253 people was born on March 19 is also 1/2, or 50 percent.

The moral, again, is that some unlikely event is likely to occur, whereas it's much less likely that a particular one will. Martin Gardner, the mathematics writer, illustrates the distinction between general and specific occurrences by means of a spinner with the twenty-six letters of the alphabet on it. If the spinner is spun one hundred times and the letters recorded, the probability that the word CAT or WARM will appear is very small, but the probability of some word's appearing is high. Since I brought up the topic of astrology, Gardner's examples of the first letters of the names of the months and the planets are particularly appropriate. The months—JFMAMJJASOND—give us JASON; the planets—MVEMJSUNP—spell SUN. Significant? No.

Medical quackery and television evangelism will be discussed in the next cahpter, but it should be mentioned here that their predictions are usually sufficiently vague so that the probability of some event of the predicted kind occurring is very high; it's the particular predictions that seldom come true. That some nationally famous politician will undergo a sex-change operation, as a newspaper astrologer-psychic recently predicted, is considerably more likely than that New York's Mayor Koch will.

THE paradoxical conclusion is that it would be very unlikely for unlikely events not to occur. If you don't specify a predicted event precisely, there are an indeterminate number of ways for an event of that general kind to take place

Chance Encounters

Two strangers from opposite sides of the United States sit next to each other on a business trip to Milwaukee and discover that the wife of one of them was in the tennis camp run by an acquaintance of the other's. This sort of coincidence is surprisingly common. If we assume each of the approximately 200 million adults in the United States knows about 1,500 people, and that these 1,500 people are reasonably spread out around the country, then the probability is about one in a hundred that they will have an acquaintance in common, and more than ninety-nine in a hundred that they will be linked by a chain of two intermediates.

We can be almost certain, then, given these assumptions, that two people chosen at random will be linked, as were the strangers on the business trip, by a chain of at most two intermediates. Whether they'll run down the 1,500 or so people they each know (as well as the acquaintances of each of these 1,500) during their conversation and thus become aware of the two intermediates linking them is another, more dubious matter.

These assumptions can be relaxed somewhat. Maybe the average adult knows fewer than 1,500 other adults, or, more likely most of the people he or she does know live close by and are not spread about the country. Even in these cases, however, the probability of two randomly selected people being linked by two intermediates is unexpectedly high.

A more empirical approach to coincidental meetings was taken by psychologist Stanley Milgrim, who gave each member of a randomly selected group of people a document and a (different) "target individual" to whom the document was to be transmitted. The directions were that each person was to send the document to the person he knew who was most likely to know the target individual, and that he was to direct that person to do the same, until the target individual was reached. Milgrim found that the number of intermediate links ranged from two to ten, with five being the most common number. This study is more impressive, even if less spectacular, than the earlier *a priori* probability argument. It goes some way toward explaining how confidential information, rumors, and jokes percolate so rapidly through a population.

If the target is well-known, the number of intermediates is even smaller, especially if you have a link with one or two celebrities. How many intermediates are there between you and President Reagan? Say the number is N. Then the number of intermediates between you and Secretary General Gorbachev is less than or equal to (N + 1), since Reagan has met Gorbachev. How many intermediates between you and Elvis Presley? Again, it can't be bigger than (N + 2), since Reagan's met Nixon, who's met Presley. Most people are surprised when they realize how short the chain is which links them to almost any celebrity.

WHEN I was a freshman in college, I wrote a letter to English philosopher and mathematician Bertrand Russell telling him that he'd been an idol of mine since junior high school and asking him about something he'd written concerning the German philosopher Hegel's theory of logic. Not only did he answer my letter, but he included his response in his autobiography, sandwiched between letters to Nehru, Khrushchev, T.S. Eliot, D.H. Lawrence, Ludwig Wittgenstein, and other luminaries. I like to maintain that the number of intermediates linking me to these historical figures is one: Russell.

Another problem in probability illustrates how common coincidences may be in another context. The problem's often phrased in terms of a large number of men who check their hats at a restaurant, whereupon the attendant promptly scrambles the hat-check numbers randomly. What is the probability that at least one of the men will get his own hat upon leaving? It's natural to think that if the number of men is very large, this probability should be quite small. Surprisingly, about 63 percent of the time, at least one man will get his own hat back.

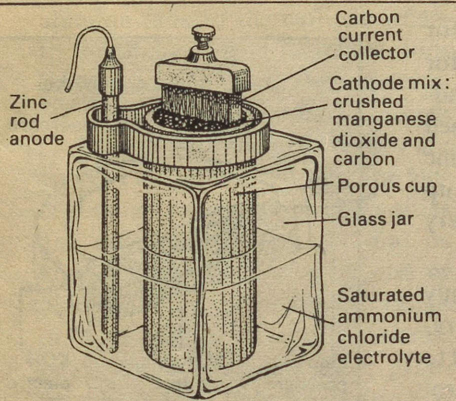
Put another way: If a thousand addressed envelopes and a thousand addressed letters are thoroughly scrambled and one letter is then placed into each envelope, the probability is likewise about 63 percent that at least one letter will find its way into its corresponding envelope. Or take two thoroughly shuffled decks of cards. If cards from each of these decks are turned over one at a time in tandem, what is the probability that at least one exact match will occur? Again, about 63 percent. (Peripheral question: Why is it necessary to shuffle only one of the decks thoroughly?)

A very simple numerical principle that's sometimes of use in accounting for the certainty of a particular kind of coincidence is illustrated by the mailman who has twenty-one letters to distribute among twenty mailboxes. Since 21 is greater than 20, he can be sure, even without looking at the addresses, that at least one mailbox will get more than one letter. This bit of common sense, sometimes termed the pigeonhole or Dirichlet drawer principle, can occasionally be used to derive claims that are not so obvious.

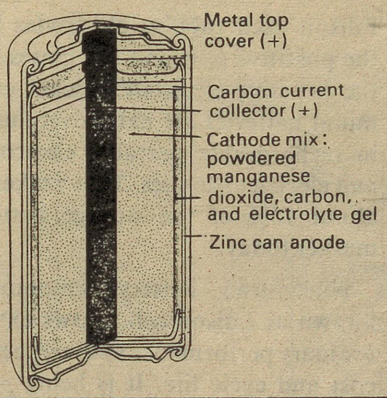
We invoked it in stating that if we had 367 people gathered together, we could be certain that at least two had the same birthday. A more interesting fact is that at least two people living in Philadelphia must have the same number of hairs on their heads. Consider the numbers up to 500,000, a figure that's generally taken to be an upper bound for the number of hairs on any human head, and imagine these numbers to be the labels on half a million mailboxes. Imagine further that each of the 2.2 million Philadelphians is a letter to be delivered to the mailbox whose label corresponds to the number of hairs on his or her head. Thus, if Mayor Wilson Goode has 223.569 hairs on his head, then he is to be delivered to the mailbox with that number.

Since 2,200,000 is considerably more than 500,000, we can be certain that at least two people have the same number of hairs on their heads; i.e., that some mailbox will receive at least two Philadelphians. (Actually, we can be sure that at least five Philadelphians have the same number of hairs on their heads. Why?)

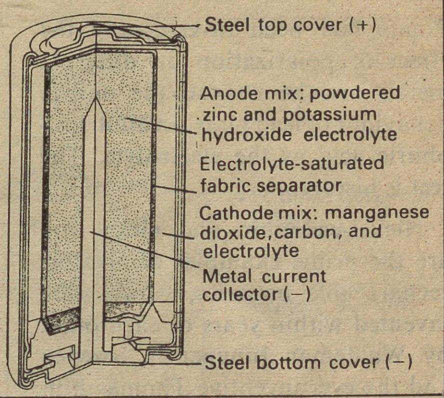
Excerpted from INNUMERACY: Mathematical Illiteracy And Its Consequences by John Allen Paulos published by Penguin Books (1988), £ 3.99. Available from : Penguin Overseas Ltd, 706 Eros Apartment, Nehru Place, N. Delhi-110019
Special Price for India: £ 2.50



Leclanche Wet cell



Carbon–zinc cell



Alkaline cell

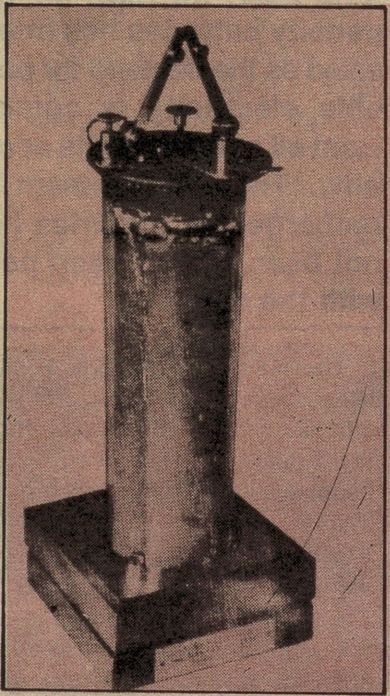
(Continued from page 13)
produced by Exxon in 1979 based on $LiAl/TiS_2$ couple. This product was later discontinued.

Lithium is attractive as a battery anode because of its low density (it is the lightest metal element) and the large chemical energy associated with its oxidation; i.e. the loss of one of its atomic electrons. However, lithium reacts vigorously with water so that lithium cells must use nonaqueous electrolytes.

In the all-solid-state lithium-iodine battery the anode is lithium metal, and the cathode a complex of iodine. The electrolyte is a thin layer of crystalline lithium iodide through which current is carried by the migration of lithium-ion vacancies in the crystal lattice. Solid-state cells of this type are hermetically sealed and may be used over a wide range of operating temperatures, pressures, and accelerations. But the relatively high electrical resistance of the solid electrolyte restricts them to applications in which current drain is low such as a cardiac pacemaker.

Lithium cells based on liquid thionl or sulphuryl chloride, containing lithium aluminium chloride ($LiAlCl_4$) as electrolyte, have among the highest energy densities of any practical battery system. For large, low-discharge-rate cells, values of 500-watt-hours per kilogram or 0.9 watt-hour per cubic centimeter have been achieved. A typical lithium-thionyl chloride battery has a practical energy output 7 times that of a standard carbon-zinc Leclanche cell and 3 times that of an alkaline cell of the same size. A wide range of these primary lithium batteries are manufactured, from miniature button cells to 60,000-watt-hour units used to provide standby power in missile silos.

An increasingly popular variant of the common zinc-carbon cell, the alkaline cell, can operate satisfactorily at higher rates. This cell has an electrolyte based on highly corrosive potassium hydroxide in place of ammonium chloride which necessitates the added expense of a steel case and a well-engineered sealing assembly.


Plante's first storage battery

The alkaline cell uses the carbon-zinc design turned inside out: a core of powdered zinc and alkaline electrolyte separated by fabric from an outer layer of manganese dioxide and electrolyte. Two other aqueous primary systems are also commercially important, the silver (zinc-silver oxide) cell and its closely related precursor, the mercury (zinc-mercuric oxide) cell. Both cells have a high volumetric energy density and electrical characteristics at least as good as lithium cells. Although widely available, mainly as low-drain button cells, the cost of materials is high, making them comparatively expensive.

THE most common electrochemical storage system is the lead-acid battery, which accounts for 90% of the market. About 40% of the world's lead production goes into the manufacture of the lead-acid battery. The earliest reference to this battery dates back to 1854, but the real commercial breakthrough came with Gaston Plante's experiments in 1859

Plante had been investigating the effect of polarization on different metals and he noticed the unique behaviour of lead plates in dilute sulphuric acid as the electrolyte. The rest is history.

Nickel-cadmium and nickel-iron are the prime examples of alkaline rechargeable batteries, which were invented within years of each other by Waldemar Jungner in Sweden and the ever inventive Thomas Edison. Both the inventors laid the foundation of major battery businesses.

In 1896, Jungner had developed pocket electrodes to hold the finely divided electrode powders, while Edison used tubular electrodes for the possitive pole and flat plates for the negative electrode. Nickel-cadmium batteries are extensively used in rechargeable portable electronic and electrical devices. They make up about 10% of the storage battery market today.

Nickel-iron battery, commonly known as Edison cell, shows extraordinary performance with respect to cost and cycle life. It is being projected as the storage battery of the future for low cost storage of solar and wind energy. It is also ideal for electric vehicles. Efforts are on to improve energy density and current efficiencies of these batteries.

Battery Terms

Current density: the current flowing per unit area of a conductor.

Current efficiency: the percentage of current utilised in the process under consideration. For a storage batter it is given by

$$100 \times \frac{\text{Charge delivered during discharge}}{\text{Charge used in charging process}}$$

and expressed as ampere-hour efficiency.

Energy density: the total quantity of energy that can be stored in a battery and withdrawn per unit of weight or volume (Wh/Kg).

Massic capacity : the ratio of the experimental discharge on the weight of active material forming the electrode (thus including the weight of the dopant). Usually employed for polymer batteries.

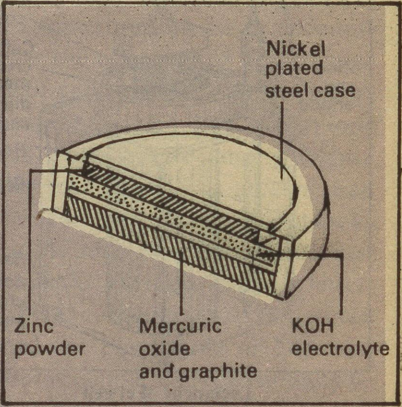
Power density: a measure of the rate at which energy can be withdrawn (W/Kg).

Shelf-life: a cell from which no current is drawn deteriorates during storage. The period beyond which it deteriorates almost completely is known as shelf-life.

THE zinc electrode has been a constant lure for electrochemist over the last 150 years. With its high energy density, low costs and high reactivity, efforts have been continuously made to produce a 'good' rechargeable system based on this electrode.

The need for high energy density batteries has intensified as the demand for portable electricity is coming from all sectors of the economy. The development of rechargeable batteries has not been able to keep pace with the demand

The conceptual design of zinc-bromine battery is about 100 years old, and it has been said that during the Franco-Prussian War, French balloonists used static zinc-bromine batteries to light 'Nernst glowers' which they used to illuminate their maps as they ballooned over the Prussian lines. Then, after a long hiatus, came the energy crisis of the nineteen seventies and the zinc/bromine and other zinc-halogen batteries were rediscovered.

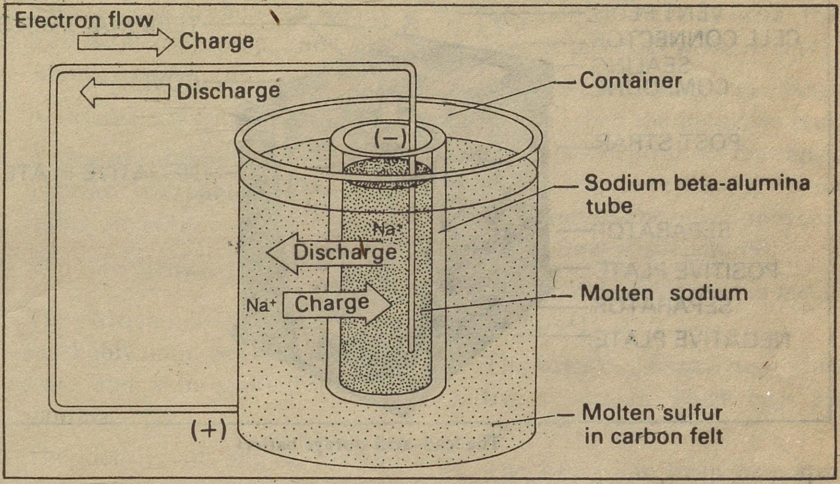


Mercury battery

The nickel-zinc battery, with a theoretical energy density of 375 Wh/kg lured large groups of electrochemists, but much of the development work has been a glorious failure.

The silver-zinc battery was developed about 50 years ago. With an energy density of 150 Wh/kg, this system has possibly the highest energy density of any rechargeable battery employing inorganic materials. Early zinc-silver oxide batteries were used in torpedoes; more recently they powered the Lunar Rovers of the Apollo Moon missions and presently are running payload-handling equipment on the U.S. space shuttle. However, the silver-zinc battery has a serious disadvantage of poor cycle life due to zinc electrode. The high cost of silver electrode is also a limiting factor in its large scale manufacture.

The concept of sodium sulphur system dates back to 1966. This system is 'true high-technology' born out of the modern 'materials age'. The reactants are molten sodium and sulphur, separated by a sodium ion conducting ceramic (beta-alumina) and the battery operates at temperatures of about 350°C. During dischage positively charged sodium ions (Na^+) migrate through the beta-alumina tube to the cathode where they combine with sulphide ions being produced there. During charging sodium ions move back through the tube to the anode where they are reduced to metallic sodium. The battery shows excellent power densities and good energy densities. But its high operating temperature, use of molten sodium and complex design presents some safety problems. Attempts to overcome these problems have been only partly successful.



The rechargeable Sodium–Sulphur, or beta battery

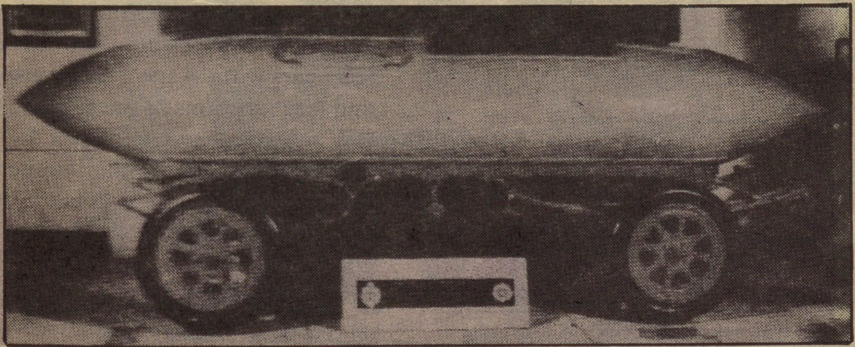
BATTERIES with conductive polymer electrodes hold the promise of being the most exciting development in the energy storage world. The unique feature of polymer electrodes is that they undergo reversible electrochemical oxidation or reduction which is identical to charging and discharging reaction of a conventional storage cell. This forms the basis for the storage of electrical energy in rechargeable (polymer) batteries.

The electrical conductivity of a polymer is increased by treatment with ionizing agents. This is similar to "doping" used in semiconductor technology where minute amounts of elements such as arsenic, boron and phosphorous called 'dopants' are added to silicon. Depending on the nature of the dopants, conducting polymers are classified into p-type and n-type conductors. They are characterized by the migration of anionic and cationic dopants into the polymer.

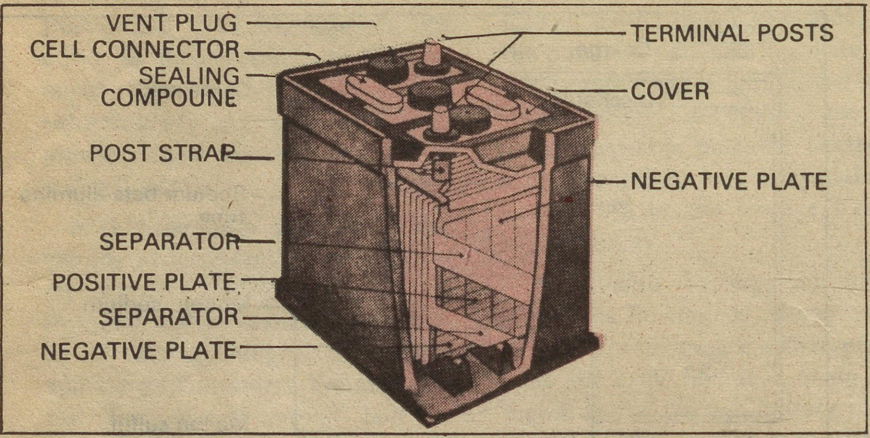
Batteries with conducting polymers as electrode materials show high open circuit voltage, as high as 4 volts or approximately twice the voltage of the well-known lead-acid battery. The energy density on a weight basis is potentially three times larger than that of lead-acid battery with a comparable energy density on a volume basis. An important advantage of the conductive polymer battery is the exceptionally high power density, a key factor in applications such as automotive starting. There are many workable combinations of conducting polymers as battery material; polymer-polymer, polymer-metal, as well as combinations of these electrodes with conventional electrodes. Each combination has particular advantages and characteristics.

The versatility of the conductive polymer battery makes it unique. The conductive polymer acts as both the electrochemically active material and the current collector. The polymer is, in fact, a high surface area "micro-grid" which results in very efficient current collection. Since only the insoluble polymer is oxidized or reduced during charge and discharge, and because ions from the electrolyte merely move in and out without changing their chemical state, the structural integrity of the electrode is maintained, which would mean longer life for the battery. In brief, the concept of conductive polymer battery is a novel idea. Exclusive study on the conducting polymer batteries has demonstrated their usefulness.

Polymer-Polymer battery: If appropriate energy densities and recyclability is desired, a most attractive rechargeable battery will be one in which both anode and cathode are fabricated from conductive polymer. This is the concept of an "all polymer battery" which may be materialised using poly-para-phenylene (PPP) or polyacetylene (PA). These are potentially inexpensive powdery material



The first battery powered car (France, 1899) which could run at 105 km/h



The lead-acid storage battery

obtained by the polymerization of benzene or acetylene. The polymeric material may be fashioned into rigid electrode plates by compressing the powdered polymer.

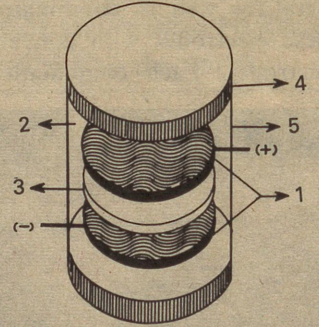
The unique feature of n-doped PPP as anode material is that it discharges at a lower and in a narrow voltage range which makes it particularly attractive as a possible substrate for lithium metal.

Polymer-Metal battery: Most conducting polymers have been examined in conjunction with traditional metals in aqueous and nonaqueous media. Each combination has certain advantages and limitations.

For the last few years intense activity has been generated in the construction of a polyaniline-metal battery. This is because polyaniline has certain advantages over other conducting polymers, such as simplicity and rapidity of the preparation of the polymer by chemical and electrochemical methods and chemical durability against aerial oxidation and moisture. Furthermore, the ability of polyaniline to store considerable charge through the redox process have led to proposals for both aqueous and nonaqueous batteries.

