APRIL—MAY 1989

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SCIENCE REPORTER

MAKING USE OF WASTEWATER

ALSO:

HAZARDS OF SMOKING

QUANTUM PHYSICS AND PHYSICAL REALITY

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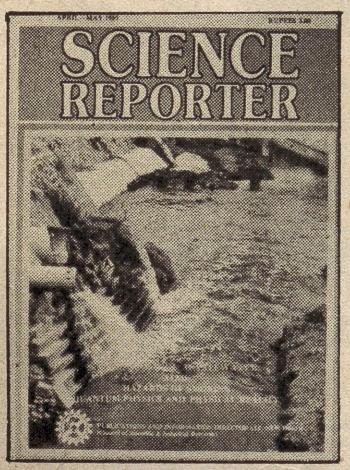

Cover : Effluent discharge into city drain (Transparency courtesy author)

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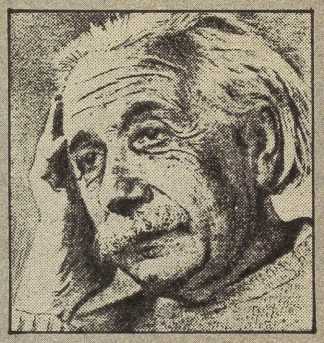

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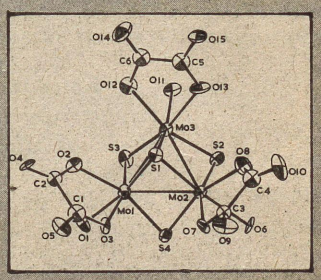

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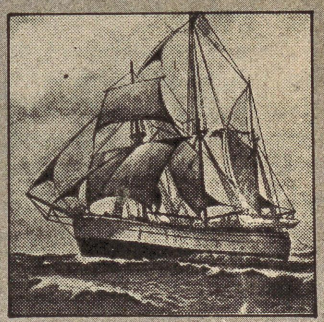

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LETTERS

Leafy spices

Sir, This has reference to the article **Leafy spices** *by* V. Prakash (*S.R.*, January 1989). The article is educative and informative. However, I would like to point out that in the article *Laurus nobilis* (Family-Lauraceae) is referred to as 'Tejpat' in Hindi. The Hindi name of *Laurus nobilis* is *Hab-el-ghar*. In most books [Umrao Singh, A. M. Wadhwani and B. M. Johri (1983), *Dictionary of Economic Plants in India*, ICAR, New Delhi; S. L. Kochhar (1986), *Economic Botany in the Tropics*, Macmillan India Ltd.] Tejpat is the name of *Cinnamomum Tamala*.

Rajesh Arora
No 1 (M) RSIU
C/O 56 APO

Computer memory

Sir, I thank Mukhtar Ahmed for his article **Computer memory** (*S.R.*, January 1989). I have also read other articles on computer in your magazine which were informative. I want to read more on computer and its applications, especially supercomputer.

Kaushik Bora
Publicity Secretary
Guwahati Student's Science Society,
P. B. No. 105, Panbazar
Guwahati, Assam

Useful to everyone

Sir, I was in search of a good science magazine which gives the latest activities in science, when one day I saw *Science Reporter* in the bookstall of Sealdah railway station. It was the January 1989 issue, **Computer memory** *by* M. Ahmad and "Science for the Young" were educative and informative. The life story of the first American woman Nobel Prize winner, Maria Goeppert Mayer, was impressive. If you publish the story of life of a noted scientist in each issue, it will be welcome.

I hope that you will always publish informative articles to win the hearts of *SR* readers.

Anis Ahmad Ansari
H/o Lal Mohd. Kariman
Lane, Garulia
P.O. Garulia
Dist. 24 Pgs (WB) 743133

Barbara McClintock

Sir, I read **Barbara McClintock—an American karmayogi** *by* Dilip M. Salwi (*S.R.*, November-December 1988). It was informative, interesting and educative. She was ignored initially like Gregor Johann Mendel, Charles Darwin, etc. But finally the Nobel Prize was awarded to her in 1983 for the discovery of "Jumping gene". Her life shows that truth finally prevails. Jumping gene can also throw light on how cancer cell develops, how bacteria become resistant to drugs and viruses work, among other things.

Mirtunjay Kumar 'Suman'
M. Sc. Botany
Magadh University, Bodhgaya
Gaya (Bihar)

Pesticide and environment

Sir, Thanks for publishing **Pesticide and environment** *by* Meenakshi Munshi (*S.R.*, Aug. 1988). The article gives information on pesticides and their health hazards. This information is certainly of use to us because we study 'Pesticide residue analysis' in our Ph. D. programme.

Rajendra Kumar Jain
Research Scholar (Botany)
Dr H. S. Gour Vishwavidyalaya
Sagar-470003 (M. P.)

Violation of wildlife protection act

Sir, Our club has come to know that some endangered animals are being sold at Patna. Golden langurs, tiger cubs, leopard and bear cubs, civet cats, slow loris, flamingos are some of the endangered animals caged in cramped, dingy accommodation, fed enough to keep them alive, and not a thought is spared to their very high casualty rates. This secret wild life bazar in Patna is on for a long time. Mir Shikar Toli is located about 11 km from the railway station near Pathar Ki Masjid. The dealers have a network of animal trappers all over Bihar, Orissa, Assam, and Nepal.

According to an estimate made in 1972-73, about Rs. 45 crores worth of birds and animals are exported every year from India. The Mir Shikar of Patna contributes about 10% to 15% of the birds and animals to this annual export. The dealer supplies birds and animals to private parties in India as well as abroad.

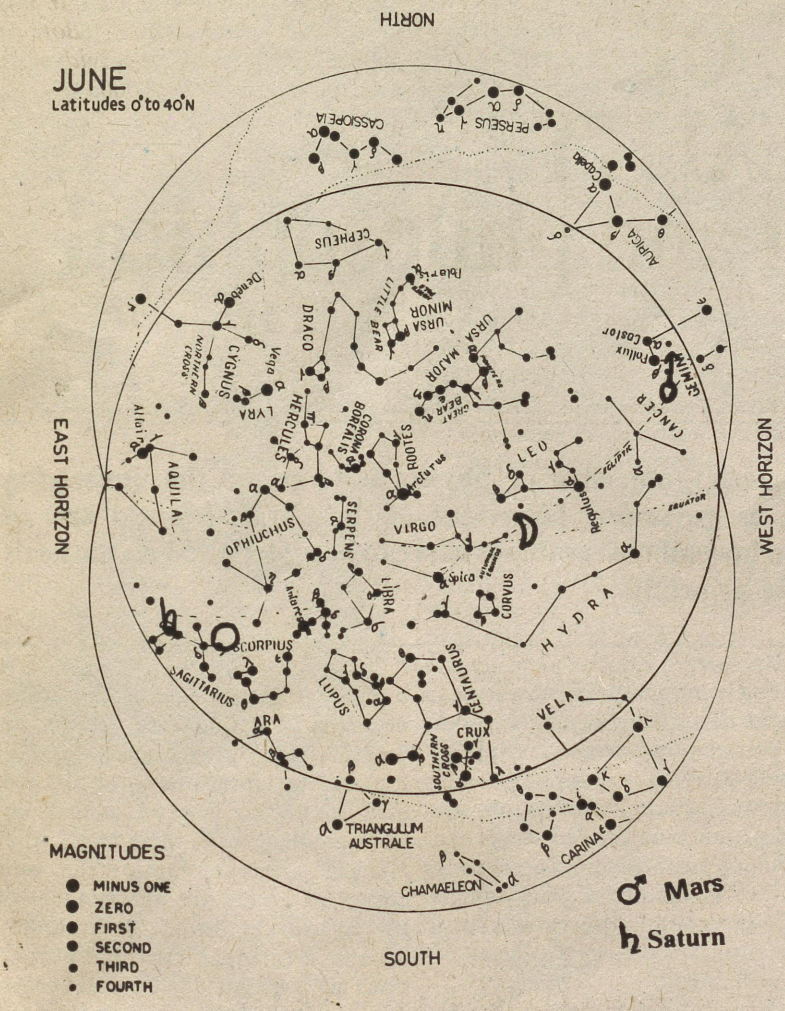
India is a member of CITIES (Convention on International Trade In Endangered Species of Wild Fauna & Flora). In other words, we should not allow any trade (import or export) of endangered species. Our club wants to know how this ruthless trade is still flourishing. We have a right to demand the enforcement of the Wild Life Protection Act.

S. P. Verma
Peacock Nature Club
B-92 ONGC Nagar
Mehsana—384001

To our readers and subscribers

We are bringing out this issue as a combined April-May '89 issue. Consequently current subscriptions would be extended by one issue.

Editor



Planetary positions for June 1989

Date	1st		10th		*20th*	
Planets	R.A.	Decln.	R.A.	Decln.	R.A.	Decln
Mercury	3h 49m	16.6N	3h 51m	15.9N	4h 17m	18.1N
Venus	5h 40m	24.1N	6h 28m	24.3N	7h 22m	23.5N
Mars	7h 29m	23.2N	7h 53m	22.2N	8h 19m	20.9N
Jupiter	5h 02m	22.3N	5h 11m	22.6N	5h 21m	22.7N
Saturn	18h 55m	22.2S	18h 53m	22.2S	18h 50m	22.3S

Adopted from figures supplied by Positional Astronomy Centre, Calcutta

The moon

THE new moon occurs on 4th at 1-23 a.m. and full moon occurs on 19th at 12-27 p.m., I.S.T. The moon passes about nine degrees north of Mercury on 3rd, five degrees north of Jupiter on 4th, about three and a half degrees north of Venus on 5th, one and a half degrees north of Mars on 6th and about four and a half degrees south of Saturn on 20th.

The moon is at perigee or nearest to the earth on 1st and again on 28th and is at apogee or farthest from it on 13th. The lunar crescent becomes first visible after the new moon day in the evening of 5th.

The earth enters the summer solstice on 21st.

The planets

Mercury *(Budha),* is too near the sun to be visible at the beginning of the month. Thereafter it is visible in the morning sky and rises about an hour before sunrise during the month. It becomes direct on 5th. It is in greatest western elongation of about 23° from the sun on 18th. It passes about 3° north of the star Aldebaran *(Rohini)* on the 23rd. It is in Taurus *(Vrisha).* Its visual magnitude varies from +2.3 to —0.5.

Venus *(Sukra),* visible in the evening sky sets about an hour after sunset during the first half of the month and about one and a half hours after it during the second half. It passes about 5° south of the star Pollux *(Punarvasu)* on 24th. It moves from Gemini *(Mithuna)* to Cancer *(Karkata).* Its visual magnitude is about—3.9.

Mars *(Mangala),* visible in the evening sky sets about two and a half hours after sunset during the first half of the month and about two hours after it during the second half. It passes about 5° south of the star Pollux *(Punarvasu)* on 7th. It moves from Gemini *(Mithuna)* to Cancer *(Karkata).* Its visual magnitude is about +2.8.

Jupiter *(Brihaspati),* is too near the sun to be visible during the first three quarters to the month. Thereafter it is visible in the morning sky and rises about an hour before sunrise during the rest of the month. It is in conjunction with the sun on 9th. It is in Taurus *(Varisha).* Its visual magnitude is about—1.9.