In nonaqueous medium lithium is usually employed as an anode material in rechargeable batteries. But the use of nonaqueous solvent in polyaniline-lithium batteries is beset with a serious problem: on charging, when lithium is plated on the lithium electrodes, dendrites tend to form, particularly at high charging rates. These dendrites can grow to considerable lengths and short-circuit a cell internally. Also, the high cathodic potential of Li/Li^{+} couple often causes decomposition of the solvent, the mechanism of which has not been fully elucidated yet. Nevertheless, mixture of solvents such as propylene carbonate and ethylene carbonate exhibit improvements for current densities in polyaniline lithium cells.

The use of polyaniline as cathode material in conjunction with lithium-doped aluminium as anode material in propylene carbonate containing 1M $LiClO_4$ in the author's laboratory displays an open circuit voltage of 3.7. The large massic capacity of 145 Ah/kg and self discharge (with separator) rate of about 8% after 90 days makes polyaniline-lithium battery more attractive for newer technological applications.



1. CONDUCTING POLYMER ELECTRODES
2. ELECTROLYTE
3. SEPARATOR
4. SEAL
5. GLASS TUBING

Coin type polymer/polymer battery using n-doped and p-doped poly-paraphenylene

In aqueous media polyaniline has been employed in conjunction with zinc or PbO_2 as the counter-electrode. Polyaniline acts as the negative pole when combined with zinc, while it acts as the positive pole when combined with PbO_2. A difficulty with zinc as the counter electrode is spontaneous dissolution in acidic media, while polyaniline is electroactive only in lower pH region. However, some specific advantages are reported over nonaqueous battery. An advantage of using PbO_2 as counter electrode is that any caution for the overcharging becomes unnecessary. In brief, polyaniline is a promising material for both aqueous and nonaqueous storage batteries.

The need for high energy density batteries has intensified as the demand for portable electricity is coming from all sectors of the economy. The development of rechargeable batteries has not been able to keep pace with the demand.

The general progress in rechargeable battery development has been poor during the last 80 years. With the advent of conducting polymers, it will not be surprising if the coming few years witness spectacular growth and large sections of the present battery markets are taken over by the new entrants. Before that happens a lot of research is necessary to improve the processibility and stability of conducting polymers.

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CROSSWORD

Across

3. The extraction of nickel by action of carbon monoxide on the impure metal. (4,7)
8. A basic device used in electronic circuits. (8)
9. The agent which causes vomiting. (6)
10. J. von—, the Bavarian optician, who found dark lines in the solar spectrum. (10)
12. The plant that completes its life-cycle, from seed germination to seed production, followed by death, within a single season. (6)
14. $C_{28}H_{43}OH$ (10)
18. The part of metabolism dealing with the chemical decomposition of complex substances into simple ones, with the release of energy. (10)
20. It forms the front surface of the eye. (6)
21. A hard white metal resembling iron. Its melting point is 2620^{0}C. (10)
25. The African tree having extremely thick stem and large woody fruit with edible pulp, known as 'monkey bread'. (6)
27. A variable electrical resistor. (8)
28. A measure of the extent to which a surface is capable of reflecting radiation. (11)

Down

1. The African animal, with remarkably long neck and forelegs, and skin spotted like a panther's. (7)
2. The density of one weber of magnetic flux per square meter. (5)
3. An elementary particle belonging to the hadron class. (5)
4. The practical unit of elastance. (5)
5. The plant living in waste places near habitations. (7)
6. A regular hexahedron. (4)
7. Various glasses and ceramics consist largely of these compounds. (9)
11. The last letter of the Greek alphabet. (5)
13. The slender piece of metal that fastens pieces of wood, etc. (4)
15. A condition reached in electric circuit when the inductive reactance just neutralizes the capacitance reactance leaving ohmic resistance as the only opposition to the flow of current. (9)
16. The small furnace used in metallurgy. (4)
17. The organ of female reproductive system in which eggs are produced. (5)
18. The fine white linen or cotton fabric of plain weave. (7)
19. An alloy of high magnetic permeability containing mostly of nickel in addition to iron, copper and manganese. (7)
22. The pre-adult form in which some animals hatch from the egg, eg., tadpoles of frogs, caterpillar of butterfly. (5)
23. A thermionic valve containing anode and cathode only. (5)
24. An obsolete name for radon. (5)
26. A staphylococcal infection of the skin which causes inflammation around a hair follicle. (4)

Vijaya Khandurie
23-L, D.I.Z. Area
Shahid Bhagat Singh Marg
New Delhi-110 001

1 C	H	A	2 R	O	3 N	■	4 E	■	5 B	O	6 S	O	7 N	S
Y	■	■	A	■	8 O	K	A	P	I	■	E	■	E	■
9 B	O	N	D	■	B	■	R	■	P	■	10 B	O	H	R
E	■	■	I	■	11 L	I	T	H	O	■	U	■	R	■
12 R	I	13 B	O	14 S	E	■	H	■	15 L	I	M	16 B	U	17 S
N	■	L	■	I	■	■	■	■	A	■	■	R	■	E
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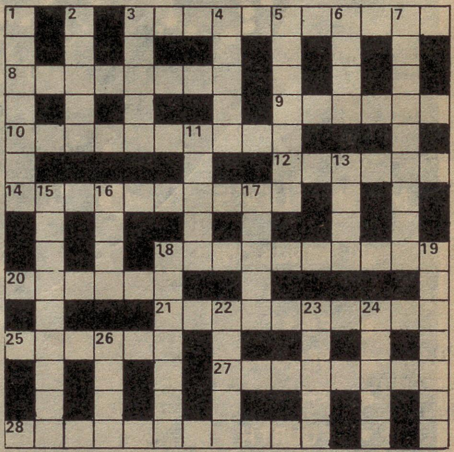
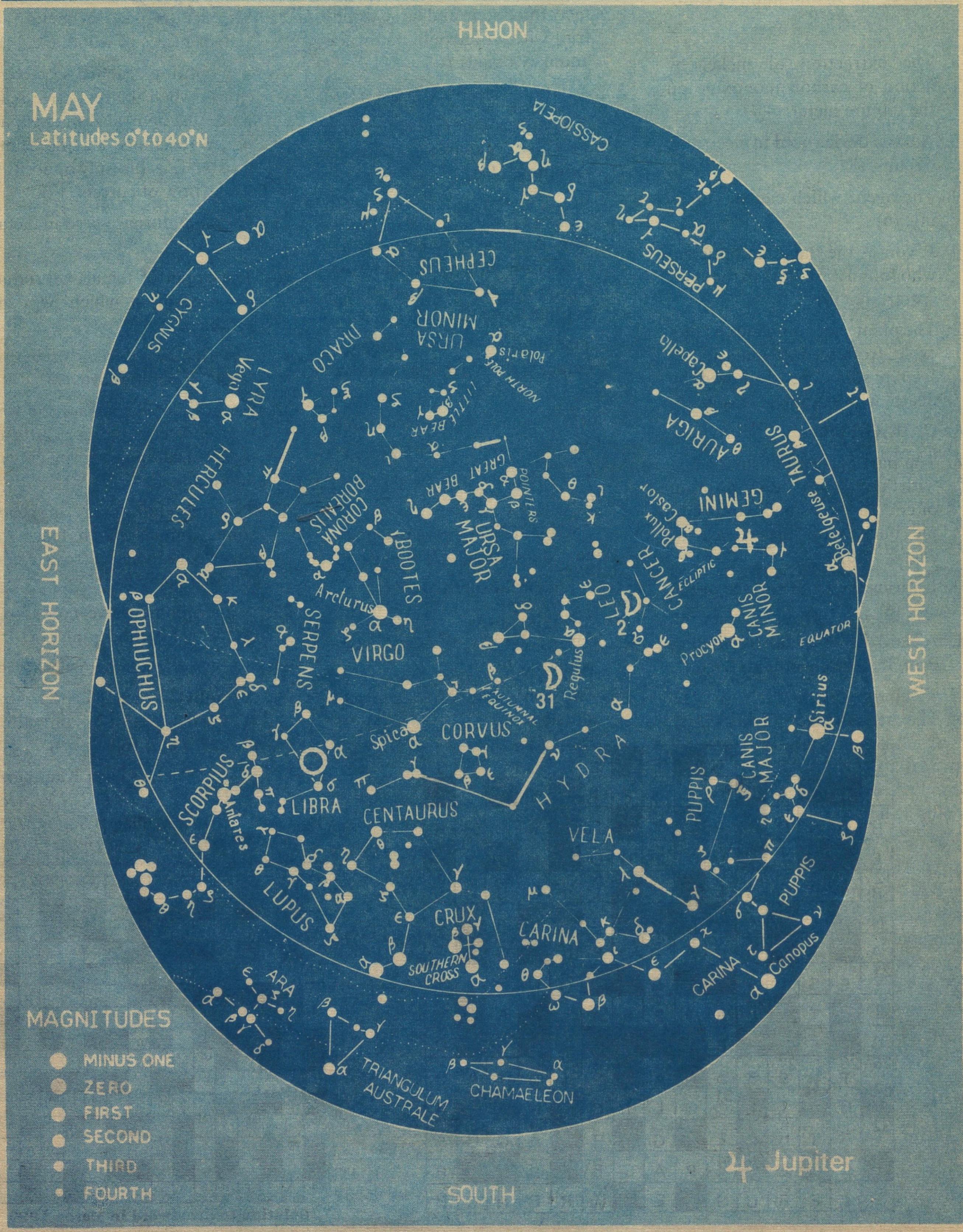
21 T	E	S	L	A	■	■	E	■	■	22 O	N	N	E	S
I	■	T	■	23 L	24 A	T	E	R	A	L	■	C	■	M
C	■	E	■	■	B	■	■	■	■	G	■	H	■	O
25 S	26 T	R	27 E	S	S	■	28 A	■	29 S	I	30 D	I	N	G
■	R	■	T	■	31 C	O	L	I	C	■	N	■	■	R
32 L	A	T	H	■	E	■	G	■	R	■	33 A	Q	U	A
■	C	■	E	■	34 S	P	A	C	E	■	S	■	■	P
35 U	T	E	R	U	S	■	E	■	36 W	R	E	N	C	H



Solution to Crossword in March 1990


NORTH
MAY
Latitudes 0° to 40°N
EAST HORIZON
WEST HORIZON
SOUTH
CASSIOPEIA
CEPHEUS
PERSEUS
CYGNUS
DRACO
URSA MINOR
Polaris
NORTH POLE
LITTLE BEAR
LYRA
Vega
Capella
AURIGA
TAURUS
HERCULES
CORONA BOREALIS
GREAT BEAR
POINTERS
URSA MAJOR
BOOTES
Arcturus
GEMINI
Castor
Pollux
Betelgeuse
CANCER
ECLIPTIC
LEO
Regulus
CANIS MINOR
Procyon
EQUATOR
OPHIUCHUS
SERPENS
VIRGO
AUTUMNAL EQUINOX
31
Spica
CORVUS
HYDRA
Sirius
CANIS MAJOR
PUPPIS
SCORPIUS
Antares
LIBRA
CENTAURUS
VELA
LUPUS
CRUX
SOUTHERN CROSS
CARINA
Canopus
ARA
TRIANGULUM AUSTRALE
CHAMAELEON
MAGNITUDES
MINUS ONE
ZERO
FIRST
SECOND
THIRD
FOURTH
♃ Jupiter

May

THE diagram shows the evening sky as seen from latitudes 0° to 40°N. The inner circle represents the horizon as seen from latitude 22° 30′ N. The chart has been extended on the northern and southern sides for use all over India. Beginners wanting to use the chart should hold it overhead and turn it in such a way that the North, South, East and West marked on the chart point to the correct directions. With some experience it would be possible to use it in a more convenient position. With the help of a few known star groups in the sky the remaining stars can be easily identified using the above chart. From a particular place these stars will be seen at about 2130 hrs., 2030 hrs. and 1930 hrs. of local mean time on 1st, 16th and 30th of the month.

The star chart meant for a particular day for a given hour can be used for the next day 4 minutes earlier and for the previous day 4 minutes later. For example, if a chart is meant for 8-30 pm for 16th May it can be used on 17th at 8-26 pm and on 15th at 8-34 pm. In the same way it can be used for other months; for 16th April it is for 10-30 pm and for 16th June it is for 6-30 pm and so on.

The stars move from east to west in the sky in their daily motion (due to rotation of the earth) at a rate of 15° per hour. The chart can also be used at other hours in the evening after taking into account the above shift in position of the stars.

Planetary Positions for May 1990

Date	*1ST*		*10TH*		*20TH*	
Planets	R.A.	Decln.	R.A.	Decln.	R.A.	Decln.
Mercury	2h 49m	17.6 N	2h 31m	13.6 N	2h 28m	11.2 N
Venus	23h 49m	2.5 S	0h 27m	1.1 N	1h 09m	5.3 N
Mars	22h 39m	10.2 S	23h 05m	7.7 S	23h 32m	4.9 S
Jupiter	6h 30m	23.4 N	6h 37m	23.3 N	6h 45m	23.2 N
Saturn	19h 49m	20.9 S	19h 49m	20.9 S	19h 48m	21.0 S

Adopted from figures supplied by Positional Astronomy Centre, Calcutta

The Moon

FULL moon occurs on 10th at 1-01 a.m. and the new moon occurs on 24th at 5-17 p.m. I.S.T. The moon passes about one and a half degrees south of Saturn on the 15th, five and a half degrees north of Mars on 20th, about seven and a half degrees north of Venus on 22nd, nine degrees north of Mercury on 23rd and about two degrees north of Jupiter on 27th. The moon is at apogee or farthest from the earth on 10th and at perigee or nearest to it on 24th.

The lunar crescent becomes first visible after the new moon day in the evening of 25th.

The Planets

Mercury *(Budha)*, is too near the sun to be visible during the first half of the month being in inferiour conjunction with the sun on 4th. During the second half it is visible in the morning sky rising about an hour before sunrise. It becomes direct on 17th and is in greatest western elongation of about 25° from the sun on 31st. It is in Aries *(Mesa)*. Its visual magnitude varies from +2.4 to +0.6.

Venus *(Sukra)*, visible in the morning sky, rises about two hours before sunrise during the month. It moves from Pisces *(Mina)* to Aries *(Mesa)*. Its visual magnitude is about -4.0.

Mars *(Mangala)*, visible in the morning sky, rises about two hours after local midnight during the first half of the month and about one and a half hours after it during the second half. It moves from Aquarius *(Kumbha)* to Pisces *(Mina)*. Its visual magnitude is about +0.7.

Jupiter *(Brihaspati)*, visible in the evening sky, sets about two hours before local midnight during the first half of the month and about three hours before it during the second half. It is in Gemini *(Mithuna)*. Its visual magnitude is about -1.9.

Saturn *(Sani)*, visible in the morning sky, rises about an hour before local midnight during the first half of the month and about two hours before it during the second half. It becomes retrograde on 5th. It is in Capricorn *(Makara)*. Its visual magnitude is about +0.4.

(*Source:* Positional Astronomy, Centre, India Meteorological Department, New Alipore, Calcutta-700 053)

PREVIEW

MAY 1990

Cover Story: Fractals—The Geometry of Nature

Euclidean geometry could explain various shapes and their inter-relations, but failed to describe the more complex shapes in nature such as a tree, a river or a cloud. Fractals, however, can.

Antarctic Meteorites

The story about thousands of meteorites found in Antarctica which may help reveal the secrets of origin of the solar system.

Weeds Too Are Useful

Much-maligned weeds have multifarious utilities. They are a valuable source of food, pulp, pigment, biogas, iodine, etc.

Also:

The Killing Heat—Summer months are ahead. Equip yourself with the necessary information to beat the heat.

Duck-bill platypus—"In male only, there is a sharp, movable, fang-like grooved spine connected with a poison gland in the thigh, a structure not found in any other animal........". And what further, read yourself.

Your Science Project—Better understanding of an area of science is the least we can gain from doing a science project. Information regarding various projects and how to execute them is provided.

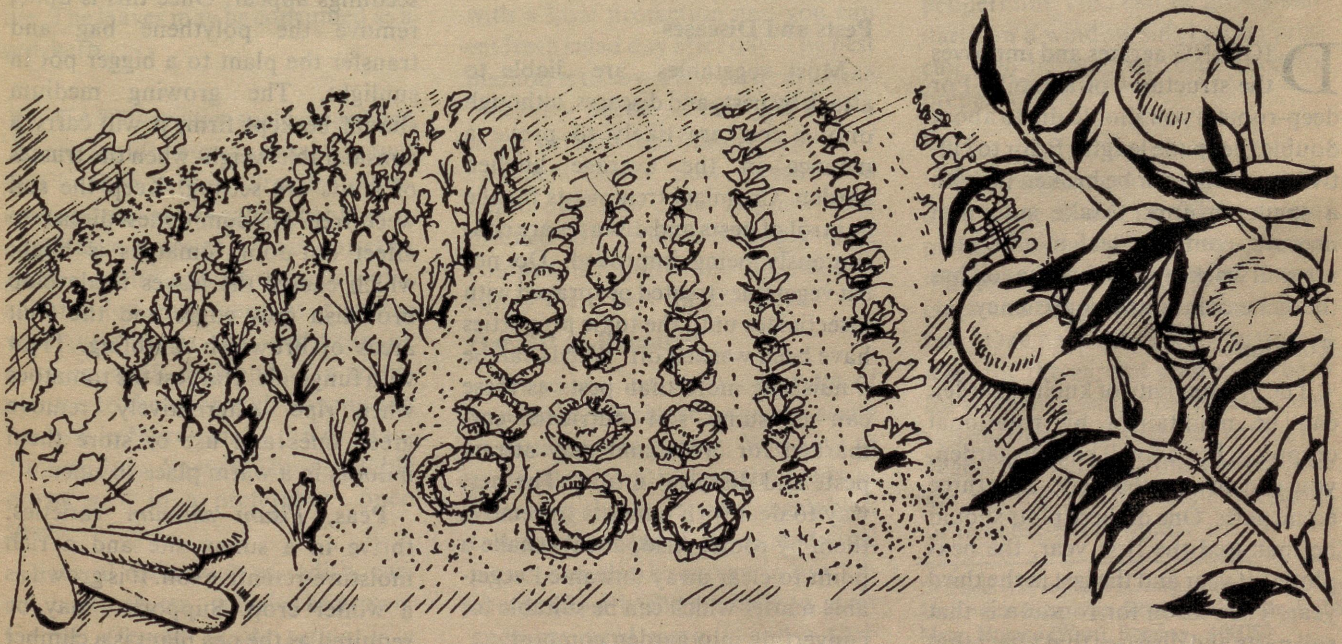
Kitchen Garden

Parul R. Sheth

IF you are not fussy about the types of peas you eat, it may not be worth the effect to grow them when reasonably priced frozen peas are available all the year round. But there are many good reasons why, even in the relatively restricted space available, you can grow your own vegetables, herbs or spices. On the face of it, the price of vegetables in the markets is an obvious reason for growing your own vegetables. Better reasons yet, are quality, freshness and range of choice. Of course, the uniformity of size and shape, etc., are largely irrelevant to the value of such vegetables in the kitchen as compared to the commercially available grown vegetables. The superiority in terms of crispness, aroma or flavour of freshly picked lettuce and tomatoes is evident. The same applies to most other home-grown vegetables; young runner beans, peas, etc., are richer in flavour if cooked when absolutely fresh. Moreover, freshness is more important in case of herbs which many a times when bought from the market, may have inevitably lost some of their scent and flavour giving properties.

Planning the Plot

The variety of vegetables you can grow will depend largely on the size of your plot. The smaller the plot, the more selective you will have to be in your choice of plants. You may decide to concentrate solely on a few favourite vegetables or cultivars or you may grow those that are usually expensive to buy. Herbs and vegetables can just easily be grown in areas of unused space near a door or against a house or garden wall if residing on the ground floor or on a window sill which receives a fair amount of sun. If staying in an apartment, certain vegetables or herbs can be grown in containers or pots of various sizes. They may also be raised in window boxes. Tomatoes will almost certainly do better if they are grown against a wall than if they are planted in garden soil. Radishes, carrots and lettuces should all do well in tubs filled with soil suitable for their specific needs. The total usable yield of a kitchen garden can be maximised by careful planning. Smaller sowings at intervals during the season will enable you to use a crop as soon as it is harvested. Successional crops allow you to use your plot more flexibly. For instance, when early peas or early potatoes have been harvested, the vacant rows can be sown with lettuce, radish, spring onions or turnips. Intercropping or growing plants in the spaces between rows of other crops is an yield-improving method. Ideally intercrops should be quick-maturing plants that do not take up much space. For example, radishes which



take up little space can be intercropped with a wide variety of main crops.

Soil

You will get good tasty crops only if you grow your vegetables in healthy soil. The topsoil or growing medium consists mainly of eroded particles of rock, decomposed organic matter (humus), various mineral salts, water and air. In addition to sunlight, water and air, plants need about a dozen nutrient elements for healthy growth. The poor draining qualities of heavy clay soils can be alleviated by mixing in sand. Addition of organic materials such as manure, cow-dung, etc., help to open up the soil structure. You will also need to add fertilisers either purchased from the market or natural fertilisers which include garden compost and manure to your soil. The three important elements which plants require are nitrogen, phosphorous, and potassium. Others include carbon, magnesium and sulphur. Trace elements such as copper, iron, manganese, zinc, etc., are required in minute quantities.

DIGGING aerates and improves the structures of all soils. For deep-rooters you should dig to about double the spade length. Prior to cultivation, soil must be broken up with a spade or fork. Make sure that manure, compost, leaf mould, etc., are well worked in so that the soil has the same colour and consistency.

Rotation

The productivity of kitchen garden can be maintained by rotational cropping. For a small kitchen garden, you can divide the area into three equal parts. One of these plots should be manured the first year, the next plot next year and the last in the third year. The reason for rotation is that soil pests and diseases that affect that particular group will be encouraged to increase if the group is always grown in the same plot. Rotation also helps you to take advantage of the fact that the roots of peas and beans if left in the soil, provide a rich store of nitrogen for the crops next in rotation. Certain plants like onions can be grown independently of such rotations and can be grown year after year in the same ground. The same goes for herbs which can be grown in pots, tubs or other containers. Tomatoes, potatoes and cabbages are especially vulnerable to attack by the soil organisms. Thus, these can be excluded from your rotations. These require a replacement of fresh material every year.

THE total usable yield of a kitchen garden can be maximised by careful planning. Smaller sowings at intervals during the season will enable you to use a crop as soon as it is harvested

Pests and Diseases

Most vegetables are liable to attack by pests and diseases, although only a few are likely to prove a menace in the average kitchen garden. Chemical treatments for the control of pests and diseases are continuously being improved. Do not eat vegetables treated or sprayed with insecticides until the toxic properties have been washed off. Weeds can be a nuisance more than pests as these can consume soil nutrients earmarked for crops and may attract pests and diseases in turn. The best way to deal with weeds is to remove them by roots. Also, always make a point to clear away unwanted vegetable matter which can be suitable for converting into garden compost.