(Contd. on page. 208)

QUANTUM PHYSICS AND THE NATURE OF PHYSICAL REALITY – Conceptual and philosophical problems

The primary objective of physics is to probe the underlying principles governing behaviour of the physical world and to explain how all observable events can be understood on the basis of these principles

DIPANKAR HOME

"NATURE! Out of the simplest matter it creates most diverse things, without the slightest effort, with the greatest perfection, and on everything it casts sort of fine veil. Each of its creations has its own essence, each phenomenon has separate concept, but everything is a single whole"—*Goethe.*

"The effort to understand the universe is one of the very few things that lifts human life a little above the level of farce and gives it some of the grace of tragedy"—*Steven Weinberg*

Prologue

The inexhaustible variety and multifaceted complexity of natural phenomena always evoked a sense of 'cosmic wonder' in man. Poets, musicians, artists and philosophers have responded in their characteristically different ways to nature's recondite mysteries. The scientific quest to unveil such mysteries began with an approach to grapple with their intricacies by dissecting and studying them (Baconian maxim of the *dissectio nature*) analytically as well as quantitatively. This approach, apart from its overwhelming practical success, has yielded rich insights into relationships between the various disciplines of intellectual endeavour. The subject of this article concerns physics whose primary objective is to probe the underlying principles governing behaviour of the physical world and to explain how all observable events can be understood on the basis of these principles.

All physical phenomena are comprehended through our senses. Hence it was natural that physics evolved through classification of these phenomena into mechanics, heat, sound and optics. (The word "physics" goes back to Aristotle who wrote a book with that title; its origin is the Greek word *physis* meaning 'growth' or 'nature'). In course of time, interconnections were seen among them and physicists preferred to concentrate on the physical events freeing them from the subjectivity of senses. For example, light was considered independent of the eye, concept of colour was replaced by the frequency of vibrations of light waves. Heat and light were unified as basically electromagnetic vibrations of different frequencies. Sound was divorced from the human ear and replaced by vibrations of the physical medium like air. A key epistemological ingredient in all these methods of analysis is the assumption that outcomes of events are independent of the measuring device. It gradually became a cardinal tenet that physics dealt with actual objects and events, independent of their being observed, and the principal aim was to discover causal (connecting cause and effect) laws governing real events in the external physical world. It was this world-view of classical Newtonian physics which came under searching scrutiny following the advent of a new system of mechanics for the atomic and sub-atomic phenomena, called quantum mechanics.

Quantum world

"Anyone who is not shocked by quantum theory has not understood it"—*Niels Bohr*

Rarely in the history of science has there been a theory as quantum mechanics which calls for such a

Dr. Home is theoretical physicist at Bose Institute, 93/1, Acharya Prafulla Chandra Road, Calcutta-700009

drastic revision of the seminal ideas of the traditional philosophy of science. Quantum mechanics (which is now more than sixty years old) is a strange theory. Despite tremendous empirical success covering a wide range of areas in the microscopic physical world, it remains laced with daunting conceptual difficulties. Worrying doubts persist about its subtle interpretational aspects, reflections on which continue to offer new surprises and puzzles.

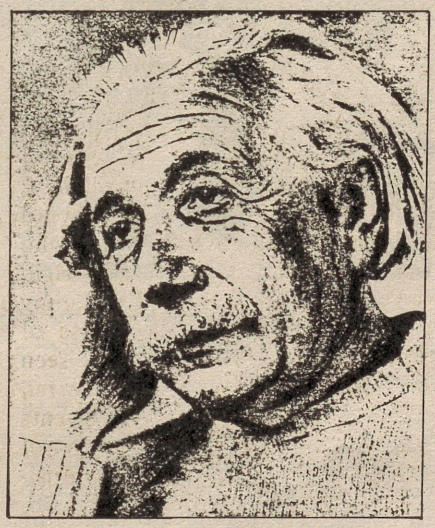
"Anyone who is not shocked by quantum theory has not understood it"

-Niels Bohr

What is quantum mechanics all about? Well, to put it succinctly, it is a systematic theory of microscopic (that is, atomic and sub-atomic) entities and their related phenomena, based on a set of self-consistent mathematical rules supplemented by appropriate physical interpretation. A striking (and also jarring !) feature of quantum mechanics is that its framework does not embody deterministic causality for individual events.

Let us now explain in simple terms what is meant by deterministic causality: if relevant initial conditions are known, one should be able to predict the future events precisely. Classical mechanics conforms to this principle in the sense that if the state of an individual particle (characterized by its position and velocity) is accurately specified at any instant, the state at any other instant can be exactly predicted using the laws of mechanics. In sharp contrast, quantum mechanical formalism is inherently probabilistic in character. Its basic equations do not represent actual motion of particles (unlike Newtonian equations of motion); they merely determine the possible states of a microphysical entity. On the basis of quantum mechanical equations one can predict, in general, only the statistical probability of experimental outcomes. Suppose we have an atom in an excited state which is going to emit light. Using quantum mechanics one cannot predict exactly at which instant it would emit light—we can only estimate the probability of emission at any particular instant. This feature is known as the indeterministic character of quantum mechanics.

The familiar concept of a localisable point particle in classical physics is replaced in quantum mechanics by an abstract mathematical object called the 'wave function'. The wave function of a particle tells us the probability of finding it at any given place at a given time, or equivalently, given a sufficiently large number of particles, it tells us the fraction that will be present at a given place at a given instant. Standard interpretation of quantum theory (advocated by Niels Bohr and his school) goes to the extent of claiming that individual events at the microphysical level are intrinsically indeterminate; the statistical character of quantum theory cannot be analysed any further and that it is irreducible even in principle. Notwithstanding this orthodox dictum, the very fact that quantum mechanics was unable to provide description of an individual micro-object behaviour appeared unacceptable to many as the final state of affairs. Some of the brilliant luminaries in physics, including even Einstein and deBroglie, found this feature of quantum theory to be rather strange and disturbing. The deliberate elimination of the question of causality pertaining to individual events became an issue of grave concern. Einstein persistently propounded his contention that "though quantum mechanics is free from logical inconsistencies, it can at best be an incomplete description of physical reality", a deep and unshakable conviction which he clung to for the rest of his life.



"Though quantum mechanics is free from logical inconsistencies, it can at best be an incomplete description of physical reality"

-Einstein

To quote Max Planck, "When we watch the waves on the seashore we have every right to feel convinced that the movement of every bubble obeys strict causal laws, although we could never hope to follow its rise and fall, even less to calculate it in advance." Following this outlook, it is of course logically permissible and conceptually viable to inquire whether in the realm of atomic phenomena there is a deeper stratum to reality where one can give a causal description in space and time of individual events; statistical predictions of quantum mechanics would then be viewed as an averaging effect over the individual events. An important motivating idea in this direction is the model according to which an atomic entity is a localized particle acted on by a wave which guides it in its motion. The action of wave on particle is determined by what is known as quantum potential whose expression can be mathematically derived from the basic equations of quantum mechanics. An upshot of studies following this approach is the realization that many of the known single-particle quantum phenomena can be self-consistently interpreted on the basis of the above model which provides causal description of

individual events in space and time. The key question, however, remains: "Do such models have (if at all) testable consequences different from

"When we watch the waves on the seashore we have every right to feel convinced that the movement of every bubble obeys strict causal laws, although we could never hope to follow its rise and fall, even less to calculate it in advance."

-Max Planck

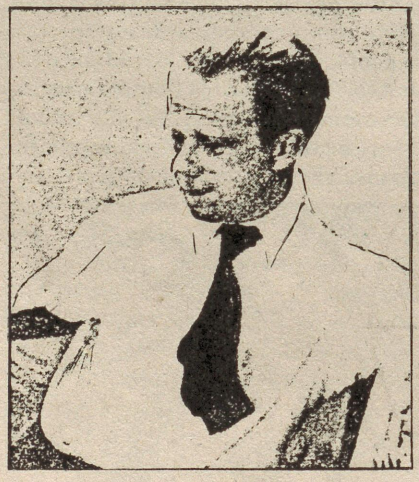
those predicted by standard quantum theory?" Investigations purporting to shed light on this question are currently in progress.

Realism and quantum theory

"I think the important and extremely difficult task of our time is to try to build up a fresh idea of reality."—*Wolfgang Pauli*

Classical concept of realism is based on our everyday experience with the familiar macroscopic world. At the core of it is an intuitively obvious notion that all the physical properties of an individual object have definite numbers associated with them at every instant of time, irrespective of whether or not they are being measured. In classical physics it is necessarily assumed that there is a complete mathematical picture of the object, which is exactly equivalent with all possible knowledge of the object itself; measurements merely reveal the individual values of physical properties which exist independent of measurements. On the other hand, the standard version of quantum theory implies that the process of measurement on microphysical entities 'creates reality' associated with their dynamical properties that did not exist prior to measurement. One of the central doctrines of quantum theory is that objective reality cannot be associated with the unobserved dynamical properties (like position, velocity, energy) of microphysical entities; reality lies only in the existence of the entities themselves and their static innate properties like mass, charge. Even when measured, not all dynamical properties of a quantum system can, in general, be ascribed sharp values at the same time. The classical equation "reality equals sharpness of all physical attributes in the mathematical description" is no longer valid in quantum theory.

The repugnance with which many encounter the above mentioned feature of quantum theory may be somewhat alleviated by the fact that the microphysical entities such as electrons or atoms are very far removed in scale from our familiar everyday macroscopic objects like tables, chairs. The standard interpretation

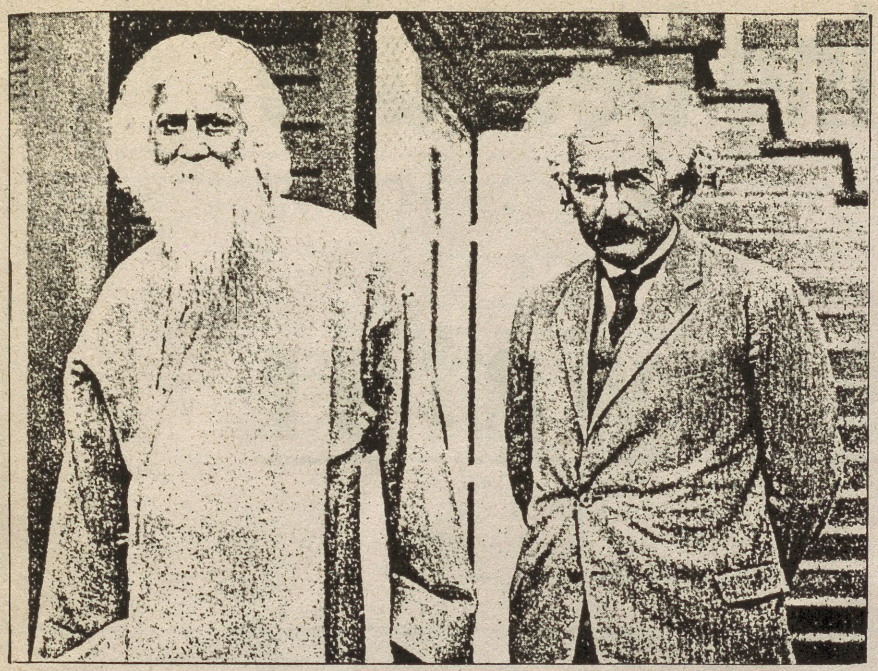


"I think the important and extremely difficult task of our time is to try to build up a fresh idea of reality"