Planting

A variety of vegetable seeds can be purchased from a nursery or market. Different selected varieties of these can be grown in small quantities at the same time and the rest can be stored, in fact, for several years if kept dry and cool. The best way is to store seed packets in a screw-top or airtight jar. Prior to sowing seeds prepare the soil by raking the soil, watering it for a few days. Sow the seeds at some intervals, cover with soil and water them. Keep the soil moist, but not over-wet during germination and after so that the plants can grow steadily without a check.

Selected Vegetable Crops

A variety of vegetables can be grown in your kitchen garden. But the selection depends on space and time. Tomato, *Lycopersicon lycopersicum,* can be grown in window boxes or large pots and even in hanging baskets. Tomatoes require sufficient heat and sunlight. Sow the tomato seeds at a depth of 2 to 3 cm . Cover the pot with a polythene bag and place in a warm site till the seedlings appear. Once this is done, remove the polythene bag and transfer the plant to a bigger pot in sunlight. The growing medium should be kept firm; it will carry a considerable weight when the trusses of fruits are setting. Keep the soil weed-free. The commonest disease to affect out-door tomatoes is blight which causes the leaves to develop brownish grey edges and the fruit areas of brownish marbling. Treat with fungicide. Harvest the tomatoes when ripe. Alternatively, remove green ones and use or store them indoors in a warm place to ripen.

Peas, *Pisum sativum* varieties, thrive in a sunny site and a rich moisture-retentive soil. It is grown as a winter crop. Supports may be required as the pea plant is a climber with a slender hollow stem. Sprinkle on a general fertiliser before sowing. Keep the soil moist and weed-free. Harvest green peas as they become ready. In the climber group, cucumbers, *Cucumis sativis,* grow easily and so are a welcome addition to a small kitchen garden. They may be grown on the flat surface or may be trained up a bamboo. Sow two or three seeds at a depth of 2 to 3 cm in pots somewhere around the month of May. The site should be warm and sunny. When few leaves have grown, pinch out the growing tip to encourage the development of side shoots. Keep the soil well-watered and weed-free at all times. Harvest the fruits when young; allowing them to mature fully will spoil their flavour and discourage the plant from producing more fruits.

Lady's finger or Okra *(Abelmoschus esculentus)* requires a long warm growing season. It grows in all types of soil, thriving best in a moist friable well-manured soil with a pH between 6.0 and 6.8. The fruits are picked when immature; usually about two and a half months after planting. These are used as a vegetable. The leaves may be consumed as a pot-herb.

WEEDS can be a nuisance more than pests as these can consume soil nutrients earmarked crops and may attract pests and diseases in turn. The best way to deal with weeds is to remove them by roots

LEAFY varieties such as cabbage or cauliflower can also be grown in a kitchen garden. *Brassica oleracea capitata,* as it is called, cabbage is a versatile brassica whose varieties give crops throughout the year and is suitable for small gardens if grown with inter crops. Its seeds can be sown in small pots and then transplanted to the main soil. Sowing can be done in March and April or May-June or July-August. This vegetable grows well in a preferably open space.

Several roots such as radish, carrot, beetroot, etc., can also be grown. Carrot, *Daucus carota sativa,* is a splendid vegetable for small gardens or for growing in tubs or large containers. Its seeds are large enough to handle individually. You can sow few at a time at intervals of about 3 weeks so as to get a succession of carrots. They should be sown in rows or blocks at a depth of 1 to 1.5 cm. The soil should be improved by the addition of peat and well-manured compost. When the seedlings are 3 to 5 cm high, heap a little soil around the root, this will help prevent development of green topped roots. Sprinkle the insecticide into the soil while sowing. Pull out the roots when ready.

Lactuca sativa or lettuce may be grown for a good part of the year with a little protection and you can eat fresh salad day after day. The best method is to sow a few seeds at a time every few weeks, so that you have a more or less continuous supply of succulent leaves. Sow seeds at a depth of 1.5 to 2 cm. A good well-drained soil enriched with plenty of compost is required for this plant. A sunny site is best for growing.

Harvest as Required

These are just a few examples of vegetables which can be grown easily in your kitchen garden. You have to go to a nursery to buy the seeds of your own choice. Besides vegetables, certain spices and herbs or medicinal plants can also be grown in our kitchens. Most herbs are easy to grow and they need warmth and a sheltered site. In fact, herbs can even thrive in poorer soils than vegetables. *Tulsi, ajowan* or Bishop's seed, ginger, etc., can easily grow in pots. *Coriandrum sativum* or coriander is another herb or a spice for curry lovers. You can sow the seeds in pots in the spring season. Remember to keep the seeds watered. Harvest the leaves when the plants are nearly fully grown, but before flowering; by then they should have maximum flavour. Harvest the seeds when the seed capsules are yellow and ripe. Dill, *Anethum (Peucedanum) graveolens,* is an annual grown for its leaves and seeds. The plants grow anything from 40 to 90 cm high and will often 'self-sow'! You can sow one or two seeds at each growing point, lightly cover with soil and water in. The site should be sunny and protected from the wind. Harvest the yong leaves when the plants are beginning to get bushy. The seeds need to be harvested just before they are ripe. This is the time when they scatter easily. When the seed capsules are beginning to turn brown, cut the heads off and hang them in an airy, dry place.

Plants like *curry patta, podina,* peppermint, etc., can be grown similarly on a window sill. Lemon grass can also be planted to be used for preparing tea.

Care

It is true that growing plants is not difficult at all and yet taking care of plants is. Timely watering, manuring, pruning or spraying of insecticides and fungicides is an important task. One has to devote some time at least for the care of plants. Perhaps for women, it will be the pleasure and satisfaction of raising and eating the vegetables herself. And the rewards are beyond any mundane questions of the cost-effectiveness.

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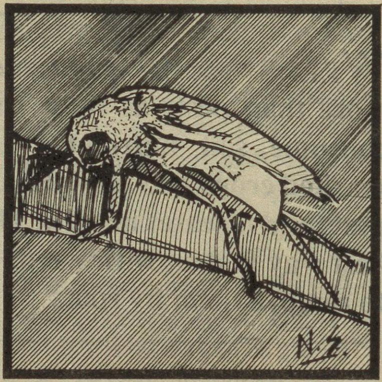
Q. What makes the firefly glow?

Sanjay Kumar Sahu
Dhenkanal 759001
Orissa



A. The firefly produces light through a complex biochemical process — a phenomenon called bioluminescence. Unlike the light produced by a candle or an electric bulb, no heat is produced in this process which involves several substances. The main fuel in firefly light production is luciferin, a chemical with the composition $C_{13}H_{12}N_2S_2O_3$, contained in the light-emitting organ at the tip of the abdomen. When luciferin combines with oxygen in presence of an enzyme called luciferase, the energy rich chemical ATP (which is found in all living cells), and magnesium (Mg^{++}), light is produced. But no light is produced if any one of these substances is missing. The flashing light of a firefly is produced by nerve impulses sent to the light producing organ.

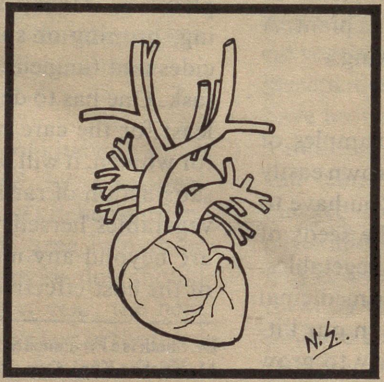
Biman Basu

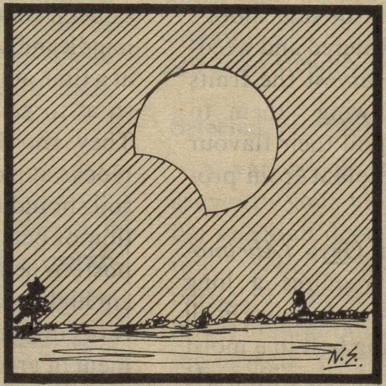
Q. Why does our heart beat faster when we are faced with danger?

Manik Banerjee
Singbhum-832403
Bihar

A. The normal rate of heartbeats in an adult at rest is 70-72 beats per minute in men and 78-82 beats per minute in women. Children have a higher rate, about 90 beats per minute. These rates are normally maintained by the heart's own pacemaker. But physical activity or emotion can increase the rate up to 140 beats per minute . Emotional conditions such as fear or anger stimulate the adrenal gland in our body to release the hormone adrenaline into blood which makes the heart beat faster and increases the blood pressure. These changes are nature's way to prepare the body for 'fight or flight' when faced with danger.

B.B.





Q. How can our eyes be affected if we look at the moon during a lunar eclipse or at the sun during a solar eclipse?

Ajay K. Nayak
Sambalpur, Orissa

A. There is no risk ıı you look at the moon during a lunar eclipse because even at full moon the brightness of the moon is too low to cause any damage to the eye. But with the sun it is different. The important point to remember is, whether there is an eclipse or not, looking directly at the sun is harmful and may even cause permanent blindness. This is because sunlight when focussed on the retina can cause burns damaging it permanently. During a solar eclipse even the partially covered sun still remains too bright for safe viewing. The safest way to view a solar eclipse is to project the image of the sun with a small telescope on a white sheet.

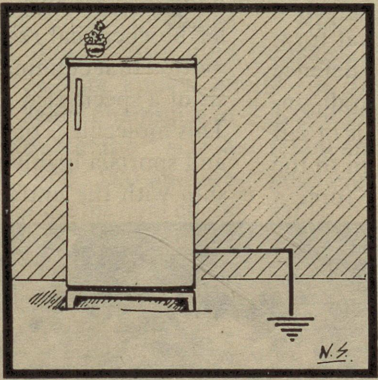
B.B.

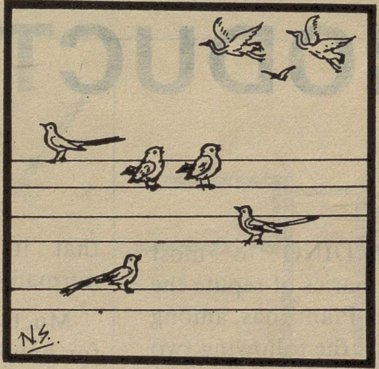
Q. Why is it necessary to earth an electrical appliance?

Girijesh Srivastava
Faizabad, U.P.

A. Normally the non-current carrying metallic parts of an electrical appliance are safe to touch, as they are well insulated. But if there is leakage, these metallic parts may become live and pose risk to anyone handling the appliance. This is because current can easily flow through the human body to the ground. Earthing prevents this risk as the earth wire offers an easier path compared to human body to the flow of leaking current to ground, thus making the appliance safe to use.

J.B.





Q. Why is a bird sitting on a live electric wire not killed?

Ram Naresh
Bulandshahar, U.P.

A. The two basic units of electricity are current and voltage. While current is the flow of electrons, voltage is the pressure that moves electron from a higher potential to a lower one. Current is the factor which kills. A bird sitting on a live-wire is neither grounded nor is it in series with the live-wire. So no current flow is possible and the bird is not killed. But if a bird sitting on live-wire simultaneously comes into contact with the ground or touches another live-wire, it completes the electrical circuit and will be killed by the current flowing through it.

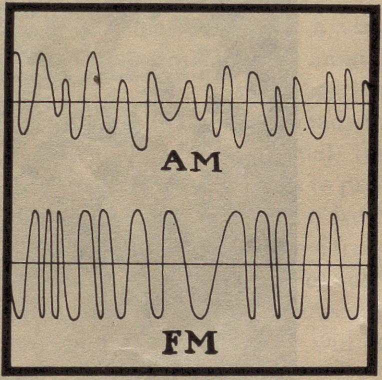
Jagdish Bist

Q. What is Frequency Modulation?

Manoj K. Bose
Saharsa, Bihar

A. In radio and TV broadcasting high frequency electromagnetic waves are used as 'carriers' of low frequency audio and video signals. For transmission, the carrier wave is modified or 'modulated' by the audio or video signal. At the receiving end the useful signals are separated from the carrier signal by 'demodulation'.

There are two ways of modulating carrier signal : by changing its *amplitude*, or its *frequency* in consonance with the imposed signal. When the latter method is used, it is known as frequency modulation or FM in short. FM gives better quality reception than amplitude modulation (AM). This is because most electrical disturbances, such as sparking of any kind or even lightning, produce (AM) electromagnetic signals which cause disturbance in AM reception. FM signals are however not affected. So FM reception comes out clear and noise-free. In television broadcasting the sound is transmitted by FM while the picture comes through AM.



B.B.

PRODUCTION "PLANTS"

BAL PHONDKE

ACCORDING to most dictionaries of repute the word "Plant" has, among others, the following two meanings. For one, the word is used to refer to an individual member of a botanical species synonymous with the word tree. It is a life form the most characteristic feature of which is the remarkable process of photosynthesis. On the other hand, the word can also be used to describe the ensemble of machinery employed in the manufacture of a man-made industrial product.

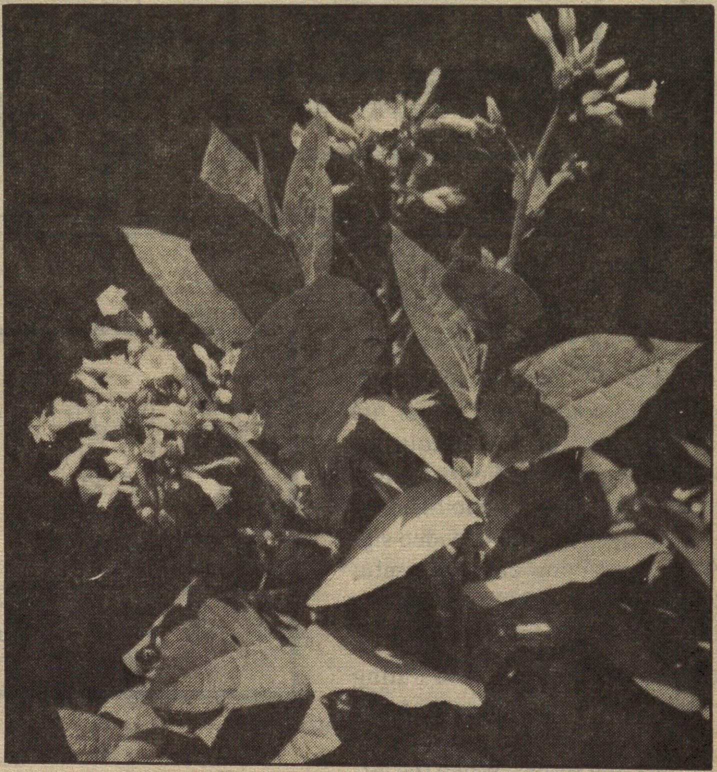
There is very little that can be considered common to these two different objects though described by the same word. One is a natural entity and has a life of its own. The other is a man-made contraption designed with a particular objective in mind. Although a botanical green 'plant' does yield a product that is quite useful to the human species, the plant is designed by nature to give rise to the product for which man in his ingenuity has found some use. Man plays no part in deciding any of the features of that product. In contrast, the industrial plant is totally designed by man and all the features of the product it manufactures are pre-determined by man as per his desire.

Be that as it may, thanks to the advances in biotechnology, scientists are engaged in assimilating these two disparate meanings and converting green "plants" into production "plants". In fact they have already succeeded in this endeavour to some extent. Scientists in California, USA have so engineered a tobacco plant that its leaves yield a protein normally synthesised by mice.

Much as man may deride nature for having created so many micro-organisms capable of bringing disease and ill-health, the very same nature has endowed man, and all mammals, with an extremely well organised defence system—th immune system.

This operates on the principle of self and non-self. Lympl ocytes, a type of white blood cells, that form the basic constituent of the defence process possess the ability to distinguish between an entity that is of self origin and one that is foreign to the body. This recognition of foreign materials is attained by reading those topological features present on the surface of any substance that are unique to it. These features which can be considered as the identity card of the substance are called antigens.

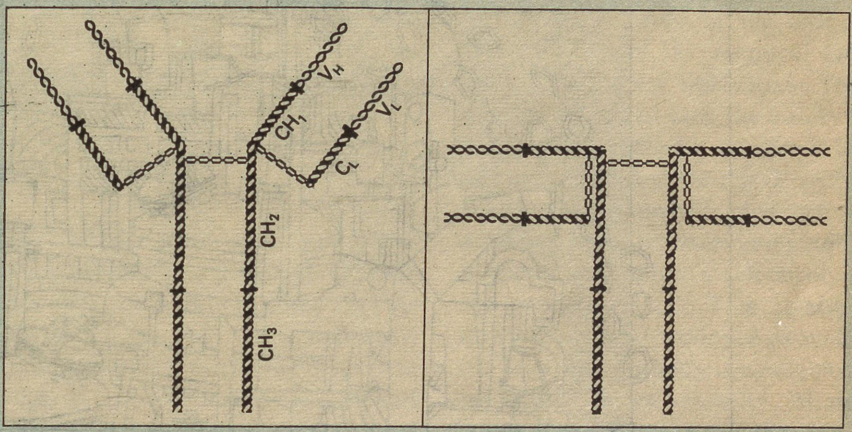
ONCE the reading of the antigenic visiting card convinces the lymphocytes that the entrant is alien and could bring harm to the body they get busy. A chain of cellular biochemical reactions is set into motion that culminates in the synthesis of a specialised protein molecule. This molecule is of a globular nature and sports a highly specific relationship with the antigen that is analo-



Nicotiana tabacum—in flower

Polypeptide Chains

AN antibody molecule belongs to the family of globular proteins collectively called immunoglobulins. There are five major classes of immunoglobulins. But the most abundant among them is the class denoted as IgG. Antibodies that afford protection against diseases usually belong to this class IgG is a Y-shaped molecule of a molecular weight of about 180,000 made up of four polypeptide chains consisting of two pairs. Both members of every pair are identical. One of the pairs consists of chains, each having a molecular weight of about 30,000. 214 amino acids are linked together to make this chain. Since these chains are smaller than those constituting the other pair, they are known as light chains. The heavy chains are of approximately double the size a molecular weight of 55,000 and are 450 amino acids long. One light chain is attached to one heavy chain with a disulphide bond. The two heavy chains are also linked together with a disulphide bridge. These bridges are so located and formed that the whole molecule has a certain amount of flexibility and can assume, in space, different shapes ranging from that of the letter 'T' to that of the letter 'Y'.



Roughly a half of the light chains consists of amino acid sequence that varies from antibody to antibody depending upon its specificity to different antigens. This is called the variable regions. The sequence of amino acids in the other half remains remarkably constant in all antibodies of a particular class irrespective of their specificities. This is called the constant region.

The heavy chain too has a variable region, of approximately the same length as that of the corresponding light chain variable region. The rest of the heavy chains can be divided into three parts of equal length each having a constant amino acid sequence. The variable regions of the two chains are so juxtaposed in space that they lie adjacent to each other. The free ends of the two variable regions together form a site at which the specific antigen can bind. Each antibody molecule thus can bind to two antigenic sites and hence is said to be bivalent. The flexibility of the molecule permits its binding to antigens of different configurations.

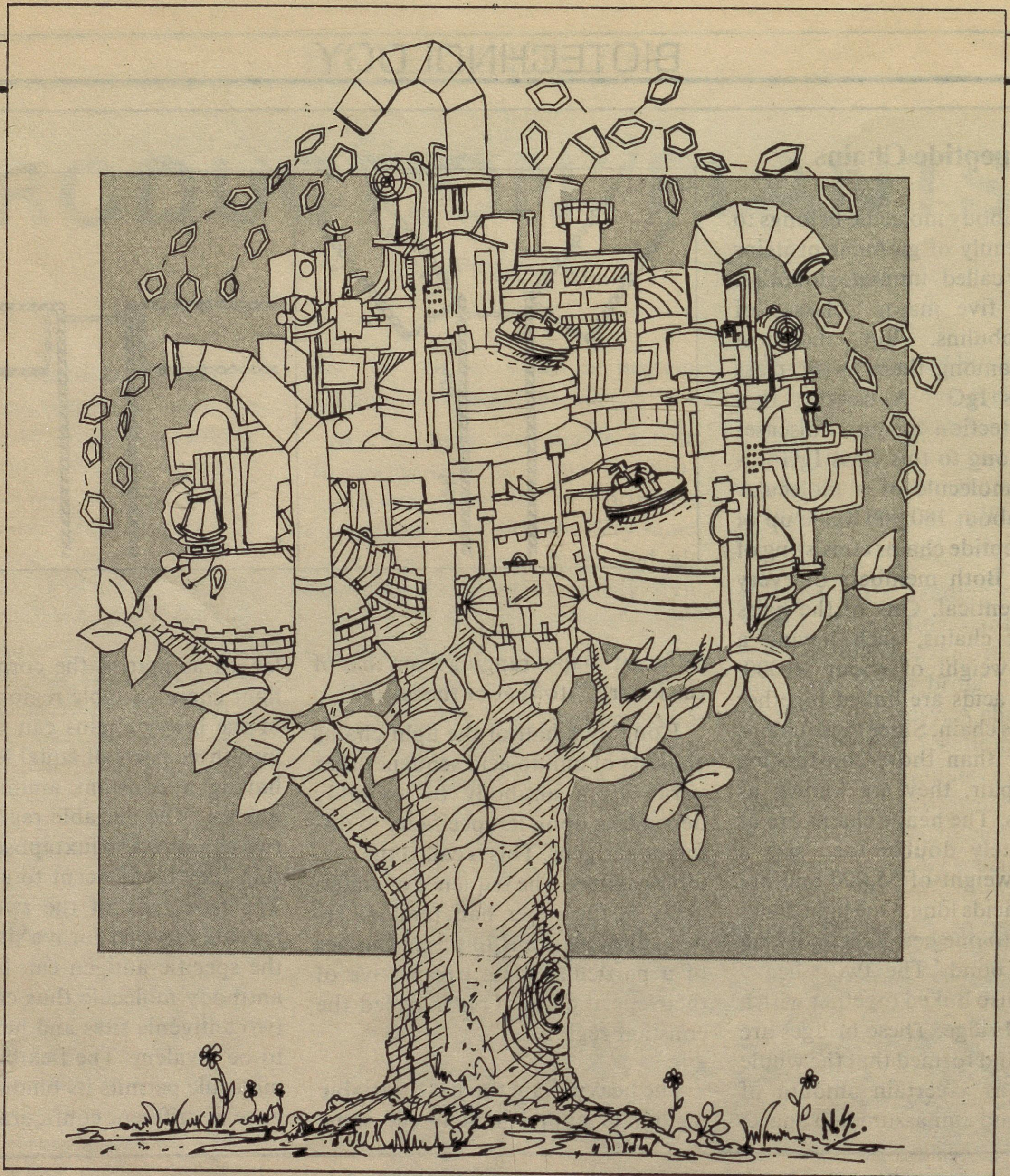
gous to that between a serpent and a mongoose or a lock and a key.