-Wolfgang Pauli

of quantum theory advocates the viewpoint that we should not ascribe to those microscopic entities the same kind of conceptual status we would to such everyday objects. Hence there appears to be an abrupt qualitative distinction between the microscopic and macroscopic levels of physical reality. Standard quantum theory inevitably implies this cut or discontinuity and does not provide any clear-cut answer as to how and precisely at what stage does the quantum mechanical description at the microscopic level get converted into a classical realistic one at the macroscopic level. One may ofcourse argue that if quantum mechanics is to be regarded as a universal theory of the physical world we are prima facie entitled to extrapolate it to the scale of the macro-world. But then such an extrapolation inexorably leads to an acute conceptual incompatibility with the classical notion of realism. This is most glaringly manifested if one tries to analyse the measuremental interaction (involving the measured microphysical entities and the measuring apparatus which is necessarily macroscopic) within the framework of quantum mechanics. A measurement, after all, is a physical process and whatever happens due to it ought to be adequately explained using the relevant theory by treating the observed system and the measuring apparatus on the same footing. A definite outcome of a single measurement clearly indicates that as a result of it a macroscopic apparatus must definitely be left in one particular state. That this obvious fact is not in conformity with a straight-forward extrapolation of quantum mechanical formalism to the macro-level for describing measurement processes is the crunch of what is known as the quantum measurement paradox. To put it in other words, application of quantum mechanics at the macroscopic level seems to deny objective reality of the state of an individual macroscopic apparatus at the end of a measurement process. This makes many inclined to suspect inadequacy of the conventional framework of quantum mechanics as a total world-view.

The problem of making a conceptually smooth connection between the quantum mechanical formalism which has been so spectacularly successful at the atomic level and the realistic classical description we employ in everyday life is the one



Tagore and Einstein

whose resolution will provide one of the next crucial breakthroughs in getting out of the present conceptual impasse and sharpening our understanding of the nature of physical reality. Some physicists cherish the hope that in the end a much more intuitively acceptable and philosophically satisfactory description of the physical world will emerge that will supersede the quantum theory. The quantum mechanical formalism will then appear, with hind sight, to be merely a convenient package of recipes which happened to give the right answers for the types of experiment feasible at this point of time. Who knows, there may be major surprises in the offing. To quote Robert Frost: "We dance around a ring and suppose, but the secret sits in the middle and knows."

Epilogue

"The point is not to pocket the truth, but to chase it"—*Elio Vittorini.*

It seems appropriate to conclude with relevant excerpts from an incisive conversation between Albert Einstein and the Indian philosopher-poet Nobel Laureate Rabindranath Tagore on the nature of reality. This dialogue conveys a flavour of the delicate complex aspects and subtle philosophical predilections concerning this absturse issue which are deeply reflected in the developments of modern physics.

Einstein: I cannot prove that scientific truth must be conceived as a truth that is valid independent of humanity; but I believe it firmly. I believe, for instance, that the Pythagorian theorem in geometry states something that is approximately true, independent of the existence of man. Anyway, if there is a 'reality' independent of man, there is also a truth relative to this reality; and in the same way the negation of the first engenders a negation of the existence of the latter..... Even in our everyday life, we feel compelled to ascribe a reality independent of man to the objects we use. We do this to connect the experiences of our senses in a reasonable way. For instance, if nobody is in this house, yet that table remains where it is.

Tagore: In the comprehension of truth there is an eternal conflict between the universal human mind and the same mind confined in the individual. The perpetual process of reconciliation is being carried on in our science, philosophy, and ethics. According to Indian philosophy there is Brahma, the absolute truth which cannot be conceived by the isolation of the individual mind or described by words. But such a truth cannot belong to Science. What we call truth in Science lies in the rational harmony between the subjective and objective aspects of reality, and can only be reached through the process of logic; in other words, by an organ of thoughts which is human.

It is not difficult to imagine a mind to which sequence of things happen not in space but only in time, like the sequence of notes in music. For such a mind its conception of reality is akin to the musical reality in which Pythagorian geometry can have no meaning. There is the reality of paper, infinitely different from the reality of literature. For the kind of mind possessed by the moth which eats that paper, literature is absolutely non-existent, yet for Man's mind literature has a greater value of truth than the paper itself. In a similar manner if there be some truth which has no sensuous or rational relation to human mind it will ever remain as nothing so long as we remain human beings.

(Details of this conversation can be found in the book *The Religion of Man* by Rabindranath Tagore)

Further reading

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2. *Quantum Implications: Essays in Honour of David Bohm,* Edited by B. J. Hiley and David Peat, Routledge and Kegan Paul, London (1987).
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Making best use of Wastewater

PARITOSH C. TYAGI
M. SENGUPTA
S.P. CHAKRABARTI

Recycling and reuse are the two key words which often go hand in hand in the modern technology of wastewater management

FRESH water which is essential for sustaining life on earth constitutes only a small fraction of the earth's total water supply—only about 2 per cent of the total. Nearly all of this, about 1.998 per cent of the total, is locked in the masses of polar ice-caps, glaciers and clouds. The remaining small fraction, about 0.00192 per cent of the total, is found in the lakes, wells and underground reserves of the world, which is tapped by mankind for various uses. Humanity is, therefore, left with a very small fraction—only one tea spoonful of sweet water for every five litres of total water.