These protein molecules tailor-made to suit the antigen are called the antibodies. The lymphocytes synthesise antibodies and secrete them. Through the blood stream the antibodies travel to the nook and corner of the body on the trail of the antigen. The moment the latter is encountered the antibody latches onto it and embraces it into a deathlock. Thus incapacitated, the antigen, or rather the organism that it represents, cannot play any more tricks. It has only to wait patiently for the scavenger cells to come and escort it out of the body.

The antibodies thus play a very crucial role in protecting the animal from the myriad disease-bearing inimical agents that are ever ready to pounce upon it. If an animal, for some reason or another, falls to produce an antibody, its infusion from outside can also save the animal from succumbing to the disease. For such a passive immuno-therapy, however, a large quantity of antibody will be needed.

Because of the highly specific, though antipathic, relationship between an antigen and its antibody scientists have found use for the latter that goes beyond what nature intended. Highly specific antibodies possessing a high affinity for the corresponding antigen can be used in the detection of the latter. Further, techniques based on this specific interaction have been devised for measuring very small amounts of the antigen.

So antibodies are in great demand for more reasons than one. However, they are in short supply. For one, only a small proportion of the lymphocytes can make them. Secondly, these cells have only a finite life span.



So they synthesise a limited amount of antibody and then call it a day.

IN the mid-seventies George Kohler and Cezar Milstein discovered a technique for overcoming this problem. They found a myeloma cell, a cancerous lymphocyte which had an unlimited life span. It produced an immuno-globulin which however was of no use as it did not possess any specificity for any antigen. But Kohler and Milstein hit upon a brilliant idea. Would it not be wonderful if a lymphocyte can be made to possess simultaneously the property of immortality of the myeloma cell and the specific antibody producing capacity of the lymphocyte, they asked.

To answer their own question they brought about fusion of the two cells and succeeded in obtaining a hybrid cell which had inherited the desired properties from both its parents. This hybridoma could now be grown in the test tube and even in an animal to yield large amounts of pure, well-defined, high affinity antibodies.

Still, growing of a hybridoma can be an expensive proposition. Moreover, it needs highly trained, skilled scientists to carefully nurture and grow these hybrid cells. If other simpler and perhaps less expensive ways can be found they would be highly welcome.

That is easier said than done. Only animal cells, that too a particular class of them, have the ability to produce antibodies. Nevertheless, since the advent of biotechnology scientists can no longer be daunted by such restrictions devised by nature. Andrew Hiatt, Robert Cofferkey and Katherine Bowdish from the Research Institute of the Scripps Clinic in La Jolla, California decided to challenge nature and make antibodies in a novel way by using plant cells.

They had noticed that antibodies are protein molecules containing two pairs of polypeptide chains (See box), that there are specific genes containing the coded blue-prints for the synthesis of these proteins and that cells of mice and of tobacco plants do process some types of proteins in similar ways. Therefore, they first looked at the two types of chains of amino acids, the light chains and the heavy chains, that make up the antibody molecule.

The recipe for the manufacture of any protein lies in the gene which resides on the DNA molecule. The DNA sits inside the cell nucleus. But the assembly line machinery for linking the different amino acids into the protein's constituent polypeptide chains lies outside the nucleus in the cytoplasm. The instructions for the production of the protein have therefore to be transported to the manufacturing site. This task is performed by the messenger RNA which has a complementary structure much like the mirror-image of the DNA which constitutes the gene.

Armed with this information Hiatt and his colleagues took a hybridoma that made a specific antibody named 6D4. Though these cells synthesised vast quantities of 6D4 that was not the only protein they produced. So even finding the gene specifically responsible for the synthesis of 6D4 was not easy, let alone its isolation.

So Hiatt and company decided to go about the task in a round-about fashion. They got hold of the specific messenger RNA and then used it to obtain the complementary DNA (C-DNA). Initially they obtained the C-DNA for the light chain and the heavy chain separately. Using the methods of recombinant-DNA technology, they inserted these C-DNAs into the cells of two different tobacco plants.

USING these cells the whole plants were grown. Hiatt and his colleagues happily noted that the leaves of these plants contained among other proteins the respective light or heavy chains of 6D4. So half the battle was won. The next target was to get the plant to produce the whole molecule. Towards that goal, the scientists took the two sets of flowering plants and sexually crossed them to generate a hybrid variety. When these hybrid plants were grown, the scientists found, as expected according to Mendel's law, that some plants contained neither of the two antibody chains. Some others contained either the heavy or the light chain only. There was, however, a fourth group of progeny hybrid plants that contained in their leaves the whole 6D4 antibody. Hiatt and his friends were also pleasantly surprised to find that the yields of the 6D4 were high, as much as 4000 nanograms per milligram of total (1 nanogram = 10^{-9}g). They had succeeded in converting tobacco plants into production plants for the manufacture of antibody. A member of the flora was cajoled into making a protein that hitherto was the prerogative of a member of the fauna. Biotechnology had scored yet another triumph.

ONE of the major uses of this remarkable new technique is obvious. Since antibodies have a highly specific relationship with an antigen, scientists have been toying with the idea of employing them as homing pigeons to carry effective drugs precisely to the site where they are wanted. The need for such a therapy is more acute in the case of cancer. Most of the chemical antidotes to cancer are highly toxic. They can kill a cell but lack the ability to distinguish between a cancerous cell and a healthy normal cell. If such a drug molecule can be tagged on to an antibody then the latter can guide it properly and deliver it selectively to the cancerous cell. This strategy, however, can be employed provided the requisite antibody is available in sufficiently large quantity. Hiatt's "plants" would make this possible.

The utility of this technique, however, does not end there. Hiatt feels that the technique would make it possible to extend the benefit of an immune defence system to the plant kingdom. The immune system devised by nature is a privilege enjoyed by animals only. Plants, which are also attacked by disease-carrying bacteria and viruses and fungi are not endowed with an immune system. But now the genes for making of the appropriate antibodies can be inserted into the plants thereby arming them with a weapon to combat the enemy.

Hiatt, of course, has even more ambitious plan. He thinks that plants which can make antibodies against certain toxic substances can be grown in polluted waters. The water containing the toxic contaminant can easily cross the rigid cell wall of the plant. Once the toxic molecule is inside it will be pounced upon by the antibody which will inactivate and immobilise it. The "arrested" toxic substance will not be able to cross the cell wall back into the outside water. Harvesting the plants then would cleanse the environment.

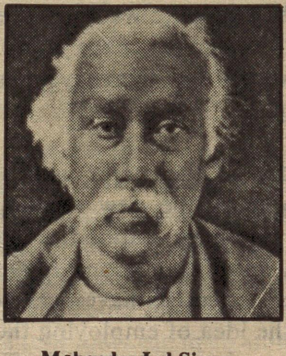
Clearly these new plants are stated to become the legendary *"Kalpavriksh"*, thanks to the advances in biotechnology. □

ORIGINS OF MODERN INDIAN SCIENCE

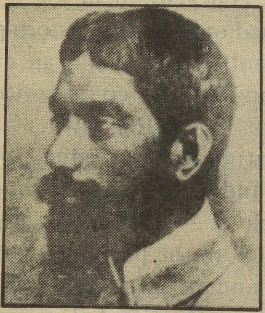
From modest beginnings in Calcutta at the turn of the century, the tradition of modern science in India has come a long way. *DEBI P. BURMA and SUBODH MAHANTI* narrate the story of the long journey

BAUDHAYANA, Aryabhata, Varahamihira, Bhaskara and others in astronomy; Charaka, Susruta in medicine and surgery; Nagarjuna in chemistry and Kanada in physics are household names in the country and speak of the glorious ancient history of science in India. Among the scientific achievements of that past era the work of grammar occupies a high place. Panini's grammar is the earliest scientific grammar in the world. Whatever the status of Indian science in those days it was more or less eclipsed during the Moghul as well as the early British period. The development of Indian science remained very much retarded for a few centuries. The light of modern science slowly dawned towards the end of the nineteenth century and it got brighter only during the early part of the twentieth century.

The wind of modern science actually started blowing in the country in Calcutta. Several persons were responsible for this : the foremost were Mahendra Lal Sircar, J.C. Bose and P.C. Ray. Although the Asiatic Society which was established on January 15, 1784 in Calcutta, had nothing to do with science directly, its inception helped to develop a proper atmosphere of science in Calcutta. William Jones, a worthy son of England, was responsible for this. Since its inception the Society acted as a source of inspiration for scientific education and research. The Society which was run entirely by the Europeans initiated publishing journals like *Asiatic Researches, Gleanings in Science* and finally *Journal of Asiatic Society of Bengal* in 1832. One hundred and thirty years later, in 1914, the first session of the Indian Science Congress was held in the same building on the same date (15th January) under the presidentship of Sir Asutosh Mookerjee. Asutosh Mookerjee was a mathematician but did not contribute much to science. However, as a Vice-chancellor of the University of Calcutta, which was founded in 1858, he was directly responsible for the development of science in the country. Members of the Asiatic Society had established the Indian Museum in Calcutta and by the time of the first session of the Science Congress, it had almost completed 100 years of its existence. In early years, this museum acted as a centre of activity for a good number of scientists. It should be noted that Indian Science Congress Association owes its origin to the foresight and initiative of two British chemists, namely, J.L. Simonsen and P.S. MacMahon, who were posted on science teaching assignment in India in 1910. They envisaged that scientific research in India might be stimulated if an annual meeting of workers somewhat on the lines of the British Association for the Advancement of Science can be arranged. The Asiatic Society of Bengal was asked



Mahendra Lal Sircar

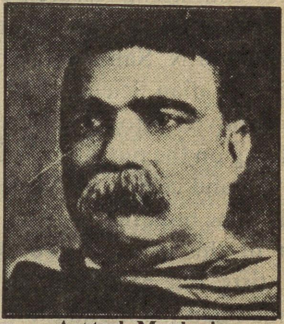


P.C. Ray

to undertake the management of a Science Congress to be held annually. During the early period of development of sciences in India this Congress played a significant role.

MAHENDRA Lal Sircar, a trained doctor of Calcutta and deeply involved in social reforms published his plans and ideas in an article "On the desirability of a national institution for the cultivation of sciences by the natives of India" in August 1969 issue of the *Calcutta Journal of Medicine*. Encouraged by the enthusiatic response from the intellectual community he established the "Indian Association for the Cultivation of Science". At a meeting held on January 16, 1876 it was decided to establish an Institute in the same name for which already some money was collected. Sir Richard Temple, the then Lieutenent Governor of Bengal, handed over to the Association an unfinished building at No. 210, Bowbazar Street. The Association was inaugurated on July 29 the same year. But due to the financial constraints the Association had to remain satisfied with arranging popular lectures by persons like J.C. Bose, Asutosh Mookerjee, Father Lafont, Dr. Tara Prasanna Roy, Dr. Kanti Lal Dev and, of course, Sircar himself. For the next twentyeight years Sircar worked indefatigably to give full shape to this Association. He had the vision to realise that scientific research would not flourish unless it was based on sound teaching of science as well as full time research in laboratories. After his death in 1904, his nephew Dr. Amrit Lal Sircar took the charge of the Association as its Honcrary Secretary and during his tenure, Chandrasekher Venkata Raman joined the Association.

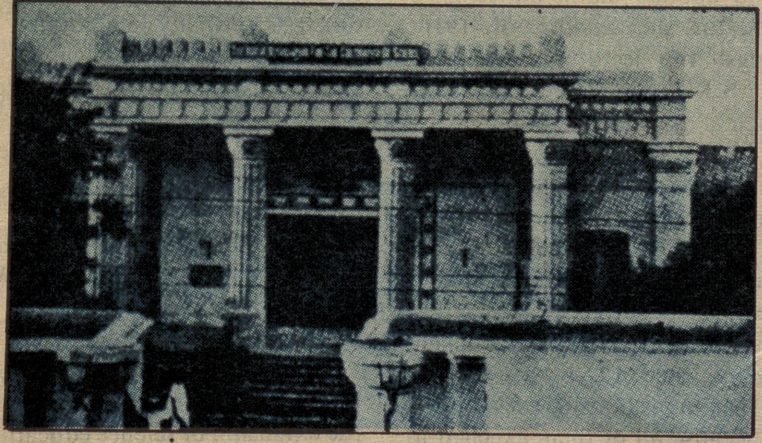
RAMAN, a brilliant student of physics at the Madras University, competed successfully for the Indian Finance Examination after receiving his Master's degree in physics. He was posted in 1907 as an officer at the Accountant General's office at Calcutta. Raman had heard about the Association and of its



Asutosh Mookerjee

Viziangram Laboratory and decided to utilise his spare time by working in this laboratory. He joined in August, 1907 and immediately created a highly active research atmosphere. Asutosh Mookerjee had started infusing new life into Calcutta University by 1912. He created endowed chairs for physics and chemistry out of the princely donations from Taraknath Palit and Rash Behari Ghosh, two great philanthropists of Bengal. Asutosh Mookerjee who had been closely watching the research career of Raman invited the latter to accept the Pālit Professorship of physics in 1913 but for several reasons, including war, his joining was delayed till 1917. Raman, however, was permitted to continue his research activities in the Indian Association for the Cultivation of Science with the help of his brilliant school. By 1928 the Association became a leading centre of researches in molecular scattering in the whole world. The Raman Effect was actually discovered in 1923. Raman was elected to the Fellowship of the Royal Society of London in 1924 and awarded the Nobel Prize in Physics in 1930.

Raman left Calcutta in 1933 to join the Indian Institute of Science at Bangalore as its first Indian Director. However, the atmosphere he created in the Association was maintained over a large number of years. The old building at Bowbazar street eventually became congested and unsuita-



Indian Association for the Cultivation of Science No. 210, Bowbazar Street, Calcutta

ble for continuing research activities in various areas and through the effort of M.N. Saha, an architect of modern Indian Science. The Association moved into its new spacious building on the outskirts of Calcutta in 1951 and celebrated its centenary in the new building in 1976. In early part of this century two Bengalee scientists: one physicist and other a chemist laid the foundation of modern science in this part of the world. Sir J.C. Bose after passing the Natural Sciences Tripos of Cambridge University, returned home in 1885 and was appointed Assistant Professor of Physics at the Presidency College at Calcutta. J.C. Bose started carrying out researches in the field of electromagnetic waves following the brilliant work of the German physicist H.R. Hertz. Bose could produce extremely short waves and effected considerable improvement upon Hertz detector of electromagnetic waves. Bose was awarded the DSc degree of the London University in 1896 on the basis of his work on "Measurement of electromagnetic waves". Eventually, Bose became very much interested in responses in plants and devoted the rest of his career in the study of such responses. As an expert physicist he devised very simple but sensitive physical devices to study such responses. To fulfil his dream he eventually established the Bose Institute in 1917 after his retirement from Presidency College and devoted the remaining part of his life to its development.

P.C.RAY, a great friend of Bose, returned to the country, from Edinburgh in July 1888 with a doctorate degree in chemistry. He joined the Presidency College in 1889 as a temporary Assistant Professor. Before 1890 systematic and sustained chemical research in India was unknown. In fact, before P.C. Ray, there were practically no Indian workers engaged in chemical research, though the chemistry department of Presidency College had started functioning in 1873. Alexander Pedler, who was Professor of Chemistry at the time P.C. Ray joined Presidency College, inspired Ray to pursue higher studies in chemistry. One of the major contribution of P.C. Ray was the discovery of mercurous nitrite. One of his other contribution was to develop chemical industry in the country. The Bengal Chemical and Pharmaceutical Works, the first of its kind in the country, was established soon thereafter.


Meghnad Saha

The foundation stone of the University College of Science and Technology was laid on March 27, 1914 but it really started functioning in 1916. The classes in physics, chemistry and applied mathematics were opened in the middle of 1916. Amongst the lecturers appointed were S.K. Bannerjee (Applied Mathematics); M.N. Saha, S.N. Bose, S.K. Mitra (physics); J.C. Ghosh, J.N. Mukherjee, P. Ray (chemistry). Asutosh Mookerjee who after being Vice-Chancellor in 1906 was instrumental in the development of the Science College, which played a crucial role in institutionalising modern science in India. He showed great insight in choosing these young men because all of them excelled in their career.

SUCH development was not confined only to the Eastern part of the country. J.N. Tata, an enlightened industrialist, could conceive as far back as in 1889, when neither industry nor technical education existed in India, the idea of funding a research and teaching institution dedicated to the promotion of intellectual and national welfare of India. He personally donated a property, then worth Rs. 3 million. When the scheme was in the making in 1904, Tata passed away and it was left to his sons Dorab and Ratan to carry out the wishes of their father and bring into existence the institute he had visualised. The Indian Institute of Science was thus founded in 1909 at Bangalore, in the Southern part of the country. As a post-graduate and research institution, this organisation played a great role in the development of science in the country. The first Director W.W. Travers, Fellow of Royal Society, was selected three years prior to the establishment of the Institute on the advice of the Royal Society and it was left to him to finalise the scheme in consultation with the Donor's representatives, Dorab Tata and Ratan Tata, the Government of India and the Government of Mysore. C.V. Raman became its first Indian Director in 1933 and in the same year the Department of Physics of the Institute was formally inaugurated with Raman as its Head. Raman was actively associated with the department till 1948; when he shifted to the Raman Research Institute created by him.

Almost at the same time a similar development took place in the Western part of India. George Clark (later known as Lord Sydenham), the then Governor of Bombay and a Fellow of Royal Society, considered seriously the extension of science education in the erstwhile state of Bombay.

Through the princely donation of several philanthropists and aid of the Government of Bombay, foundation stone was laid in 1911 of the Royal Institute of Science which started properly functioning in 1920. The first Principal of the Institute was C.J.J. Fox who was also the Professor of Chemistry.

At this stage two important advances in the field of physics gave a glorious touch to the dawning Indian science. In 1923 S.N. Bose, then 29, working at Manindra Laboratory of Dacca University (now in Bangaladesh) sent a paper entitled "Planck's law and hypothesis of quanta" to *Philosophical Magazine,* which turned it down. Bose then sent this paper to Albert Einstein requesting him to evaluate it and if he found it worthwhile to send it to the German Journal *Zeitschrift für physik*, after translation. Einstein did so and Bose-Einstein statistics came into existence. Bose's explanation of the behaviour of light particles (photons) and their energy in a radiation field inspired the Nobel Laureate British physicist Paul Dirac to coin the word "Boson" to represent a class of elementary particles with integral spin and which obey Bose-Einstein statistics.

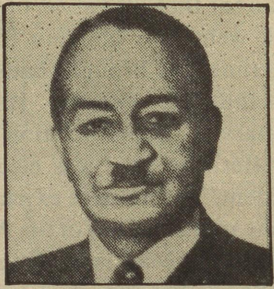
ANOTHER Indian physicist, Meghnad Saha, who was a contemporary of S.N. Bose, also propounded at the same time a theory for the "Thermal ionisation and its application to stellar atmosphere". The equation that goes by his name was first published in a paper entitled "On ionisation in the solar chromosphere", in the *Philosophical Magazine* for October 1920. Saha also played a very important role in the development of science in India. He held the chair of physics at the Calcutta University and later brought the Institute of Nuclear Physics in existence in 1951. The Indian Association for the Cultivation of Science which went into oblivion for quite some time was brought back to life by Saha. He became Honorary Secretary of the Association in 1944 and after one year was elected the President. The massive expansion in the research activities of the Association in recent years is solely the result of Saha's initiatives, resourcefulness and great devotion to science. He dreamt of the project on the Damodar Valley Corporation (DVC) in the style of Tennessee Valley Authority. He also started the publication of *Science and Culture* at the instance of P.C. Ray, to disseminate scientific knowledge among the masses and also to create a medium for scientific publications.


Homi J. Bhabha

Similarly, another Indian physicist of international reputation, H.J. Bhabha, played an important role in the shaping of Indian science. He joined the Indian Institute of Science, Bangalore, in 1940 as a Reader to head a special cosmic ray research unit and after two years he became Professor. While he was working as Professor at the Indian Institute of Science, during the Second World War, he dreamt of a scientific institution in India solely devoted to fundamental research, especially in the newest branches of physics, namely, nuclear physics and high-energy physics. J.R.D. Tata came forward with the financial assistance and the Government of Bombay got involved in this affair as it wanted to start a strong department of physics at Royal Institute of Science. The duplication of effort was prevented by starting the Tata Institute of Fundamental Research which was inaugurated in 1945 in a small wing of a flat in Peddar Road but later moved into the old buildings of the Royal Yacht Club in 1948. This Institute has become a centre of excellence in the country. When the Atomic Energy Commission was established in 1948 by the Government, the Tata Institute of Fundamental Research not only provided the first shelter but also supplied trained personnel specially in physics. One of the first steps undertaken by the Institute for the Commission was the setting up a small electronics group to design and build electronic instruments without which the atomic energy work was impossible. Eventually the Atomic Energy Commission assumed a gigantic stature at Trombay. This was possible solely due to the untiring efforts of Bhabha. Bhabha was mainly responsible for the initiation of the Indian space programme through the setting up in 1962 of the Indian National Committee for Space Research under the Chairmanship of Vikram Sarabhai.

In mathematical sciences, Srinivasa Ramanujan who was born in 1887 in poor but renowned family in Madras achieved significant success in early part of the twentieth century. He had special flavour for mathematics from his childhood. After failing twice in Intermediate examination, somehow he managed to get a clerical job in Madras Port Trust. Fortunately, Sir Francis Spring, Ramanujan's employer took special interest in Ramanujan's mathematical pursuits. Spring sent some of his works to the Cambridge mathematician Professor G.H. Hardy, who not only appreciated the originality of Ramanujan but also arranged a scholarship which enabled Ramanujan to go to Cambridge to pursue his interest in mathematical research. He could not stay in Cambridge for more than five years due to his poor health, but during this short period he could publish 21 most outstanding papers of amazing originality. The Royal Society of London made him a Fellow in 1918 and at the same time he was made a Fellow of the Trinity College, Cambridge University. Ramanujan died at the age of 33.