Water is the most essential commodity for human consumption and also for industrial use. Probably because it is the cheapest to purchase in countries like India, it also tends to be extravagantly used. Water is mostly employed for supporting life (drinking); as a general-purpose carrier to maintain active systems, as in electroplating; to remove unwanted materials, as in vegetable processing, or to transport materials or energy, for example in cooling water. The overall effect is generally to downgrade water by adding contaminants or pollutants.

Recycling and reuse

These are the two key words which often go hand in hand in the modern technology of wastewater management. 'Recycling' is frequently defined as the internal use of wastewater by the original user prior to discharge to a treatment system or some other point of disposal. The wastewater is recovered, treated or untreated, and then recycled for repetitive use by the same user. Each recycling may be through a succession of lower quality uses with little or no treatment as part of the cycle, or it may include treatment to maintain a certain quality. The term reuse is applied to wastewaters that are discharged and then withdrawn by a user other than the discharger. Wastewaters potentially available for reuse include discharges from municipalities, industries and irrigation. The reclaimed waters are generally used for (1) irrigation, (2) cooling, (3) alga and pisciculture, and (4) other industrial uses. Various intentional reuses that are considered feasible are shown in Figure 1.

Although India is predominantly rural, it has still a large population (about 15 crore) living in its urban areas. These urban centres are also the nuclei of industrial growth. Since growth is an unavoidable element in human survival, society has to live with its by-products—the wastes.

Municipal wastewater

The class I cities (population above 1 lakh) and class II towns (population between 50,000 and 1 lakh) in India constitute about 70 per cent of the urban population. The numbers of class I cities and class II towns, according to 1981 census were 212 and 269 respectively, and the rate of increase is estimated at 50 and 40 percents respectively in a span of ten years. By the turn of this decade,

Dr. Tyagi is Chairman, Dr. Sengupta is Scientist, and Dr. Chakrabarti is Environmental Engineer at Central Pollution Control Board New Delhi.

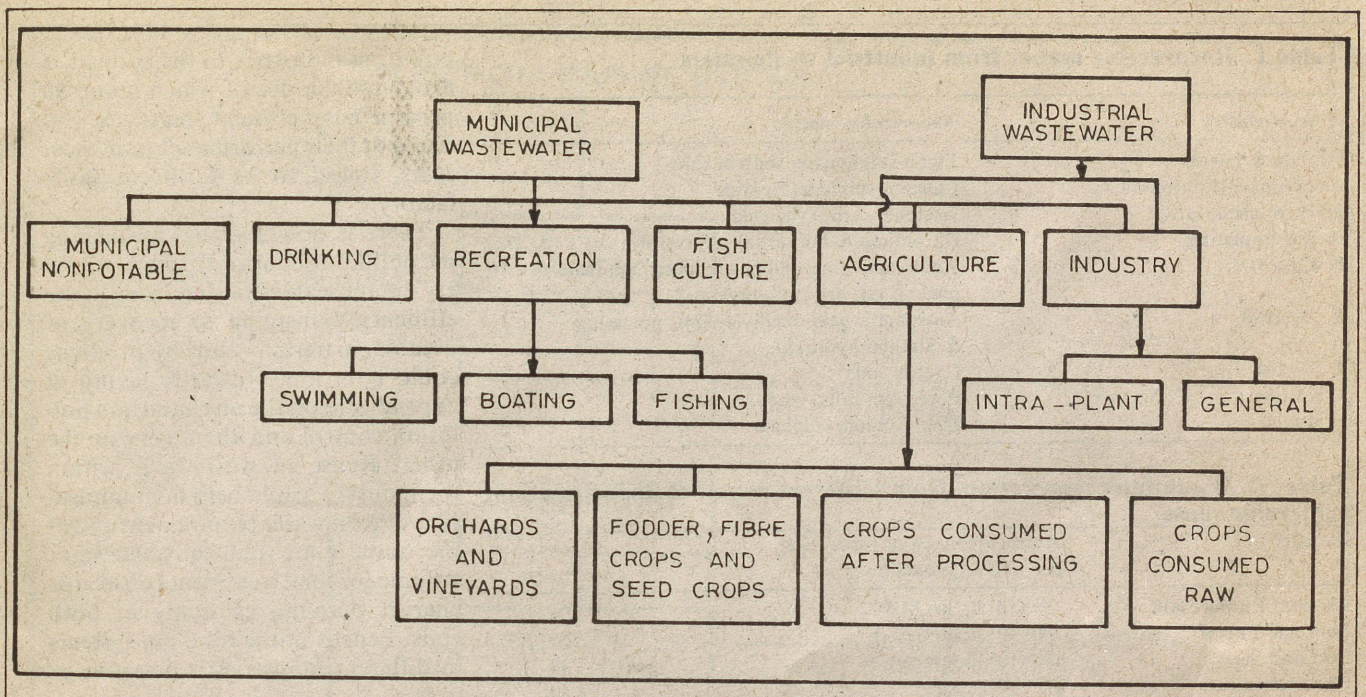

Fig. 1. International reuse of wastewater

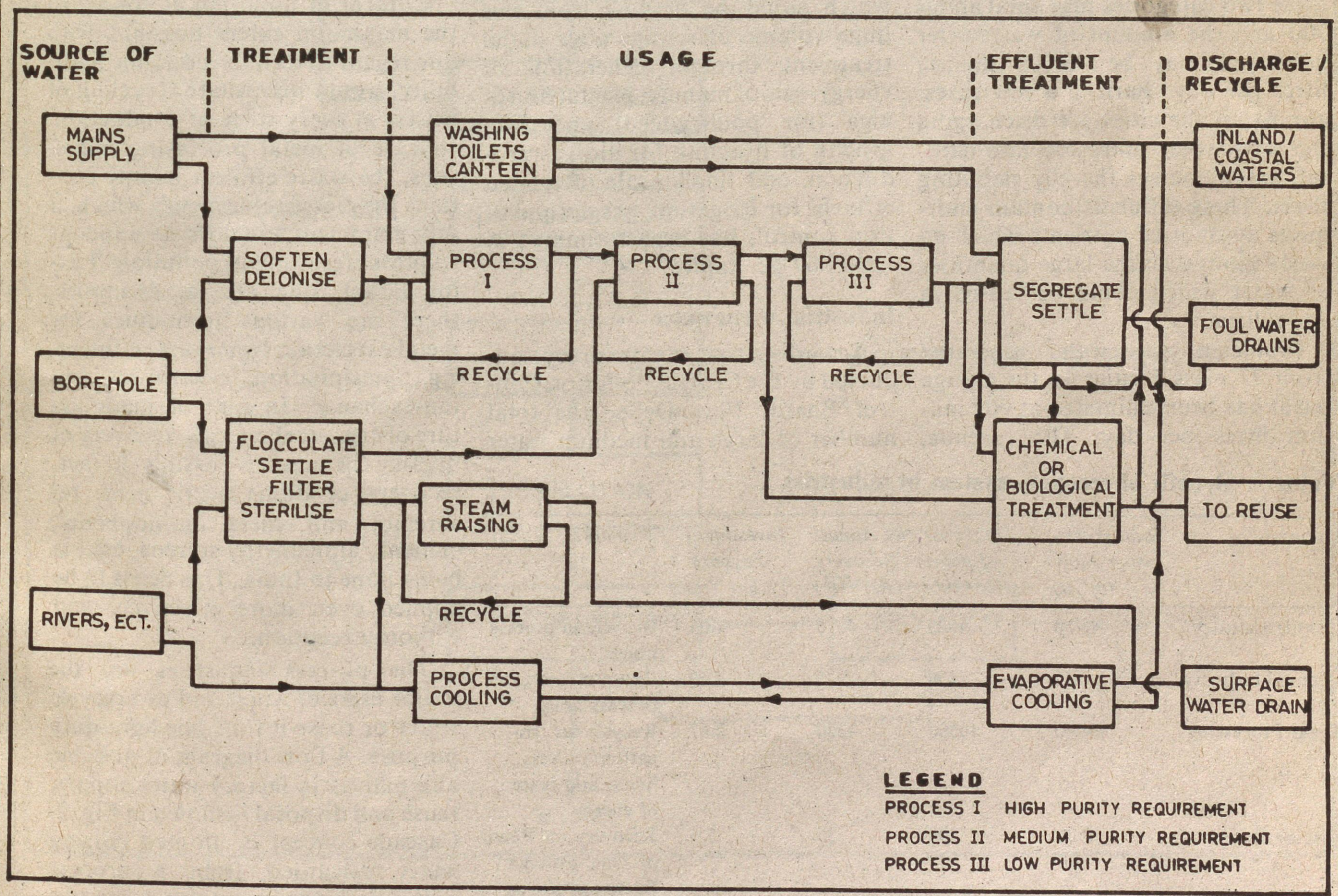

Fig. 2. Factory water supply: usage and disposal

Table 1. Recoverable matter from industrial wastewaters

S.N. Industry	Recoverable matter
1. Pulp & paper	Ligno-sulphonate, sodium salts
2. Fertilizer (Phosphatic)	Calcium sulphate, fluoride
3. Petro-chemicals	Acetone, carboxylic acid
4. Electroplating	Chromium & Nickel salts, Silver cyanide
5. Coke oven	Ammonia, Ammonium sulphate, naphthalene, phenol, tar, aromatic organics
6. Dyestuffs	Anthranilic acid, methylaniline, potassium & Sodium hydroxide
7. Textile	Caustic soda
8. Distillery	Potassium salts, yeast
9. Rayon	Zinc, Sodium sulphate

Table 2. Wastewater generation from different types of industries and achievable reuse

Industry	Average volume of wastewater per unit of products	Percent reuse achievable
Thermal Power Plant	155×10^3 lit/hr/MW	98
Pulp and Paper	250×10^3 lit/tonne	50
Iron and Steel	150×10^3 lit/tonne	40
Pharmaceuticals	4.5×10^3 lit/kg	40
Distillery	15 lit/lit of alcohol	25
Textile	250 lit/kg of cloth	15
Tannery	34 lit/kg of raw hides	12

these two categories may total about 700 and the amount of wastewater generated may be 18,000 million litres per day. Barring a few cases, almost all the cities are discharging the wastewater untreated into natural water courses thereby polluting them. These effluents contain enormous amount of nutrients which go waste alongwith the large quantities of water which could be reused in agriculture.

Municipal wastewater generated from 27 class I cities in the Ganga basin has been estimated at 902 million litres per day. The revenue, which could be derived from this huge volume of sewage after initial treatment through generation of energy, sale of manure, production of alga (for poultry-feed) and fish, growth of hyacinth for bio-gas production, and finally, sale of treated effluent for irrigation, besides pollution control, has been estimated at Rs. 37.00 per capita.

Industrial wastewater

According to a recent survey conducted by the Central Pollution Control Board, New Delhi, the total number of large and medium water polluting industries in the country is around 4000, out of which about 50 percent have effluent treatment system, but their performance is, in most cases, found to be far from satisfactory.

There is now a global awakening on pollution control through recovery of reuseable matter from waste effluents. Salvaging or recovery of useable materials and by-products could contribute towards saving of expenditure on the one hand and pollution control and abatement on the other. Reuse of wastewater within the industry would help in minimisation of freshwater requirement and at the same time reduce wastewater volume for final treatment before discharge, deriving economy at both ends. Benefit of the recovery systems in different industries is lucrative as well.