UNFORTUNATELY, however, India has not so far produced any Raman, Saha, Bose or Ramanujan in biological sciences. The reason for this is not properly understood. May be, mere observation of phenomena and collection of data without any query were and are still the main aims of biological research; the indepth study was and still is comparatively rare. So many pioneering institutes were established in this country in the early stage but most of those were mainly for researches in physical and chemical sciences. Lately, however, a few institutes engaged in researches in biological sciences came into existence but they have a comparatively short history. We are primarily indebted to the British scientists to initiate research in this area but their research interests were mainly confined to medical sciences. The first attempt to organise medical research in India was made in 1884, when the India Medical Congress submitted a resolution to the Government of India urging it to establish a Medical Research Institute and central and provincial laboratories. India, then being a part of British Kingdom and also one of the most disease-ridden countries of the world, attracted a large number of British biologists (both medically as well as non-medically qualified), as a potent test laboratory. One of these pioneers was Waldemar Mor-



S.S. Bhatnagar

decai Haffkine. He came to Calcutta in 1893 to test the efficacy of the cholera vaccine prepared by him a year earlier and had to rush to Bombay in 1896 to combat the epidemic of plague that broke out in the city. In the same year Haffkine had set up a Plague Laboratory in a room at the Grant Medical College, Bombay, which was later shifted to the old Government House, Parel. This Laboratory formed the nucleus of the present Haffkine Institute. Almost at the same time when Haffkine came to India, another India-born British pioneer returned to India. Ronald Ross, who was born in India at Almorah, in the Kumaon Hills, had his training in medicine in England. He then entered the Madras Medical Service and took part in the Burma War. He again went to England to study bacteriology. Returning to India, he began in 1892, to take special interest in malaria. Patrick Manson infused in him the concept of transmission of malaria through mosquito. 14 years earlier, Charles Lavoran had discovered the malaria parasite and named it 'plasmodium'. Ross went to Secunderabad (near Hyderabad) in 1895 under Imperial Medical Service and frantically started research to demonstrate what he had heard from Manson. When he was transferred to Presidency Hospital at Calcutta he continued his activities and eventually could demonstrate the transmission of malaria through mosquitoes using birds which are susceptible to malaria. He got the Nobel Prize in 1902 for this work. A few years after the discovery of Ross, Donovan working in the Physiology Department of Madras demonstrated the presence of the parasite known as *Leishmania donovani* in the spleen of cases suffering from *kala-azar* (leishmaniasis). After a short interval of this discovery, Leonard Rogers demonstrated the effectiveness of emetine in the treatment of amoebiasis. It may be noted that it was the enthusiasm and determined effort of Rogers that the Calcutta School of Tropical Medicine came into existence.

AT the end of nineteenth century the British Government realised the necessity of establishing research institutes of medical science which was partly due to initiative taken by the Indian Medical Congress. The ravages of enteric fever and cholera led to the establishment of a Bacteriological Laboratory at Agra in 1892. The establishment of a Plague Institute at Bombay, which enventually became the Haffkine Institute has already been mentioned. As per the plans of Pasteur treatment in India, the first Pasteur Institute was established at Kasauli in 1900 which was later renamed as Central Research Institute in 1906. Three years later, the King Institute was established at Guindy. In 1907 another Pasteur Institute was organised at Coonoor in South India. These efforts were supplemented in 1905 by creating a cadre of scientific workers known as the Bacteriological Department of the Govenment of India. However the bureaucracy of the Government was creating some difficulties in developing proper research atmosphere. To overcome these difficulties the Indian Research Fund Association was founded in 1911, interestingly enough, two years prior to the establishment of the Medical Research Council in England. Credit goes largely to the wisdom and foresight of Harcourt Butler, then member of the Viceroy's council and Pardy Lukis, the Director-General of Indian Medical Service, for bringing this Association into existence. An important contribution by the Association was initiated in 1918 of what was then called 'Beri Beri' enquiry at Coonoor under the able guidance of Robert MaCarrison. Although it was in great trouble initially, this organisation eventually blossomed into an important national laboratory devoted to nutritional research. It was later named as Nutrition Research Laboratory and at the time of its golden jubilee it was renamed as National Institute of Nutrition which is at present located at Hyderabad. Notable among the various other enquiries started by the Association were 'Quinine and malaria enquiry', '*Kala-azar* anciliary enquiry' and 'Research on indigenous drugs' under Col. R.N. Chopra. After the Independence the name of Indian Research Fund Association was changed into Indian Council of Medical Research in 1949 and the scope of its function was considerably expanded.

WHEN medical research was taking shape in India, an Institute was started at Poona (now Pune) in 1889 to work on the many faceted problem of development and conservation of livestock. It was known as Imperial Bacteriological Laboratory and was shifted to Mukteswar—Kumaon Hills in 1893. Its name was changed to Indian Veterinary Research Institute. Alfred Lingard, designated as Imperial Bacteriologist, took charge of the Laboratory and succeeded in getting three noted bacteriologists—Robert Koch, Wilhelm F.P. Pfeiffer and Goerge T.A. Gaffky, to visit the Institute and advise in the matter of research. The Institute at Mukteswar had eventually its Headquarters at Izatnagar. In the beginning of the century, the Government of India recognised the need for the establishment of a sound system of scientific investigation in connection with agriculture. Thus in 1905, the foundation of Agricultural Research Station and the Experimental Farm (later called the Imperial Institute of Agricultural Research and still later, after Independence, the Indian Agricultural Research Institute) was laid at Pusa (Bihar) with the help of a donation of $ 30,000 made by an American philanthropist Henry Phipps of Chicago. This Institute was later shifted to New Delhi after the Bihar earthquake in 1934. A Royal Commission on Agriculture was appointed in 1926, to examine and report on conditions of agriculture and the rural economy of the country, with particular reference to the measures being taken for the promotion of agricultural and veterinary research and education. It was as a result of the recommendation of the Commission that the Imperial (now Indian) Council of Agricultural Research was brought into being in 1929 as a registered society, with the primary object of promoting, guiding and coordinating agricultural research and education throughout India.

THE first attempt to organnise medical research in India was made in 1884, when the Indian Medical Congress recommended setting up of a medical research institute

Although research work was going on in various universities of the country during the British period, there was not much emphasis on 'applied research'. Further there was not much involvement of the Goverment in scientific activities. The Indian Industrial Commission had urged the Government of India in 1918 to promote 'applied' research. The Government took seventeen years to establish a Bureau for Industrial Intelligence and Research. The Bureau was superseded by a Board of Scientific and Industrial Research in 1940 : to advise the Government on industrial research and development of Indian Industry. Dr. Ramaswami Mudaliar passed the following resolution of November 19, 1941 in the Legislative Assembly which led to the formation of the Council of Scientific and Industrial Research "This Assembly recommends to the Governor General in the Council that a fund called the Industrial Research Fund be constituted for the purpose of fostering industrial development in this country and that provision be made in the budget for annual grant of Rs. 10 lakhs to the fund for a period of five years". The Assembly passed the bill. The CSIR was registered on March 12, 1942 as an autonomous body under the Registration of Societies Act XXI of 1860.

S.S. Bhatnagar and H.J. Bhabha played a crucial role in formulating the science policy in the post-independent India, acting as principal advisers to the Prime Minister Jawaharlal Nehru. Their first priority was to create facilities in the form of well-equipped laboratories and to create a well paid cadre of scientific and technical personnel with the thought that such a step would ignite research activities in the country. The second priority was to create necessary facilities to train scientific and technical personnel.

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Misleading Measles

Ramesh D. Potdar

THE clock on the tower of the church struck two loud tolls. Dr. Sharma, smugly under his blanket, turned over barely listening to them. He was just reentering into his dreams when the doorbell rang creating for sometime a raucus. Dr. Sharma jumped up from his bed and half dazed, tried to go towards the main door which was some distance from his bedroom. Before he reached the door, his servant had already opened it and was talking to the untimely intruders on doctor's privacy.

The patient was only a child of two years, lying dazed in the hands of his mother. Dr. Sharma could guess that something was seriously wrong with the child.

As soon as the parents and the child were settled in his small anteroom just adjacent to the main hall he asked the parents what had happened?

The sum and substance of the story was that the child has had high fever for last 4 to 5 days and around 1.00 a.m. or so he threw a ghastly fit where he rolled up both the eye balls, started twitching of all the limbs after making them stiff for a while and was continuously convulsing till a couple of minutes before they had rung the doorbell of Dr. Sharma.

"OH! must be a febrile convulsion—" said the doctor to himself. But as was his habit, he would never allow himself to be prejudiced by first impressions and impulsive intuition. He always believed in "DO IT YOURSELF" by talking, looking and listening by himself as far as medicine was concerned. The parents said that the child has had similar fever about two weeks back but there was no convulsion. Doctor told the mother to undress the child. The first thing that he noticed was the dark spots all over his body especially face and trunk. He knew that the child must have had measles about two weeks back. He was not surprised that the mother never told him so. Taking measles for granted as a disease of no consequence is a very common habit amongst people from all over the world. Some actually feel (wrongly, of course) that measles is a disease worth having and be done with.

Dr. Sharma asked the mother whether the child had measles sometime back. She said "Yes, doctor but he has had a fully blown red rash all over the body, entire heat from her body came out. So we were happy. But suddenly the fever restarted and he got a fit" When Dr. Sharma examined the child, he found that he was semiconscious but was responding to painful pressure on the eyebrows and wringing of his ears. He looked for any stiffness of the neck and any evidence of paralysis of one side (called hemiplegia in medical terms). No such signs were present. He made a provisional diagnosis of "Post measles Encephalitis" which in simple terms meant "Swelling or inflammation of grey cells of the brain". Naturally the child needed hospitalization and active and intensive management.

He sent the child with a note to hospital doctor advising further treatment and assured the parents that though the child was in a dangerous and serious condition at present, it was likely that he would come around by 48 to 72 hours.

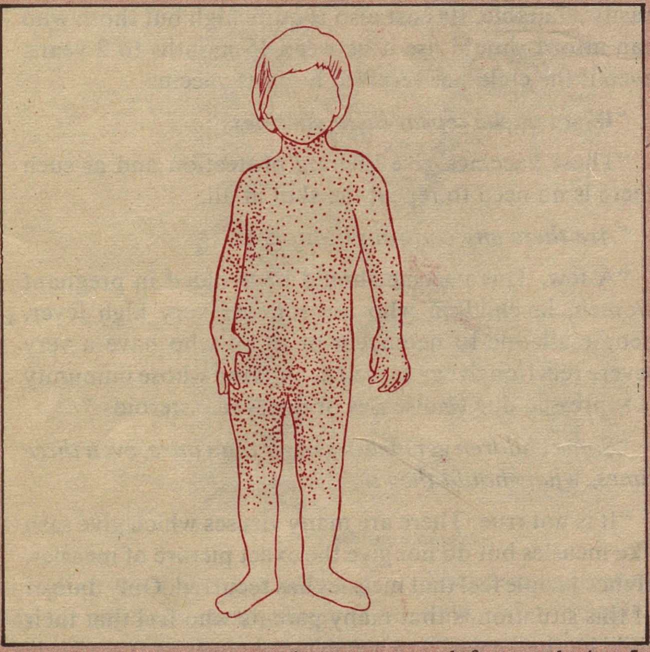
NEXT day on his rounds, he found that the child still had fever but his consciousness had improved a lot and he had not thrown any more fits. "This is a good sign" said the doctor to himself, "the blighter seems lucky to have escaped any permanent damage". He did not tell the parents though, because the good old doctor knew vagaries of measles the deadly disease which could mislead the parents and doctors into a lull and then cast its deadly spell suddenly.

Fortunately, for the family the dawn of third day brought with its bright rays, a bright smile on the child's face. He was conscious, though weak due to the turmoil he had undergone. Parents had a look of gratitude in their eyes when Dr. Sharma told them that "he is out of danger at present but to know more about the deadly disease they should attend his group discussion session at 4 p.m. that afternoon at his clinic.

MEASLES like many other infectious diseases like chickenpox and now eradicated small pox is a virus disease. For those of you who do not know what a virus is, in spite of repeated use of the term I will make it clear. These are germs smaller than bacteria of 20nm to 300 nm sizes which means they can't be seen unless viewed under electron microscope. There are many types depending upon their shapes, contents and ability to cause various problems. Measles as a virus belongs to a large family of paramyxoviruses and contains RNA. It is only one type as far as its ability to generate immunity in the affected person (antigenicity) is concerned. However, there are other measleslike viruses which can cause similar trouble.

"But, doctor, pardon my intrusion," said an old man, *"everybody gets measles in childhood, what is so great about it? All my children and grand children had it and they are all quite well, touch wood".*

Dr. Sharma gave an agreeable nod and said, "yes, Measles is (or rather was) a universal disease. Virtually the whole child and adult population of the world must have had suffered from measles sometime or other in their life, but, he added, 'What we know about measles now, is far more dangerous than we ever thought! "You see", he continued, "the actual disease consists of high



fever, cold, sore eyes running nose, cough for nearly 4 to 5 days followed by red rash starting from forehead to toe and disappearing in the same way as it appears. However, we all feel that once fever settles, everything is going to be fine. This is actually a misleading situation because the real complications which take place in some of the children are far far more dangerous than the main disease"

"Oh, my God, we never knew this", quipped the father of the child, who was recovering from post measles encephalitis. "What are the complications, doctor?"

Dr. Sharma, adjusted the knot of his tie and said, "let us take them one by one, so that we get a true picture of the damage measles can cause. The very first and uniformly common trouble that it causes is a great reduction in the fighting capacity of the child against many other infections. In medical and scientific world it is called 'immunological incompetence'. If we trace many childhood acute and chronic diseases and disorders like even tuberculosis, whooping cough, malnutrition, invariably there will be a history that child was well till it got measles after which the problems have started".

"*Right you are, doctor,*" said a mother of a four year old kid". *"I remember, my son Amit had won a Healthy Baby Competition prize when he was one year old but then he got measles and lost all his health. Nearly for 2 years he remained thin and suffered from frequent colds and coughs which only now are on the decline".*

"What are the other complications? doctor", the mother of our little patient seemed quite anxious. "The most fearsome and fairly common complication is what is called Measles Bronchopneumonia. In this condition, both the lungs of the child are filled up with phlegm and the child starts breathing fast. If any child below two years breaths faster than 50 breathes per minute especially after measles he needs to see his doctor urgently. If neglected it can result into starvation of oxygen to lungs and may even cost him life. Especially in children who are undernourished and underweight this complication can be disastrous".

"But, doctor, in our community we never take medicines for measles, why, we don't even fry things in the house, nor do we cook any nonvegetarian food till the rash completely disappears" said a woman who was visiting the town for a few days.

"Many communities do that and pay a dear price for the same, my dear," said doctor, "though measles is a virus and there is no specific drug available to kill the virus itself, the bronchopneumonia is caused by other types of bacteria who are more dangerous especially in the weakened state of the lungs and body Therefore giving such a child antibiotic treatment is an absolute must. The child must continue to eat (even if he may develop loss of appetite) whatever he is used to, since he needs strength to fight with the double nuisance of virus and bacteria. Whether to eat vegetarian or nonvegetarian diet depends on your food habits and measles virus has no way of identifying whether you are a Brahmin, Vaishya, Kshatriya or Shudra. In that sense it is very impartial", said the doctor in the lighter vein, to bring the point home and correct misbeliefs.

BY this time the audience of Dr. Sharma had become completely captive and there was a hushed silence when doctor took a break for a glass of water.

"Please continue, doctor!" requested an elderly lady, mostly an aunt of a patient.

"Well, the other complication which can be called as a major one which may not kill but maim is post measles encephalitis which comes up about 2 weeks later. This may be either as a direct affection of the grey matter of the brain, or as a result of an antigenic reaction of the virus. In either case there is a grave danger of residual effects in the form of mental retardation, epilepsy or some other defects of the central nervous system. Very very rarely, and mind you, I really mean very rarely, the virus may remain in body for a period of 8 to 9 years and then cause a degenerative brain disease called subacute sclerosing pan encephalitis of SSPE which causes sudden jerks of arms or legs called myoclonus, regression of mental faculties and blindness and slow death over a period of 6 months to one year.

The atmosphere in the waiting room had become gloomy with the dark and tragic picture so eloquently painted by Dr. Sharma who also felt that he had overdone the bite about complications. So he said, "Well, don't be scared, measles can affect almost all the systems and one can go on and on with many long tongue twisting names but suffice it to say that it is a disease not very benign and should preferably avoided."

"Can we avoid it, doctor", was the expected question simultaneously asked by two persons in the audience.

"Yes, of course, very much preventable! Since the advent of the vaccine. You see that the peculiarity of this disease is that it is highly infective even before the rash is seen. So you really can't practice isolating the patient in whom measles rash is seen. This is because by that time all others around him have not only received the infection but are spreading it to their contacts in turn. It is therefore worthwhile immunizing each and every child in the community."

"What is the vaccine called?" asked the old lady.

"Measles vaccine comes either as a single vaccine called measles further attenuated vaccine which gives immunity against only measles and as MMR or mumps, measles and Rubelia German measles effective against all the three diseases named therein.

THOUGH ideally they should be given at 15 months we find that in India, measles is very common after about 8 months. However, if the vaccine is given earlier than 9 months of age it is not effective in creating adequate protective titres of antibody in the blood and hence it is desirable to give measles vaccine at 9 months of age. There are some trials going on with human diploid cell measles vaccine which will be useful from fourth month onwards. That will be a real boon.

"Is the vaccine safe?" asked the old man who had earlier said that it is better to get measles than to take vaccine.

"Yes, quite safe. The reaction consists of mild fever after 8–9 days for a couple of days and occasionally a mild rash like measles. If this vaccine is given within 72 hours to a contact of patient with measles, it can be partially effective and minimize the expression and complications of measles."

"What about MMR?", asked the gentleman sitting next to the old man.

"While measles is available free under governmental programme of universal immunization, MMR is still not easily available. Its cost also is quite high but those who can afford should use it between 15 months to 2 years, even if the child has received measles vaccine.

"When do we repeat these vaccines?"

"These vaccines give lifelong protection and as such there is no need to repeat the shot at all.

"Are there any contraindications?"

"A few. This vaccine should be avoided in pregnant women, in children who are running very high fever, people allergic to neomycin or those who have a very severe reaction to egg as well as children whose immunity is supressed due to diseases or drugs like steroids."

"Some children get measles more than once, even three times, what should they do?"

"It is not true. There are many viruses which give rash like measles but do not give the exact picture of measles. Hence people feel that measles has recurred. Only danger of this situation is that many parents who feel that their child has had measles (when in fact it never had) are likely to refuse measles vaccine or doctors may not give it to the child. In any case it is always safer to give the vaccine than not to give.

"How do we know that the quality of the vaccine is good?"

"If the cold chain is maintained from the manufacturer to the child who receives it the vaccine can be taken as good. It should not be exposed to light and preserved between 2°C to 8°C. Well, that's all for today!" Dr Sharma got up to leave.

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Crystallographer Extraordinary

IN the first quarter of the present century money for conducting research was in short supply in England. One housewife feeling disgusted at the money being frittered away on trivial things in the country wrote to *The Times* lamenting the difficulty of procuring money for research. Soon, a military organisation wrote to her offering money for research on a subject of military interest. The housewife flatly declined the offer because she did not want to conduct research for military goals. When the Second World War started and German planes began to bomb England, every citizen was supposed to register oneself for war duties. But the housewife did not register herself even for civilian duty. When the authorities came to know of this, she was summoned and asked to register herself. But she declined again, even to pay the penalty of two pounds for the default. She was put behind the bar. Nevertheless she pursued her research interests within the four walls of the jail. And not simply that, she made friendship with prisoners and jailers, and discussed the problems facing them. When she was freed, she brought in changes in prison rules and regulations. Such was her courage of conviction against war, her devotion to research, and her human qualities.

Kathleen Lonsdale

That housewife was Kath een Lonsdale, who despite her household responsibilities, rose to become a leading crystallographer in the world and also a leader of scientific and technological matters.

Unlike most women scientists, who belonged to well-to-do families, Kathleen's (Yardley) family always teetered on poverty. She was born on January 28, 1903, at Newbridge, Ireland, to a postman in army. A man who had ran away from his family as a boy, Kathleen's father kept her mother chronically short of money. Their family was large, too. Kathleen was the youngest of the children, of which only six survived. Her father often lived away from the family due to army duties but whenever he came home he was drunk and quarrels followed. Kathleen's mother, who had earlier worked as a waitress and tailor, somehow managed to make both ends meet. She made all her children pledge at a tender age not to touch alcohol. When her father retired from service due to a chronic illness, her eldest brother, who had won scholarships in school, had to give up his studies to earn for the family. Later, he became one of the first wireless operators and went on to start the first wireless operator training school in England.

ALTHOUGH irresponsible as a householder, Kathleen's father had a passion for reading books. He had even developed a novel firing technique when he was at a war front. Kathleen inherited the passion for facts and the bent for research from her father. From the childhood she also developed a distaste for war. During the First World War she had witnessed the shooting of a German Zeppelin and the deaths and miseries of the near and dear. Her church upbringing further convinced her that war was an evil and had to be avoided at any cost. As a student she had a good memory and could recall any subject verbatim. Quite social, she played games, rambled in the countryside, and was a good gymnast. She received distinctions in several subjects, including the Gold Medal of the Royal Geographic Society for obtaining the highest marks in geography.

In higher classes Kathleen was the only girl to take science and so had to join a boys' school. In the school, she was the only girl in her class. Although good at mathematics, she switched over to physics because she did not want to become a teacher of mathematics, the only career then open to a woman. Her headmistress advised her not to take physics because she felt Kathleen would meet stiff competition from men folk. But Kathleen did not heed her advice and joined the Bedford College for women. In 1922 she topped in B.Sc. honours examination which brought her to the notice of W.H. Bragg, the eminent crystallographer, who was one of her examiners. He offered her a place in his research team at the University College, London. For Kathleen this was an opportunity both to earn her livelihood and to do research, and she jumped at the offer. Bragg imparted his love for pure science to her and also encouraged her to pursue her own research interests.

WHEN an X-ray beam falls upon a crystal, the internal arrangement of atoms "diffracts" it forming patterns. In other words, every atom in the crystal structure reflects the X-ray beam. These reflected X-rays superimpose upon one another and produce the diffracted patterns whose measurements reveal the positions of atoms. W.H. Bragg and his son Lawrence Bragg received the 1915 Nobel Prize in physics for developing this technique of determining the internal structure of crystals and opening the field of X-ray crystallography. Bragg and subsequent workers had determined the internal structure of simple crystalline compounds such as common salt. When Kathleen joined the research team of Bragg it was thought that the internal structure of organic compounds, howsoever complex, could also be determined despite practical difficulties. Bragg encouraged Kathleen to determine the internal structure of complex compounds. Kathleen set up the apparatus for studying complex organic compounds and also read Herald Hilton's book on mathematical crystallography. Her knowledge of mathematics enabled her to apply the new theory of space groups to analyse X-ray diffraction patterns of organic compounds and to obtain the internal arrangement of the atoms. Succinic acid was the first compound whose internal structure was determined by Kathleen. In fact, Kathleen received her Ph.D. for this pioneering work in X-ray crystallography.

In 1927, Kathleen married Thomas Lonsdale whom she had met at the University College. When she decided to give up research for the sake of family he objected saying that he had not married her to get a free housekeeper and encouraged her to pursue research. Often, he would help her in setting up apparatus for an experiment. Later, he would also look after the family in her absence. That is the reason why Kathleen later remarked, "For a woman, and especially a married woman with children, to become a first class scientist she must first of all choose, or have chosen, the right husband. He must recognise her problems and be willing to share them". When Thomas secured a job in Leeds, Kathleen had to give up her research at the Royal Institution which she had joined subsequently. In course of time, she gave birth to three children and was deeply involved in domestic affairs but she still did not give up research. She kept herself abreast of the subject by reading latest books, perusing latest journals, doing calculations and keeping in touch with scientists in the field. When her children grew up, she began to devote herself fully to scientific research again. She was the first to determine the internal arrangement of atoms in hexamethylbenzene and hexachlorbenzene. She was the first to show that benzene ring is flat and defined its dimensions. She also determined the internal structure of atoms in kidney stones and both natural and synthetic diamonds.

When the Second World War started and she was put behind the bar as narrated above, she took advantage of this opportunity to look into prison affairs. She made friendship with a number of prisoners, discussed their problems and tried her best to bring in changes in prison rules. On her recommendations, prisoners were allowed to retain their personal belongings, such as comb or handkerchief, which were removed from their person when they were admitted into a jail. After her short stay in jail she had the confidence to talk with any person about anything. Later, whenever she visited any country, developed, developing or underdeveloped, she always paid a visit to their prisons, talked with prisoners and tried to find out how they could be improved.

OVER the years Kathleen through her steady contributions to X–ray crystallography was recognised as a leading scientist in the field. At the age of 43 she was offered professorship at the University College, and later she became the Head of the Department of Crystallography. Her lectures on the subject were a bit difficult to follow because she had little patience with those who could not go by her line of reasoning. In 1936 she also took upon herself the task of bringing out tables on crystal structure determination which became a handy reference for crystallographers all over the world. For her contributions she received several honours and some firsts because she was a woman. In 1945, for instance, she became the first woman along with Marjory Stephenson to be elected a Fellow of the Royal Society, London. In 1968 she was also elected the President of the British Association for the Advancement of Science. She was the first woman to have attained this honour.

Short and bespectacled, Kathleen always wore simple dresses and was ever cheerful. She was practical and persuasive but was also a stickler for rules to the extent of blocking an action. Among her crystallographer friends, she was known as a "Martinet". She also regularly kept a diary which she wrote in her neat handwriting. Till her death on April 1, 1971, she travelled extensively even to the U.S.S.R., China and India, and spoke on topics as diverse as military establishments, drug trade, noise pollution, peace, ivory tower scientists, Vietnam war, problems of industrial civilizations, vanishing flowers etc. She also wrote a number of pamphlets and an authoritative book on crystals and X rays. She was quite concerned about the brain drain from the developing to the developed world and sincerely felt that the latter should compensate the former by establishing schools and colleges there. She was also concerned about the future of the younger generation and her bye word to herself and scientists were—"Never refuse an opportunity to speak at school".

Dilip M. Salwi

Complement Pairs

ANY number, say, *n* greater than 1 can be expressed as a sum of two numbers *r* and *n-r*, *r* varying from 1 to *n*-1. Such pairs of numbers form complements of *n* and the number of such pairs is *n*-1, if the order is taken into account.

Number games involving complements of a number are not so common. Two games requiring the determination of the sum of components of complementary pairs of a number are mathematically interesting and hence worth consideration.

To concretise the game with complements, dice are handy. The numbers on the opposite faces of a dice sum to 7. In other words, the numbers on any pair of opposite faces form 7-complements and there are three pairs of opposite faces.

Consider, say, 4 dice to provide two typical games. Once the insight into them is obtained, the number of dice can be altered. Not only that; any finite number of repeated sets of complement pairs of a number greater than 1 could then be handled.

Game 1

Let the numbers on the faces of a dice A, say, be represented by a_1, a_2, a_3, a_4, a_5 and a_6, where $a_1, + a_6 = a_2 + a_5, = a_3 + a_4 = 7$. For convenience, a_6 can even be taken as a'_1, a_5 as a'_2, a_4 as a'_3, etc. And so on, for dice B, C and D.

Roll the four dice. Let the numbers showing up on their top faces be a_1, b_2, c_3 and d_1 without any loss of generality. Let their sum be S. Now $a_1 + b_2 + c_3 + d_1 = S$. Reverse *some* of the dice, say, *two* of them, B and D, so as to make opposite faces show up; add the numbers showing up now to S. So the new sum is $S + b'_2 + d'_1$. Roll these two dice B and D again and add the numbers showing up to the sum obtained hitherto to get say, $S + b'_2 + d'_4 + b_4 + d_3 = T$ (say), again without any loss of generality. Now add the numbers on the top faces of the four dice A, B, C and D in their present position. The sum is obviously $a_1 + d_1 + b_4 + d_3 = G$ (say). The game is *to find T given G*

It can be easily shown that

$T - G = 2 \times 7$ (as *two* dice alone are reversed)

$$T = S + b'_2 + d'_1 + b_4 + d_3$$
$$= a_1 + b_2 + c_3 + d_1 + b'_2 + d_1 + b_4 + d_3$$
$$= a_1 + c_3 + b_4 + d_3 + (b_2 + b'_2) + (d_1 + d'_1)$$
$$= G + 7 + 7$$
$$= G + 2 \times 7$$

If p dice are taken and q of them are reversed and sums on similar lines obtained, if follows that

$$T = G + 7q$$

Generalising further, if p sets of n-complement pairs are taken, q of those sets ($q < p$) are taken in reverse order, and sums on similar lines obtained, it follows that:

$$T = G + nq$$

Game 2

A more involved game can also be set up. Concretising again the game with four dice, the game now is to find, say, $a_1 + b_2 + c_4 + d_3 = S$ (say) given in a rolled position and $a_1 a'_1 + b_2 b'_2 + c_4 c'_4 + d_3 d'_3 = P$ (say) and $a_1 b_2 + a_1 c_4 + a_1 d_3 + b_2 c_4 + b_2 d_3 + c_4 d_3 = Q$ (say) in the same rolled position. It can now be seen mathematically:

$$a_1 a'_1 + b_2 b'_2 + c_4 c'_4 + d_3 d'_3 = P$$
$$\rightarrow a_1(7-a_1) + b_2(7-b_2) + c_4(7-c_4) + d_3(7-d_3) = P$$
$$\rightarrow 7(a_1 + b_2 + c_4 + d_3) - (a_1^2 + b_2^2 + c_4^2 + d_3^2) = P$$
$$\rightarrow 7(a_1+b_2+c_4+d_3) - (a_1+b_2+c_4+d_3)^2 + 2(a_1 b_2 + a_1 c_4 + a_1 d_3 + b_2 c_4 + b_2 d_3 + c_4 d_3) = P$$
$$\rightarrow 7S - S^2 + 2Q = P$$
$$\rightarrow S^2 - 7S - (2Q - P) = 0 \text{ as } 2Q > P.$$

This shows that 2Q–P can be split into two factors, f_1 and f_2, such that $f_1 - f_2 = 7$, and it follows:

$$S^2 - f_1 S + f_2 S - f_1 f_2 = 0$$
$$(S - f_1)(S + f_2) = 0$$
$$S = f_1 \text{ or } -f_2.$$

Omitting the negative solution, $S = f_1$

As before, the game can again be generalised to cover first p dice and then p sets of n-complement pairs.

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Remembering Places

Medha S. Rajadhyaksha

A NEW model of a computer, with a new set of dramatic functions leaves us breathless. We marvel at the speed of computation and at the complexity of information stored 'bit' by 'bit' in the lifeless machine. We wonder at the 'memory' stored, integrated with new information and retrieved at the touch of a key. Yet, we often fail to admire the assemblage of a far more complex system, with many delicate, intricate functions caged in the modest space of our cranium—the bony box that lodges our brain. This throbbing, pulsating, mass of cells transmits information without fatigue and with remarkable reliability through the years spanning the life of an individual. It performs the mundane neural functions that keep our body machine running as also the higher functions that culminate in 'consciousness'. It executes primitive functions that form our 'instincts' together with special capacities of thought and jurisdiction. All these attributes are lodged in a pattern of simple network of cells. Our sensitivities, our artistic aspirations, our likes and dislikes, our fears and happiness are physical realities—in the form of these cells—the neurons. These are the cells, helping us 'learn', accumulate and store our knowledge—that we could recall at will. These are the cells that make us intelligent beings.

As Carl Sagan, the American Cosmologist puts it, "intelligence is not information alone, but also judgement, the manner in which information is coordinated and used. Still, the amount of information to which we have access is one index of our intelligence". This capacity to store information, accessible instantly on demand has another popular name, 'memory'. Memory, no doubt, has been one of the major, though not the only index of measuring intelligence. Regrettably, more often than not, knowingly or unknowingly, this index dominates our critical evaluation of individual competence in school and college examinations. This property of our brain, which plays such an important role in our social and personal existence, has been very difficult to study and it is only recently that more definite information is available.

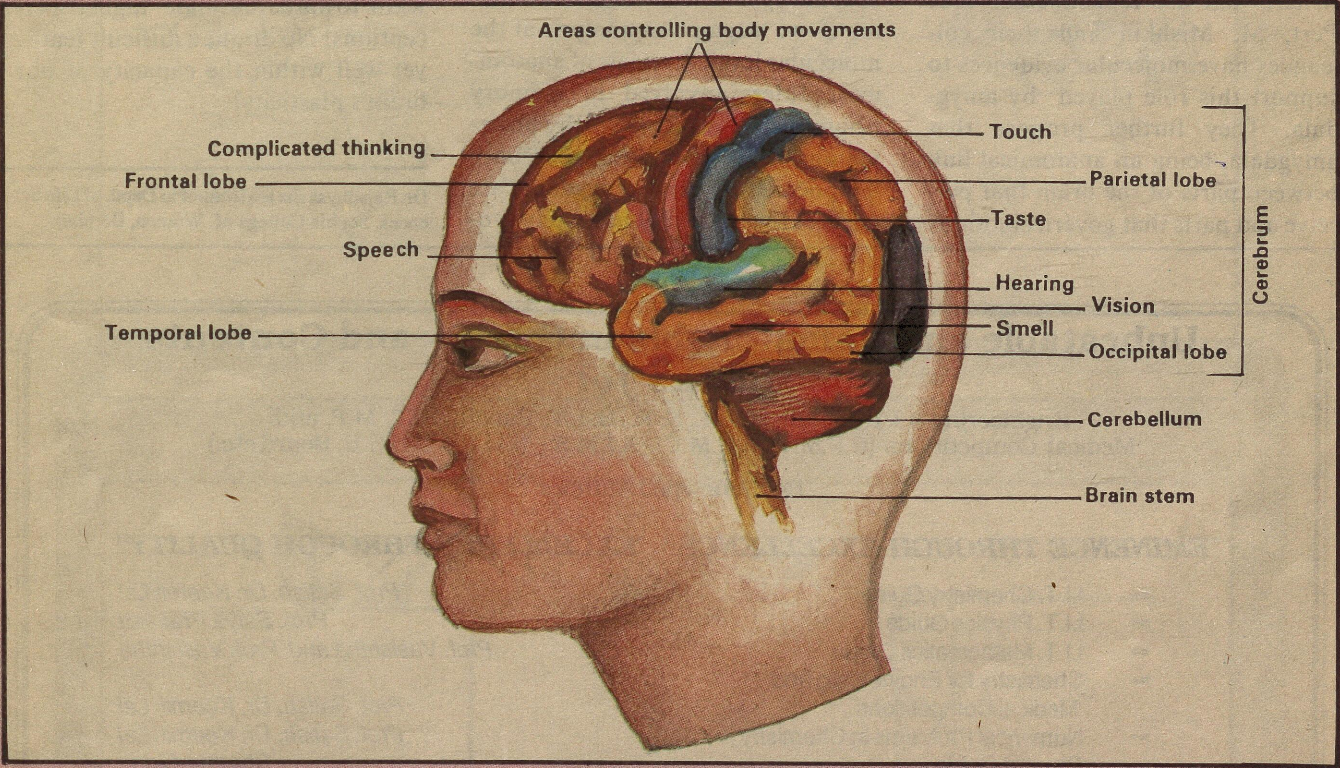
A set of early experiments on memory in this century was carried out by the well known psychologist Karl Lashley. His work culminated in an essay entitled 'In search of engram'! However, the essay did little to encourage further studies on memory, for it suggested that 'engram' the 'memory traces' did not exist. Memory appeared to be hazily spread—the diffused property of the brain—inaccessible to any concrete experimental approach and thus bringing the scientists to a dead end. It was the work of two other psychologists, Donald Hebb of Montreal and Jerzy Konorski of Poland, that revived specific interest in 'memory cells'. Their suggestion, that a group of cells made very definitive contacts to form 'memory circuits', opened new avenues of research. Soon reports poured in to substantiate the idea that the brain had vibrant cell assemblies, making connections of permanent nature in response to persistent sensory information drilled in. On the other hand, few and inconsistent sensory inputs do little to keep a neural connection intact for a significant time. (That is to say—if one doesn't read one's lessons frequently enough—memory fails!). The visuals we see, the musicals we hear, the aroma we inhale all pass through neural pathways in the cerebellar cortex (the outermost part of the brain) that transforms these experiences into things to be remembered. However, decisions as to which perception is worth remembering is made in the deeper structures of the brain.

When the twentyseven year-old machine, by the name H.M., got operated for relief from epilepsy, in 1953, little did he know that he would find a place in neurophysiology books. Twentyeight years after his operation Suzanne Corkin and her colleagues from Boston report "—he does not know where he lives, who cares for him or what he ate at his last meal." H.M. was operated by W. Scoville and B. Milner at Montreal Neurobiological Institute and a very specific part of his brain was bilaterally removed—'hippocampus' was the name of this part. Needless to say, such a surgery was discouraged in times to come. However, neurological cases that show amnesia to a variable degree, either due to accidental brain damage or disease, have supported the suggestion that hippocampus is the major anatomical location involved in the storage of memories, especially for longer time period.

CLASSIFIED as a part of the 'Limbic System', sitting deep inside, snugly against the almond shaped—'amygdala' is the 'hippocampus'. As the name suggests it looks like a tiny 'sea horse'. Each one of these structure is lodged on either side of the basal region of the brain.

one sensory information—for circuits often are interconnected. An advertisement seen several times over, makes a strong impression—of the visual and of the jingle. Hippocampus helps store these impressions. A similar tune heard later brings back in a flash the visual too—for memory did not get stored in isolated sets of neurons but as superbly mixed, interlinked pathways—criss-crossing and stimulating each other. (These are the target pathways of a product campaign—aiming at mak-

diencephelon or 'between brain'. It links the middle part of the brain (mesencephelon) with its front part—the forebrain. The thalamus is the station that responds to a signal demanding recall of the stored cortical treasure! Well ramified connections from the thalamus touch almost all the sensory pathways engraved as memories. It is the thalamus that passes on the information to the cortex as to which 'action replay' should be switched on. An appropriate neural circuit touched upon makes us



Major divisions of the brain

Very closeby is the edge of the temporal lobe—as it folds inwards and upwards on the lateral sides of the brain. It is to the hippocampus that important sensory pathways from the cerebral cortex report their perceptions. If the perception is strong enough to stimulate the hippocampus, a fairly strong neural connection is established in the cortical region that can be replayed. The replay could bring back more than

ing the advertisement an experience to be remembered—though the visuals and the tune may have little to do with the product propagated!). Hippocampus is not the only one so intricately controlling our ability of storing inputs. Another very important station involved is the thalamus, located in the center of the brain. Thalamus along with another partner, hypothalamus forms the connecting part of the brain—the

rush back through time, to recapture experiences of the days bygone!

Remembrances bring back associated emotions too. Emotionally touching encounters are better remembered. In fact, impressions made when lit with emotions like rage or fear are often out of proportion. This intermixing of emotions and sensory information is a complex interaction—a difficult proposition for investigation. However, experiments on other primates offer some information. A study conducted by H. Khiver and P.C. Bucy on monkeys suggest that 'amygdala' is important for development of association between memories and emotions. With its anatomical partner 'hippocampus', the amygdala forms the structure that surrounds the hypothalamus. The hypothalamus totally rules our emotion and is in league with the amygdala—together they form the complex that gives an emotional tone to the experiences that are remembered. C.B. Pert, M. Mishkin and their colleagues have molecular evidences to support this role played by amygdala. They further propose that amygdala, being an anatomical link between parts of the brain that perceive and parts that govern emotions it may play a role of a 'selector'. Anything emotionally important receives "selective attention" and is perceived better. A sensitive perception helps remembering an experience better. This delicate role of amygdala makes it an important locale in the scheme of registering and retaining worthwhile infor-mation.

THE story is by no means complete—yet more lacunae become apparent in our understanding as we attempt an analysis at the molecular level. A review of anatomical centers involved in memory brings forth some noteworthy observations. It is interesting that both 'hippocampus' and 'amygdala' are parts of the brain that have long evolutionary history—they have developed from our original 'archibrain'. It is these two primitive parts that seem to screen our sensory information and help store it! Our so called 'higher functions' are well under control of the fundamental and universal anatomical centers! We could barely be called advanced as long as these centers, charged with primitive emotions of anger and fear control our perceptions. A conscious freedom from these emotions, as we suffer the sensory inputs, is the only step forward towards ultimate 'higher' perceptions! No doubt a difficult feat—yet well within the capacity of our brain's plasticity!

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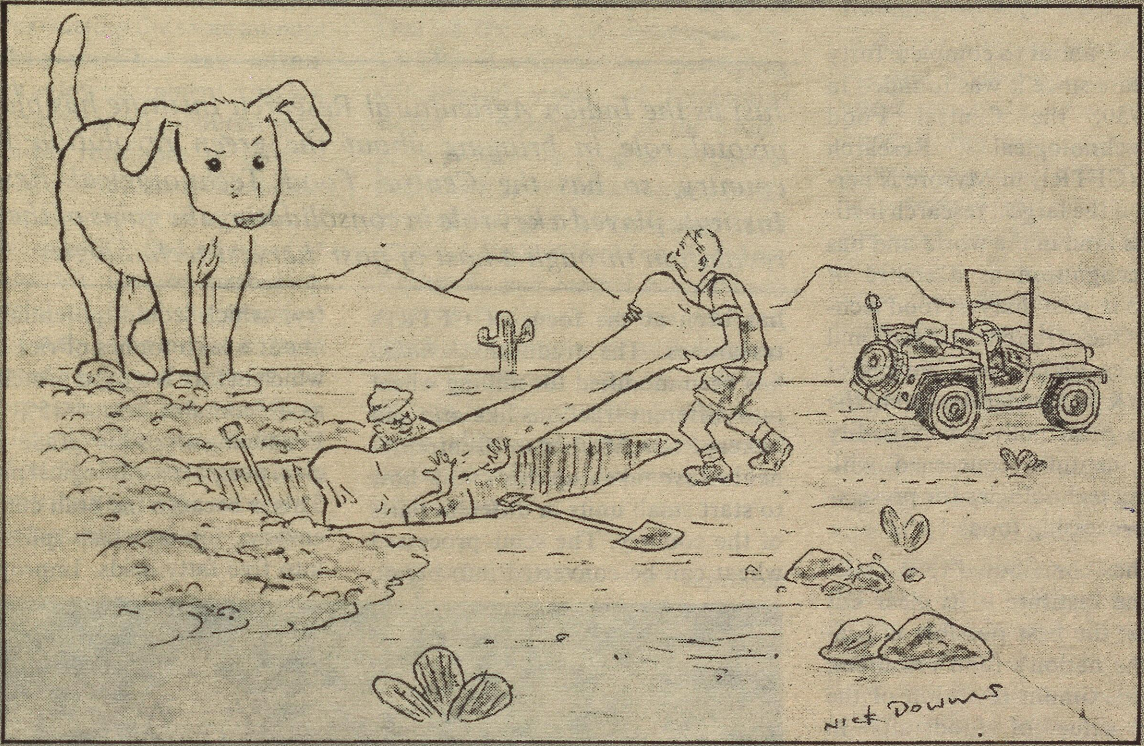
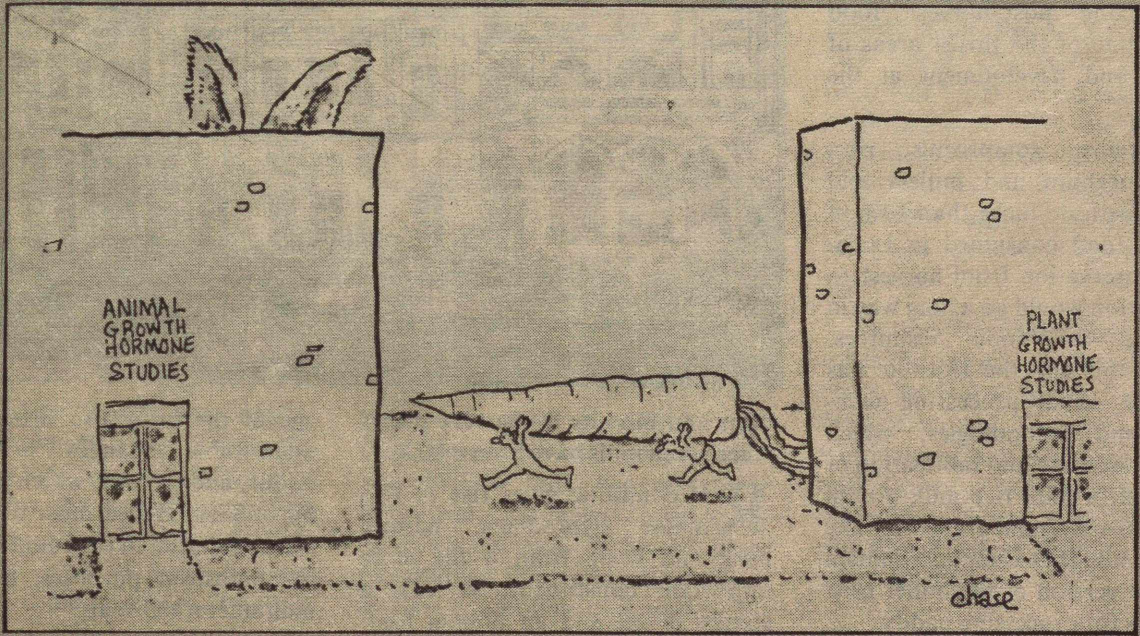




From *Science*

Central Food Technological Research Institute

Just as the Indian Agricultural Research Institute has played a pivotal role in bringing about the green revolution in the country, so has the Central Food Technological Research Institute played a key role in consolidating the gains of the green revolution through a host of post-harvest technologies

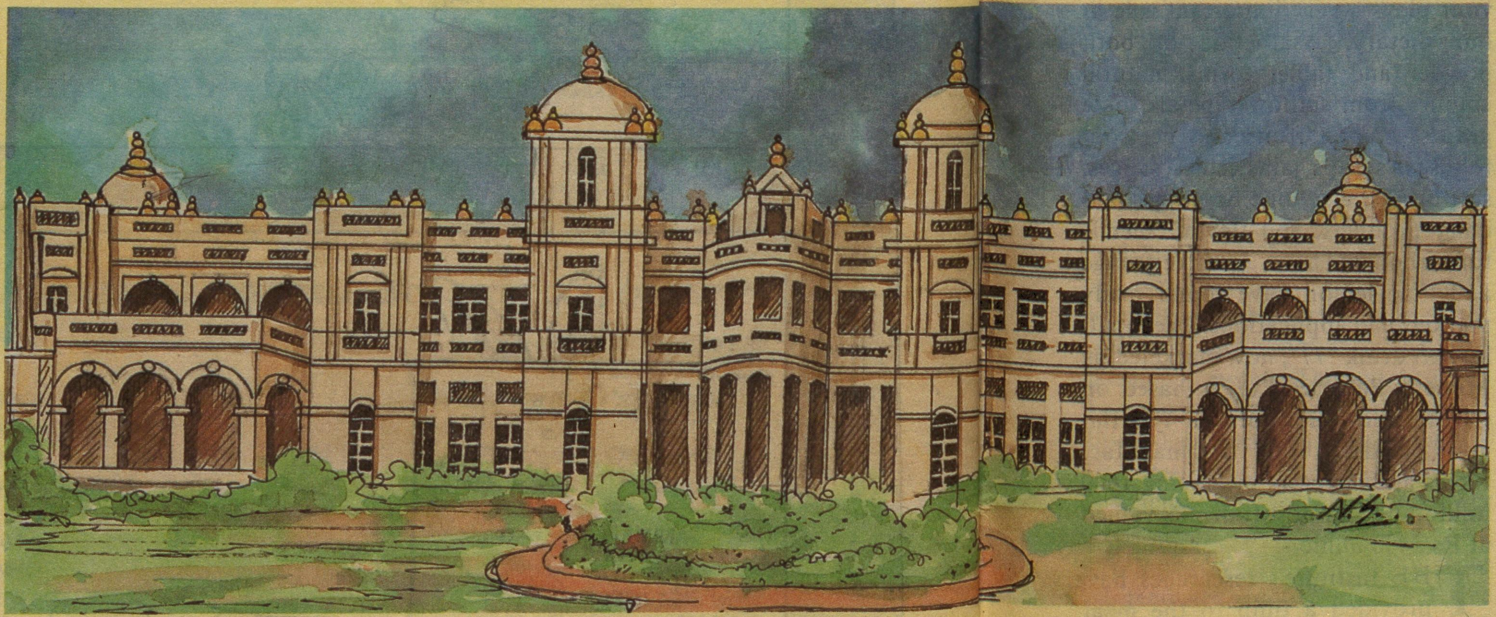
JUST about to complete forty years since it was founded in 1950, the Central Food Technological Research Institute (CFTRI) in Mysore is perhaps one of the largest research institutes of its kind in the world and has gained recognition as a centre of excellence in post-harvest food technologies. One of the chain of national laboratories under the Council of Scientific & Industrial Research, the CFTRI is principally a commodity research institute, concerned with developing technologies for preserving and processing foods.

What has contributed to the success of the Institute is its clear-cut objectives: the best possible utilization of the nation's food resources, and the maximum retention of the nutritive value of foodstuffs in general and vegetable-based ones in particular.

Minimizing post-harvest food losses is one of the thrust areas of research and development at the Institute.

Foodgrains comprising rice, wheat, sorghum and millets and pulses constitute more than 80% of the total food consumed in India. Their conservation from harvest to consumption would go a long way in stretching the food resources. Towards this end the Institute has developed cereal processing techniques and technologies, which include the design and fabrication of a destoner, a mini rice mill, a mini wheat mill and a mini grain mill. The mini rice mill, for example, is a much improved version of the huller used in villages for processing paddy.

Providing milling technologies which villagers can afford and use has been at the focus of CFTRI's researches. The traditional *chakki* has been modified for milling wheat into different fractions like *atta* and bakery flour. More than 70 entrepreneurs have taken up this know-how to start small units in different parts of the country. The semi-processed wheat can be converted into bread, buns and biscuits in the very places where such mills have been installed.



RICE milling gives rise to two major byproducts, namely husk and bran. Bran is the more important constituent, as it is a source of oil and an animal feed. About 5 million tonnes of rice bran are produced annually in the country, which could potentially yield about 6 lakh tonnes of rice bran oil, which in turn is a good protein source as it contains about 15% protein. Producing an edible-grade oil, however, poses technological problems. This is because the bran contains an enzyme, lipase, which splits the fats into free fatty acids. Improper storage of the bran also brings about undesirable changes in colour, odour, and flavour, which affect the oil quality. Hence most of the rice bran produced in the country is used for industrial purposes, as in the manufacture of soap.

One of the novel methods the Institute has developed for stabilizing

bran is a chemical process in which the rice bran is sprayed with concentrated hydrochloric acid. The acid-stabilized bran requires a lesser quantity of solvent than raw rice bran for extracting the same amount of oil. The process has many advantages such as low equipment cost, low energy consumption, reduced processing time, resistance to infestation, etc. Moreover, chemical stabilization can be adopted in all types of mills, big or small, and all types of brans, whether raw or parboiled. Commercial trials of the chemical process of stabilizing rice bran have been started in several mills of the Food Corporation of India in South India. Utilization of the rice bran as a source of edible oil would go a long way in contributing to the success of the technology mission on oilseeds.

PROVIDING improved milling technologies is one strategy for stretching the foodgrain resources of the country. An equally important strategy is offering better storage conditions. This is because more than 10% of foodgrains produced in the country is lost for human consumption because of the ravages of microbes, insects, rodents and birds. Improving the methods of storing, handling and conservation has therefore received the attention of the Institute right from the beginning. One of the earliest techniques the CFTRI developed for protecting commercial stocks of foodgrains stored in warehouses is the Durofume process—a process of fumigation which destroys rodent and insect pests at all stages of development and prevents fresh infestation. Ethylene dibromide and methyl bromide are used as fumigants in this process, which has proved to be both efficient and economical. Variants of this process for home-scale fumigation, using tablets and ampoules containing the fumigants, have stretched the application.

HARNESSING the vegetable protein resources of the country is a fruitful line of research. Here the Institute has specialized in formulating a bewildering variety of foods and beverages. The infant food, Amul Baby Food for example, has become a byword for CFTRI. Yet the significance of the research that led to this household product is unknown to the millions of its users. This baby food is based on buffalo milk, which had never before used for making infant foods owing to its high fat content and high curd tension. Before the CFTRI breakthrough and its commercial establishment in the 1960s India was solely dependent on imported baby foods and these were formulations based on cow's milk. The Amul Baby Food is as much of an economics breakthrough as it is a technological marvel. Buffalo milk has a definite advantage economically over cow's milk as a raw material for manufacturing infant foods and milk powder, as large amounts of butter fat obtained as a byproduct bring down the cost of production.

The infant food is produced both by roller-drying and spray-drying methods.

Since 1960s the Kaira District Cooperative Milk Producer's Union in Anand, Gujarat, has been producing and marketing the infant food under the trade name Amul Baby Food. Other brand names such as Vijayaspray and Milk Care, which have entered the market in recent years, are also based on the CFTRI technology. The country produces more than 50,000 tonnes of baby foods worth over Rs 2000 million.

Producing protein-rich foods from the easily available oilseed cakes is one of CFTRI's widely acclaimed pieces of work. The starting material for the preparation of several of these foods is specially processed edible flour from groundnut cake. First in this series of foods is the well-known Multipurpose Food, a blend of edible groundnut flour and Bengal gram flour in 3:1 ratio, fortified with vitamins and minerals. With about 42% protein, MPF provides 360 calories per 100 g. Another formulation, known by the generic name Bal-ahar, consists of 70% wheat, 25% edible groundnut flour and 5% skimmed milk powder or Bengal gram flour, fortified with minerals and vitamins. With about 22% protein, Bal-ahar provides about 400 calories per 100 g. It is being used in several nutrition programmes.

To supplement the diets of children in the age group of 6 months to 5 years, several weaning foods have been developed. Energy foods, protein isolates, and a vegetable toned milk known as Miltone are some of the nutrition foods which have found widespread use in community feeding programmes.

THE Institute has added a new dimension to the traditional

foods of the country by introducing convenience foods—foods which cater to the needs of the middle and upper classes. The range of such instant mixes and ready-to-use formulations is ever growing. Though not by design, these convenience foods have popularized South Indian dishes like *dosa, idli, vada, jilebi, jamun* and many crispies and snacks. Add to these the tamarind juice concentrate and tamarind powder with their brand names like Tomcon, Tampro, Dri Tam and Ranga you have all the recipes which make the working lady's life in the kitchen a pleasurable chore.

About 54 million tonnes of fruits and vegetables are grown on 5 million hectares in the country. However, 10 to 30% of the produce is lost owing to spoilage before it reaches the consumer. Preventing such losses is essential not only for export but for domestic consumption as well. Hence the Institute has pioneered the development of a package of technologies from the harvesting stage to the packaging stage to minimize spoilage losses. These include, for instance, the optimum time of harvesting fruits like bananas, mangoes, guavas and oranges; applying an antifungal formulation on the cut ends of banana bunches; techniques of dehydration of bananas, grapes, potato, carrot, onion, cabbage, beetroot, etc.; and development of fruit-based products like clarified juices, beverages, juice powders, fruit bars, and fruited cereal flakes to absorb seasonal surpluses. The phenomenal growth of the fruit-processing industry in India owes not a little to the technologies offered by the CFTRI. Its consultancy services in this area have spawned fruit and vegetable processing plants in many states—Karnataka, Kerala, Bihar, Haryana, Maharashtra, Punjab, Goa and North Eastern states.

PLANTATION crops like coffee, tea and cocoa as well as spices constitute one of the important segments of the Indian economy with immense potential for earning foreign exchange. Post-harvest technologies for plantation crops have therefore received the attention of this Institute since its inception. High-quality spice oleoresins and oils, dehydrated green pepper with its characteristic flavour and colour, monsooned coffee beans with golden brown colour and mellow flavour are examples of technological innovations arising from the work of CFTRI. The economic benefits accruing to India's international trade and commerce are considerable though hard to quantify. Much of the research on coffee, tea, cardamom and arecanut is as a result of sponsorship from the respective commodity boards, which attests to the confidence these bodies have reposed in this Institute. Coffee and tea researches have led to the development of a host of products and processes like soluble coffee, coffee concentrates and ready-mix coffee beverages, decaffeinated coffee, carbonated coffee, instant tea (soluble even in cold water) from fermented green leaves, instant tea from green tea leaves, ready-mix tea, and lemon crystals, to mention a few of them.

DEVELOPMENT of food flavours and colours has also been CFTRI's stronghold, for flavour plays a very important role in our dietary. Asafoetida in both powder and tablet forms, natural colours from safflower petals, blue grapes, *kokum* fruits and beetroot for use in syrups, jams, jellies, sauces, soft drinks, alcoholic beverages and dairy products, and flavour blends for carbonated beverages like orange and lime-lemon have found ready markets and applications. The familiar soft drink "77", now marketed by Modern Bakeries Ltd, is based on CFTRI know-how for cola-type flavour blends. About fifty manufacturers are currently producing 1600 million bottles of soft drinks valued at Rs 1400 million.

THE Institute's researches have provided a fillip to the meat, poultry and fish industries. Here the laboratory lays emphasis on developing new consumer products, improving the quality of known products, and offering new storage packages. Well-known products are the concentrated meat gravy, corned beef, sausages, egg powder, and fish meal oil. The value of the average annual commercial production of meat products based on CFTRI technology is estimated at about Rs 8 million. The Institute has also been offering special nonvegetarian foods to the personnel of the Antarctic expeditions. Such foods include meat chunks in brine or curry, keema in curry, chicken in brine/curry, sausages and ham in brine, fish pickle, and freeze-dried shrimp. Most of them need only to be heated or reconstituted with hot water before being consumed. To meet uncertainties and emergencies in the hostile environment, an emergency ration—vegetarian though—consisting of specially prepared bread and vitamin tablets, as well as canned drinking water, also formed part of the food kit. These foods are not only nutritious but highly palatable.

APART from groundnut-based foods to bridge the protein malnutrition gap, the Institute has paid much attention to the optimum utilization of the scarce oilseed resources of the country, long before the technology mission on oilseeds came into operation. The Institute's researches cover almost all the oilseeds grown in the country. Its process for dehulling of rape and mustard seeds helps remove the bitter and anti-nutritional factors in the extracted meals. The oil crushed from such dehulled seeds by the traditional method is of superior quality with desirable colour and flavour. A machine for dehulling sunflower seeds prior to oil expulsion, also developed by CFTRI, helps increase oil recovery, reduce wax and free fatty acids, while improving the oil colour. Dehulling also improves the efficiency of expellers and reduces the processing cost.

YET another area of research and development on which CFTRI focuses attention is food packaging, right from the point of production to the market and beyond. The packages must be such as to meet the functional needs of the various foods, both fresh and processed. Simple in design and efficient in function, the packaging and pre-packaging techniques make use of agricultural waste products like *arhar* twigs and fibre boards and have found wide application for transporting fruits. Re-usable fish containers and cushioned containers for eggs are some of the utility devices the Institute has offered to small and big producers. Elegant and functional packages like leaf cups and plates and a small machine for producing such containers have not only helped set up cottage-scale industries but have become popular even among elite sections of the society frequenting hotels and restaurants.

Developing unsophisticated techniques and gadgets so that they find cottage-scale application and also generate employment opportunities has also engaged the attention of the Institute. A *papad*-making press, leg-operated as well as hand-operated, which can also be used for *chapati* making, has become a very popular household gadget. Going by the number of entrepreneurs who have taken up the fabrication of the gadget its impact is tremendous.

RESEARCH in biochemistry and microbiology is at the base of all processes and products put out by the Institute. This is because the food industry uses large quantities of enzyme preparations for creating or reinforcing the flavour and aroma of foods, modifying their texture and stability, and improving the assimilation of complex molecules such as the proteins. It is CFTRI's endeavour to meet the industry's needs for these enzymes which are mostly imported. Its researches have led to processes for the production of fungal enzymes like diastase, amyloglucosidase, pectinase, and acid protease, for example. Amyloglucosidase can be used in the production of pure glucose from starch. Pectinase is useful for clarifying and liquefying pulpy fruits such as guava, banana and apple.

Over the years the Institute has developed well over 270 processes or products in food and related areas. And the cumulative commercial production of various products by these processes over this period is estimated at about 27 million tonnes of products worth about Rs 56,000 million. Viewed from a different angle, the technologies have generated employment potential to the extent of about 68,000 million workdays. In terms of foreign exchange, the amount saved would run into about Rs. 22,000 million besides an amount of Rs 4200 million earned through exports.

As a reference centre for food analysis the Institute acts as an appelate laboratory under the provisions of the Prevention of Food Adulteration Act. CFTRI is also an important centre for training technical workforce in food technology and related fields. It runs a postgraduate course for trainees from developing countries and as the UN University's associated institution it offers advanced training and research in post-harvest conservation and processing of food. An International School of Milling Technology is part of the Institute and offers courses in flour milling technology.

The Institute provides an extensive food information service, known as Food Science and Technology Information Service, with global coverage. CFTRI's regional centres help diffuse the technology it develops.

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COMPUTER

In The World Of BASIC—VIII

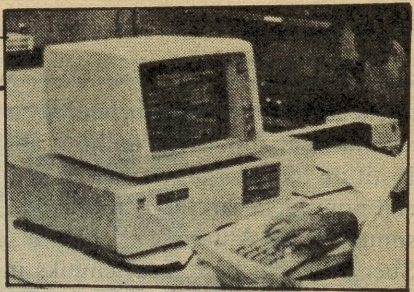
IT may be necessary at times to have a command which could take an operation through different paths, or alternatively in some programs one may have to come back repeatedly to a particular step. In the last part, where an example of candidate's gradation was given, it may be necessary to run the program several times but the steps would be the same. These can be easily done by branching operations. One such branching operation is done by using a simple command called GOTO statement. A GOTO statement is written as:

40 GOTO 100

(a gap should be left between 40 and GOTO and again between GOTO and 100; GOTO can be a single word or two separate words). As soon as line 40 is reached, execution jumps to line 100 skipping the rest of the lines.

Such a GOTO statement is an unconditional GOTO statement. Two Programs, viz., Program-1 and Program 2 illustrate the use of GOTO command. They are identical in all respects except in Program 2 a GOTO statement is inserted in line 40 which now reads GOTO 70. When Program 2 is run, after lines 20 and 30 are executed, it jumps to line 70 skipping line 50 and 60.

Such GOTO statements can be introduced in several line numbers and, further, the command can take it to an earlier line number. Program 3 is a funny Program involving several GOTO statements. However, the reader must note that a GOTO statement should be carefully used, for otherwise an endless loop operation may set in. Program 4 illustrates such a case. After lines 20 and 30 are executed the GOTO statement in line 40 takes it back to line 20 and an endless loop operation continues. The screen gets filled with the same two lines (as to how such an endless operation can be terminated has been mentioned earlier; CTRL and



SCROLL LOCK knobs have to be pressed simultaneously).

Conditional GOTO Statement

Though the unconditional GOTO statement is very useful, there are occasions when control has to be transferred to a particular line under specified conditions. A program involving train reservations over several routes must therefore be so devised that only if the ticket for the first route is not available it should proceed to the next route; alternatively, in grading students, a particular grade A or B or C is given if the total marks are greater than 80% or 70% or 60% respectively.

These can be done by writing a conditional GOTO statement as shown below:

30 IF N>20 THEN GOTO 50

(In some computers it is not necessary to write THEN GOTO; a simple GOTO is enough or THEN 50 will do). In the above, when line 30 is reached, the computer will ascertain if the variable N is >20 or <20; if N is greater than 20, then execution will jump to line 50; otherwise execution will continue in normal sequence. By using proper syntax, six types of conditional GOTO statements can be given:

Case 1 IF N = 20 THEN GOTO 50
Case 2 IF N > 20 THEN GOTO 50
Case 3 IF N >= 20 THEN GOTO 50
Case 4 IF N < 20 THEN GOTO 50
Case 5 IF N <= 20 THEN GOTO 50
Case 6 IF N >< 20 THEN GOTO 50

The reader must note that some of these are slightly different. In case 1, only if N is exactly equal to 20, control is transferred to line 50. In case 2, only if N > 20, control is taken to line

INPUT	OUTPUT
10 REM PROGRAM	
20 PRINT "HALLO !"	HALLO!
30 PRINT "HOW DO YOU DO?"	HOW DO YOU DO?
40 PRINT "THIS IS MY COMPUTER"	THIS IS MY COMPUTER
50 PRINT "HOW DO YOU LIKE IT?"	HOW DO YOU LIKE IT?
60 PRINT "THANK YOU"	THANK YOU
70 END	

Program 1. Without GOTO statement

INPUT	OUTPUT
10 REM GOTO STATEMENT	
20 PRINT "HALLO!"	HALLO!
30 PRINT "HOW DO YOU DO?"	HOW DO YOU DO?
40 GOTO 70	THANK YOU
50 PRINT "THIS IS MY COMPUTER"	
60 PRINT "HOW DO YOU LIKE IT?"	
70 PRINT "THANK YOU"	
80 END	

Program 2. Above with GOTO statement

50. But in case 3, whether N = 20, or > 20, execution will jump to line 50. The same holds for case 4 and case 5. Case 6 implies that only if N is not equal to 20, then control should be transferred to line 50 (the symbol >< stands for not equal to).

Program 5 (referred to briefly in last part) shows the use of one such conditional GOTO statement. Lines 20 and 30 are input statements and the candidate's name and his marks are entered. Line 40 prints this information. In line 50 a conditional GOTO statement is given. Line 50 reads IF M>= 40 THEN GOTO 80. When execution reaches line 50, the program compares the marks; if the marks are greater than or equal to 40 execution goes to line 80 which prints a statement, CANDIDATE—IS PROMOTED. If however the marks are less than 40, the program continues to the next line and the statement, CANDIDATE—IS FAILED, appears. It may be noted that there are two END statements, one in line 70 and the other in line 90. The END statement in line 70 is necessary in order for the Program not to continue further if M<40.

This Program can be used to evaluate the results of the entire class. Simply retype lines 70 and 90 as :

```
70 GOTO 20
90 GOTO 20
```

After the first candidate's result is processed, the program restarts.

It may be mentioned here that some commands such as PRINT, END can be combined with a conditional GOTO statement as :

```
10 INPUT N
20 IF N>50 THEN PRINT N
```

In this case, if the value of N is greater than 50, it will be printed. Further such conditional GOTO statements can also be used with string variables :

```
20 IF AN$ = "YES" THEN
GOTO 50
```

On reaching line 20, the string variable AN$ will be compared with YES and if they are equal, execution will jump to line 50. It is also possible to make the program jump to two different paths by writing :

```
20 IF N>30 THEN 70 ELSE 100
```

In the above, on reaching line 20, if N>30, further execution will jump to line 70; otherwise to line 100. It is also possible to combine two conditional statements in the same line as :

```
20 IF AN$ = "YES" OR AN$ =
"NO" THEN GOTO 300
```

Here if the string variable AN$ satisfies either of the two conditional control is transferred to line 300.

V. Ramshesh
10 C Kamet, Anushakti Nagar
Bombay 4000 9

```
INPUT                                OUTPUT
10 REM WRONG GOTO STATEMENT
20 PRINT "HALLO!"                    HALLO!
30 PRINT "HOW DO YOU DO?"            HOW DO YOU DO?
40 GOTO 20                           HALLO !
50 END                               HOW DO YOU DO?
                                     (SCREEN BECOMES FULL)
```

Program 4. Wrong use of GOTO statement

```
INPUT
10 REM CLASS EVALUATION
20 INPUT "CANDIDATE'S NAME IS"; CN$
30 INPUT "MARKS OBTAINED ARE"; M
40 PRINT "MARKS OBTAINED BY CANDIDATE"; CN$;" =";M
50 IF M > = 40 THEN GOTO 80
60 PRINT "CANDIDATE": CN$;" IS FAILED"
70 END
80 PRINT "CANDIDATE"; CN$;" IS PROMOTED
90 END
RUN
CANDIDATE'S NAME IS? MURALI
MARKS OBTAINED ARE? 75
MARKS OBTAINED BY MURALI = 75
CANDIDATE MURALI IS PROMOTED
```

Program 5. Conditional GOTO statement

```
INPUT                                OUTPUT
10 REM MANY GOTO STATEMENTS
20 PRINT "HALLO!"                    HALLO!
30 GOTO 70                           HOW DO YOU DO?
40 PRINT "THIS IS MY COMPUTER"       THIS IS MY COMPUTER
50 PRINT "HOW DO YOU LIKE IT?"       HOW DO YOU LIKE IT?
60 GOTO 90                           THANK YOU
70 PRINT "HOW DO YOU DO?"
80 GOTO 40
90 PRINT "THANK YOU"
100 END
```

Program 3. Several GOTO statements

The Symphony Of The Double Helix

THE least common biological denominator of all living things is doubtless the DNA. But what else is common to Francis Crick, the co-author of the double helix of DNA, and John Keats, the creator of the immortal odes? To frame the question differently, why did Francis Harry Compton Crick, the arch reductionist, have to choose *What Mad Pursuit!** for the title of his book from Keat's 'Ode on a Grecian Urn'? For, Keats the romanticist lamented "science would unweave a rainbow".

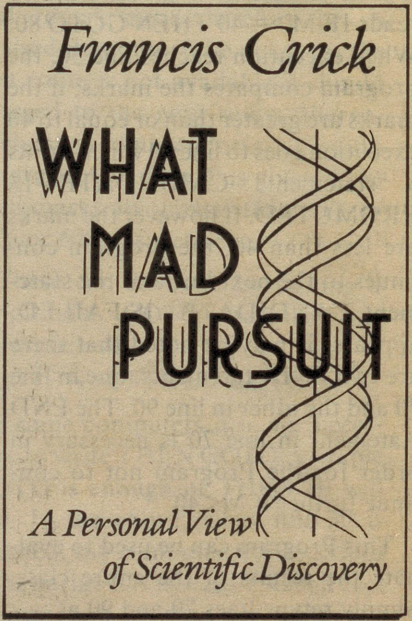
If in the ode Keats was recalling the glories of the past and the permanence of Art in contrast to the evanescence of the nightingale's song, Crick is here reminiscing the golden period at Cavendish, which revealed not only the intrinsic beauty of the double helix but put biology on the forefront of science in the mid-fiftees. If the odes have immortalized Keats the poet, the sheer elegance of the double helix has immortalized Watson and Crick the scientists.

True, the title carries a hint of 'self-mockery', suggestive of the idle venture that nonscientists think scientists indulge in. Nothing could be farther away from truth. The title Crick has chosen for his autobiography is the same one he had chosen, at the suggestion of John Kendrew (the 1962 Nobel laureate in chemistry) for a seminar talk in which Crick had suggested an ingenious X ray diffraction method (known as the isomorphous replacement method) for determining the structure of complex protein molecules. This was also the paper which was purported to mock at the redoubtable Sir Lawrence Bragg's approach to unravelling protein structures. So much for the background.

"I have never known Francis Crick in a modest mood," thus begins James Watson's much celebrated *The Double Helix*. Watson might have been honest. But the picture you get of Crick from his autobiography, coming out later than twenty years after Watson's book, is however one of modesty and restraint. If he was arrogant, it is only because scientists of the calibre of Watson, or Crick, or Medawar, cannot suffer fools gladly. Crick's annihilation of adversaries is however devoid of rancour.

CRICK makes no secret of his undistinguished undergraduate career. All that he could boast of is a second class honours degree in physics. And his first research problem was 'the dullest imaginable': determining the viscosity of water, under pressure, between 100° and 150°C. His lack of expertise when he was nearing thirty, with no published papers at all, did not deter him from taking the road to fundamental research. His greatest asset lay in his ability to turn his head to new things: switching from physics to biology. Would he succeed in pure research? This misgiving vanished into thin air when his friend and the distinguished mathematician George Kreisel said, 'I've known a lot of people more stupid than you who've made success of it."

The most important theme of the book, Crick says, is natural selection. "It is this basic mechanism that makes biology very different from all other sciences." Biology, he con-



tinues, is very different from physics. The basic laws of physics can usually be expressed in exact mathematical form, and they are probably the same throughout the universe. The "laws" of biology, by contrast, are often only broad generalizations, since they describe rather elaborate chemical mechanisms that natural selection has evolved over billions of years.

While Occam's razor is a useful tool in physical sciences it can be a very dangerous tool in biology, cautions Crick. The point that Crick labours is to drive home that a theorist in biology has to receive much more guidance from experimental evidence (however cloudy and confused) than is usually necessary in physics.

Although there are in passing a few self revelations, like his distaste for mathematics or chemistry ('a set of recipes rather than a science', as taught then, of course), which make the autobiography an enjoyable read, what is at the heart of his opus is the account of his voyage of intellectual discovery and his reflections on the process by which biological truth is quarried.

LEAVENING the work are also a few anecdotes. As lowly a creature as a singer in Honolulu nightclub not only knew the names of Watson and Crick but cursed them for all the difficult things she had to learn about DNA in her school. At the other extreme, the Cavendish professor Neville Mott, who succeeded Sir Lawrence, had thought that Watson and Crick were one person—Watson-Crick! There are cute stories about Sir Lawrence and Maurice Wilkins, who are discovered in odd places: Bragg works incognito as a gardener in a certain lady's house in a London suburb (for the love of plants only!) and Maurice makes a beeline to the kitchen in a host's house to see what is cooking.

Crick's lateral thinking to solve the problems of the structure of DNA, which had defied orthodox analysis, is what surfaces time and again in the book. And this is the insight which led to the seamless fusion of physics and biology, now known as biophysics. This, however, is not to underplay the role of Watson, whose arrival at Cambridge, as Max Perutz (another 1962 Nobel Laureate) says in his recent book *(Is Science Necessary?)*, had 'an electrifying effect on us because he made us look at our problems from the genetic point of view'.

If Watson is gossipy and irreverent, Crick could be a gadfly. So let's hear from Perutz how the duo went about their chosen task at Cambridge. "Like Leonardo, Crick and Watson often achieved most when they seemed to be working least. They did an immense amount of hard studying hidden away, often at night, but when you saw them they were more likely to be engaged in argument and apparently idle. This was their way of tackling a problem that could be solved only by a tremendous leap of imagination, supported by profound knowledge." Yet Crick's motto "Reading Rots the Mind" hung on the wall behind his desk in the Cavendish lab!

The three-dimensional structure of DNA must be now familiar to every biology student, as it was to the nightclub singer. To keep his story as simple as possible, Crick relegates the hard core of mechanism of the replicating helix to an appendix. The lucidity with which Crick explains the structure and the replicating mechanism is proof of a great mind which can unweave complexity. The genetic code is also set out in another appendix. Drawing attention to the common misconception (among laymen) that the genetic code means the entire genetic message in an organism, he clarifies that the genetic code is the little dictionary that shows how to relate the four letter language of the nucleic acids to the twenty-letter language of the proteins—like the Morse code which relates the language of dots and dashes to the 26 letters of the alphabet. As in the elucidation of the structure of DNA, so in the genetic code, Crick had a major role to play. In this his partner was Sidney Brenner, for whom Crick has handsome compliments: clarity, incisiveness and fertile enthusiasm.

Having been in the forefront of molecular biology, Crick decided to leave his first love—the borderline science between the living and the nonliving—to take up an equally challenging frontier area of neurobiology—the formation and function of nerve cells. In between, his interests took him to embryology (or developmental biology) and science-fiction-like endeavour, known as directed panspermia, which expounds the idea that microorganisms were deliberately directed to the Earth through space and seeded all life. This dalliance resulted in a popular book entitled *Life Itself.*

One of the problems that have fascinated Crick, who has now been working at The Salk Institute, La Jolla, California, is the neural nets and their connection to what is called REM sleep or dream, REM standing for rapid-eye-movement. The essence of the idea is that memories in the mammalian brain are likely to be stored in a very different way from that in a filing system or a modern computer. Crick admits that his ideas are now speculative. Who knows one day he might become the founder of another frontier science! Of one thing he is certain. In a generation's time researchers in psychology departments would be working on molecular psychology.

Written for the Alfred Sloan Foundation series that seeks to promote public understanding of science, *What Mad Pursuit* is bound to fill the bill. More important, it would provide insights into the clarity of thinking of great minds.

P.S. Shankar

***WHAT MAD PURSUIT: A Personal View of Scientific Discovery,** *by* Francis Crick, *George Weidenfeld & Nicolson Ltd.*, London, 1989, Pp. 182, Price £ 12.95, ISBN 0 297 7953 X

Molecules Within Molecules

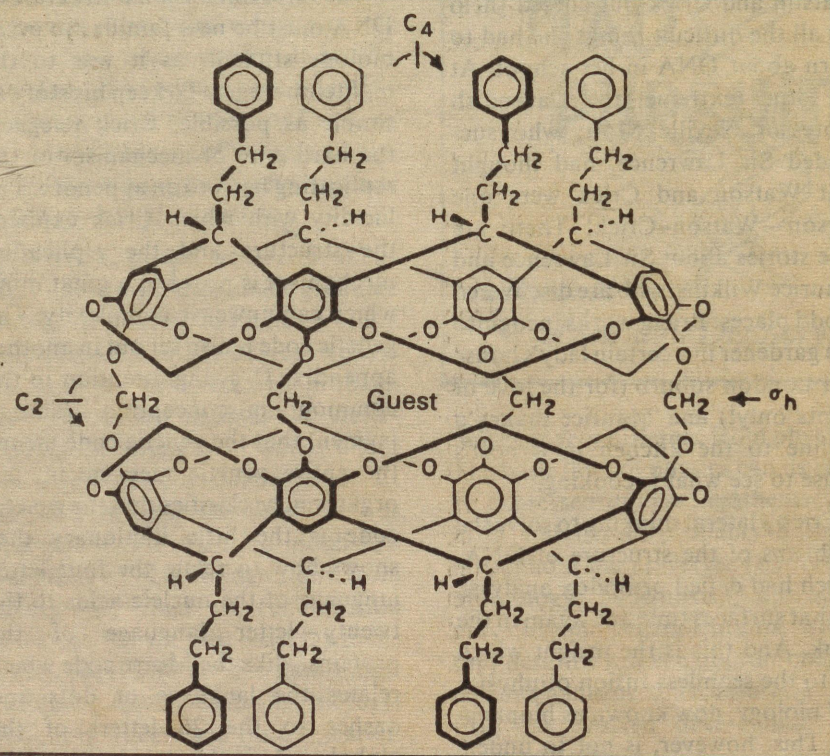
STONE carvers of Tamil Nadu in the halcyon days of the Cholas and Pandyas had carved spherical stone balls in hollow cavities in pillars supporting vimanas in temples and inside the mouths of statues of mythical animals. Alas, such skilled carvers are no longer around, and hardly any living sculptor can match their skills in moulding and shaping stones into a variety of aesthetically pleasing forms as if stone was an yielding mass of butter.

But today in the University of California, Los Angeles, we have a new kind of carvers whose art is no less enthralling than that of the Tamil sculptors of ages past. The new carvers, led by Nobel prize winning organic chemist Professor Donald Cram, do not chisel stones but play around with complicated organic molecules. I should say molecules within molecules, for what they do is to put a smaller 'guest' molecule inside a larger 'host' molecule which is almost a hollow sphere. In chemical jargon, the hollow organic molecule is called a 'carcerand' and the combination of the host and the guest molecules is called a 'carceplex'. The carcerand is a molecular sphere with essentially no holes in it, and it has a large enough interior to accommodate other molecules.

Carceplexes can find applications in two areas: medicine and materials science. In medicine one could visualise two kinds of applications. Because these complex molecules are quite large they may not fit into any enzyme pockets. If the carceplex or the carcerand part of it is not metabolized and if they can pass through physiological systems without being metabolized then one would have the option of putting radioactive materials inside them, and follow their pathway in physiological systems, just as we use iodine in the bloodstream to record angiograms.

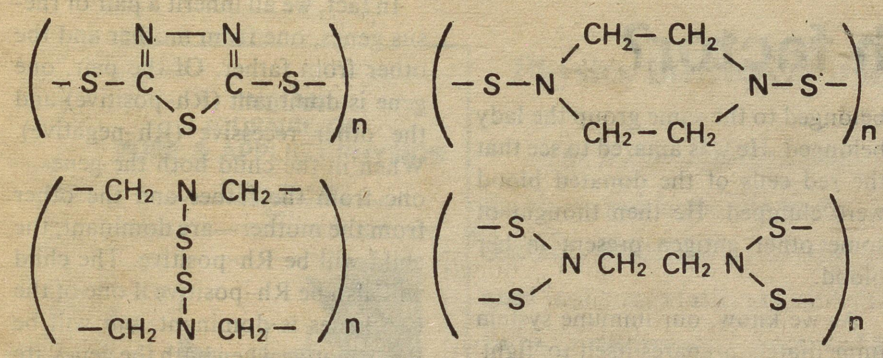
The second possibility is in drug delivery. There would be certain enzyme systems that would attack these very large molecules, possibly immune system enzymes, made specifically to deal with these molecules as part of the immune response. Now, if carceplexes were metabolized, they might be metabolized at specific places and spill their contents—the guest molecule residing inside the hollow spheres—in those places.

Putting a radioactive substance inside a carcerand is rather easy, says Prof. Cram, since radioactive metal ions are quite small. It may even be possible to wrap the metal ion together with ligands inside a carcerand, because carcerands big enough are now being prepared. But, putting drug molecules inside a carcerand is not that easy. Drugs are usually large molecules. One way to overcome this problem is to use hemicarcerands rather than fully spherical carcerands. Currently, Cram and colleagues are trying to put in small antibiotics. Some of the more important antibiotics have to wait till larger-hollow hemicarcerands are built.



A typical caruplex synthesized at Prof. Cram's laboratory

The interesting applications of carceplexes in materials science arise from the solid state nature of the hemicarceplexes. In the solid state, the molecules are virtually frozen,



Some Organosulphur redox polymers evaluated

and can have only very limited translational motion. However, the guest molecules trapped in the hollow cavity can have different degrees of mobility. It is like a static or immobile container with its content being mobile! If the material inside the container has a sizable dipole moment, then by applying an electric field to the material one can cause the dipoles to orient themselves.

MOLECULAR arrangements–whether they are lined up in some order or arranged randomly—can determine the properties of materials, especially their optical properties. Also, lining up random molecules in a particular fashion requires certain specific amount of energy, and the process of ordering and disordering on the application and withdrawal of the electric field takes a certain specific amount of time. By appropriate choice of the guest molecules, one can think of making light switches. When oriented one way, the mobile molecules will act as a light gate and when aligned the other way they would block light. Eventually, such an arrangement can find use in communication industry.

Currently Cram is examining different kinds of guests. For instances, can right-handed and left-handed molecules of the same formula, when used as guests, have different propensities of getting out of the host molecule. Linear molecules like ethanol go in and out much more easily than ring molecules such as benzene. In another exciting set of experiments, Cram is trying out the possibility of changing the gram-positive and gram-negative balance by changing the host molecule's tendency to attract water and other solvents.

What, in the first place, made Cram think of carceplexes? Throughout his research career, Prof. Cram has been looking for making compounds that would have unusual and unpredictable properties. His favourite question is "What kind of molecules look interesting and haven't been made before?" It is this question which led him about ten or twelve years ago to think of molecules within molecules. Says he, "Many times I've felt a bit like Columbus setting sail." He is rarely bothered about applications. "They come later", he says.

Subbiah Arunachalam

Development of Advanced Fuel Cells

WORK on the development of an advanced solid-state method of generating electric power—the tubular solid oxide fuel cell—is being accelerated at the Westinghouse Electric Corporation's Science & Technology Center in Pittsburgh, Pennsylvania, USA. The Center has received a \$ 8 million grant from the US Department of Energy towards completion of the current phase of the project.

The company expects that this highly efficient technology will be ready for worldwide commercial application by the mid 1990s. Because these tubular cells are constructed in modules, they are expected to be economical over a wide range of power ratings for utility, industrial and commercial applications.

Why are fuel cells important? Fuel cells are an attractive option, especially when environmental consciousness is on the upswing all over the world, for quietly transforming the chemical energy in fuels such as natural gas, coal-derived gas and petroleum distillates into electricity without combustion and its associated pollution problems. These create no toxic by-products, nor do they require expensive cleaning systems required by other forms of fossil-fuel based power generation systems.

The all-solid-state construction of the tubular solid oxide fuel cells allows operation at higher temperatures—over 1000°C, and is expected to lend itself to low-cost manufacture. These cells are especially suited for applications where the exhaust heat is used, either for heating commercial buildings or industrial processes or even for combined-cycle power generation in electric utilities where the cell's exhaust is hot enough to drive a steam turbine generator.

The three-kilowatt test units have exceeded 18 months of continuous operation and have shown an availability of over 98%.

S.A.

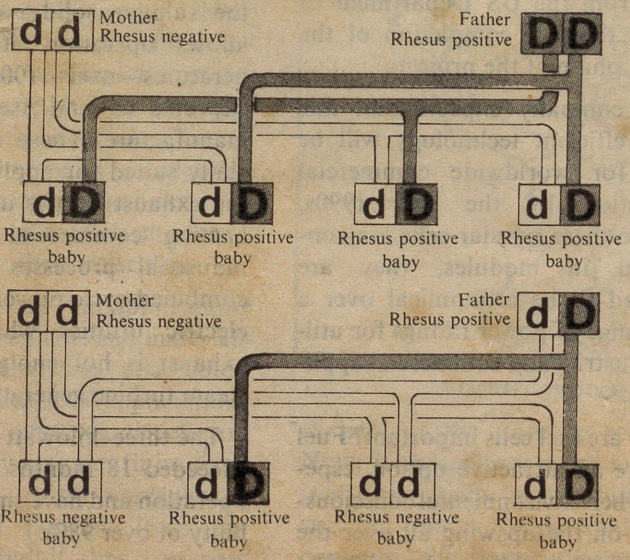
What Is Rh factor?

WHILE discussing ABO system under "Blood groups" in the last issue, we had come across a term—Rh factor. This is another system of blood grouping. In fact, in addition to these two, there are fourteen other blood group systems with more than a hundred blood factors. However, we would restrict ourselves to Rh factor only.

Rh factor is an inherited agglutinogen found in the red blood corpuscles of 85 per cent people who are called *Rh-positive* and the rest 15 per cent are *Rh-negative*. Rh or rhesus factor was first detected in 1939 by a young gynaecologist, Levin, who was working with Noble Laureate Karl Landsteiner in Rockefeller Institute in New York. Since this antigen was also found to be present in the blood cells of Rhesus monkeys, he called it Rh factor. What had actually happened was that a lady, in sixth month of her second pregnancy, needed blood transfusion which Levin did with her husband's blood that belonged to the same group the lady belonged. He was amazed to see that the red cells of the donated blood were clumped. He then thought of some other antigen present in her blood.

As we know, our immune system immediately prepares itself to 'fight' and 'destroy' any foreign substance that enters the body by producing antibody against it. Rh-negative blood likewise reacts when Rh-positive blood is mixed with it. Body takes Rh substance as an intruder. This problem normally occurs during transfusion of blood in a patient who is Rh-negative. When such a patient receives blood from a Rh-positive donor, his blood produces antibodies that will clump the red cells of the donated blood. This may however not be the case in the first transfusion, but in subsequent transfusions anti-Rh antibodies are formed and prove fatal to the patient. Rh-negative blood can be transfused to a Rh-negative patient without any complications.

The inheritance of rhesus factors



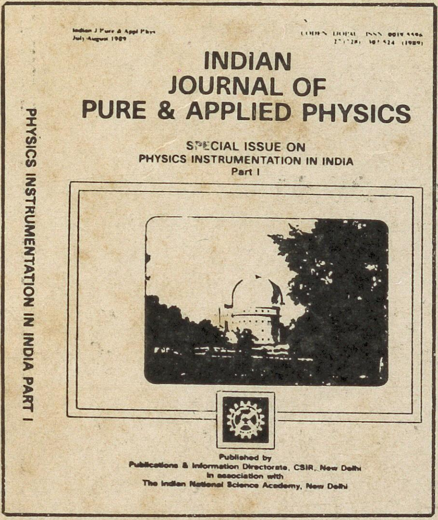
In fact, we all inherit a pair of rhesus genes, one from mother and the other from father. Of the pair, one gene is dominant (Rh-positive) and the other recessive (Rh-negative). When in the child both the genes—one from the father and the other from the mother—are dominant, the child will be Rh-positive. The child will also be Rh-positive if one of the two genes is dominant, but will be Rh-negative when both the genes are recessive.

As stated earlier, in pregnancy Rh factor plays a vital role. Miscarriage, still births, child born with yellow skin (haemolytic jaundice) or anemia are some of the effects caused by it. The problem begins right from conception, especially when the Rh-negative mother conceives a Rh-positive child. Sometimes the foetus' Rh-positive blood comes in contact with the mother's Rh-negative blood stream. This particularly happens during first delivery. On the first occasion, when foetus' blood and mother's blood mix, only the antibody producing mechanism is alerted. In this situation the Rh-negative blood is said to have become sensitized to the presence of Rh-positive blood. If this sensitized blood subsequently becomes mixed with Rh-positive blood again, even 20–30 years later, the antibody making machinery goes into action immediately to make anti-Rh antibodies.

The anti-Rh antibodies so formed in the blood of the mother then pass into the blood of the foetus and clump or destroy its red blood cells. As a result the child may be born dead, or with a damaged heart and liver, or mentally retarded. This condition is known as erythroblastosis fetalis. Roughly one in every 200 babies is at risk from Rh incompatibility.

C.B. Sharma

NEW PUBLICATIONS



Physics Instrumentation in India : Parts I & II

The *Indian Journal of Pure & Applied Physics* has brought out the above publication in two parts in October 1989. The publication contains 50 articles written by specialists associated with sophisticated instrumentation of several prestigious scientific projects in India. Information contained in this publication will be highly valuable to scientists in all disciplines as instrumentation is an integral part of all research activities. Dr. K R Rao of the Bhabha Atomic Research Centre, Bombay, as Guest Editor, has guided in the compilation of this issue.

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