Table 3. Benefit of recovery system in industries

Industry	Total Wastewater Flow (m^3/d)	Total cost of plant ($Rs.\times10^3$)	Net Annual Recovery ($Rs\times10^3$)	Investment Payback Period Yrs.	Remarks
Textile Industry	6450	4625	4375	1.05	Recycle in process house
Alcohol Industry	1725	2250	975	2.30	Reuse of energy in process house
Food Processing	1460	10500	4250	2.47	Recycle for irrigation/process house and reuse of energy
Viscose Rayon	4500	200	36	5.5	Recovery and Reuse of Zinc; Foreign Exchange saving

Source: Personal communication from Dr. P. Khanna, Director, NEERI, Nagpur.

Technology for reuse/recycling/recovery

Control of pollution at source to the maximum extent possible, with due regard to techno-economic feasibility, would necessitate recycling of wastes at every stage of production. In case of metal processing industries, the waste effluent mainly contains the recoverable metals which, if not extracted, are lost in aqueous solution, resulting in pollution. Taking nickel, zinc, etc., as examples, there are various techniques for metal extraction from waste effluent, e.g., precipitation, electrolysis and ion-exchange. In case of manufacture of organic chemicals, recovery of organic chemicals is possible. In fact, recovery of dilute acetic acid, resorcinol and meta aminophenol, cumene, alphamethy styrene, etc., is being done in India. This needs to be applied even more effectively and without exception.

The process industries are the major users of water and can recycle water or reuse it for some light-duty purpose. A flow diagram of possible alternatives in factory water supply, reuse and disposal is shown in Fig. 2. Cascade concept is adopted reusing water discarded from a process requiring higher purity to a process requiring lower purity. If required, a

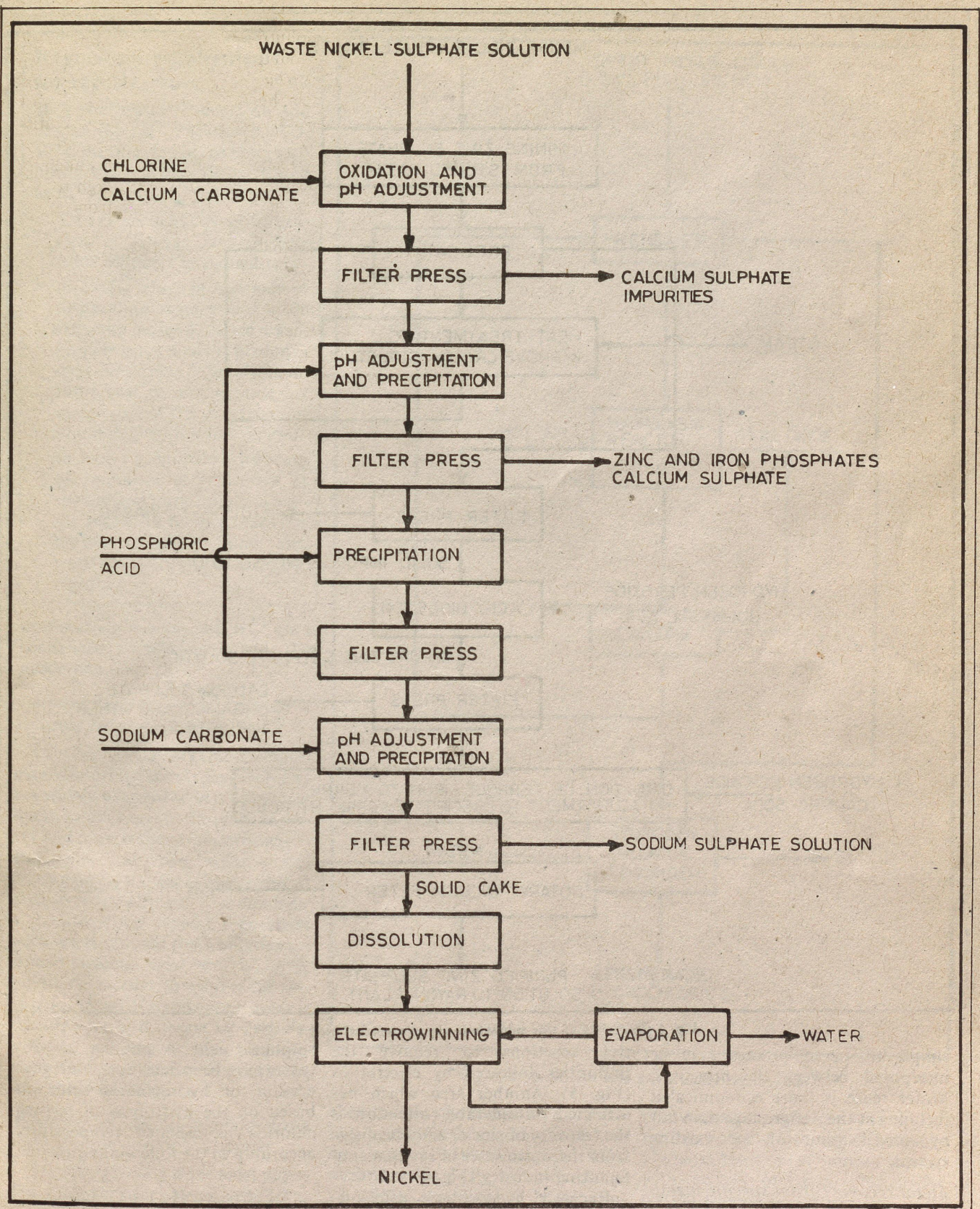

Fig. 3. Precipitation process for nickel recovery

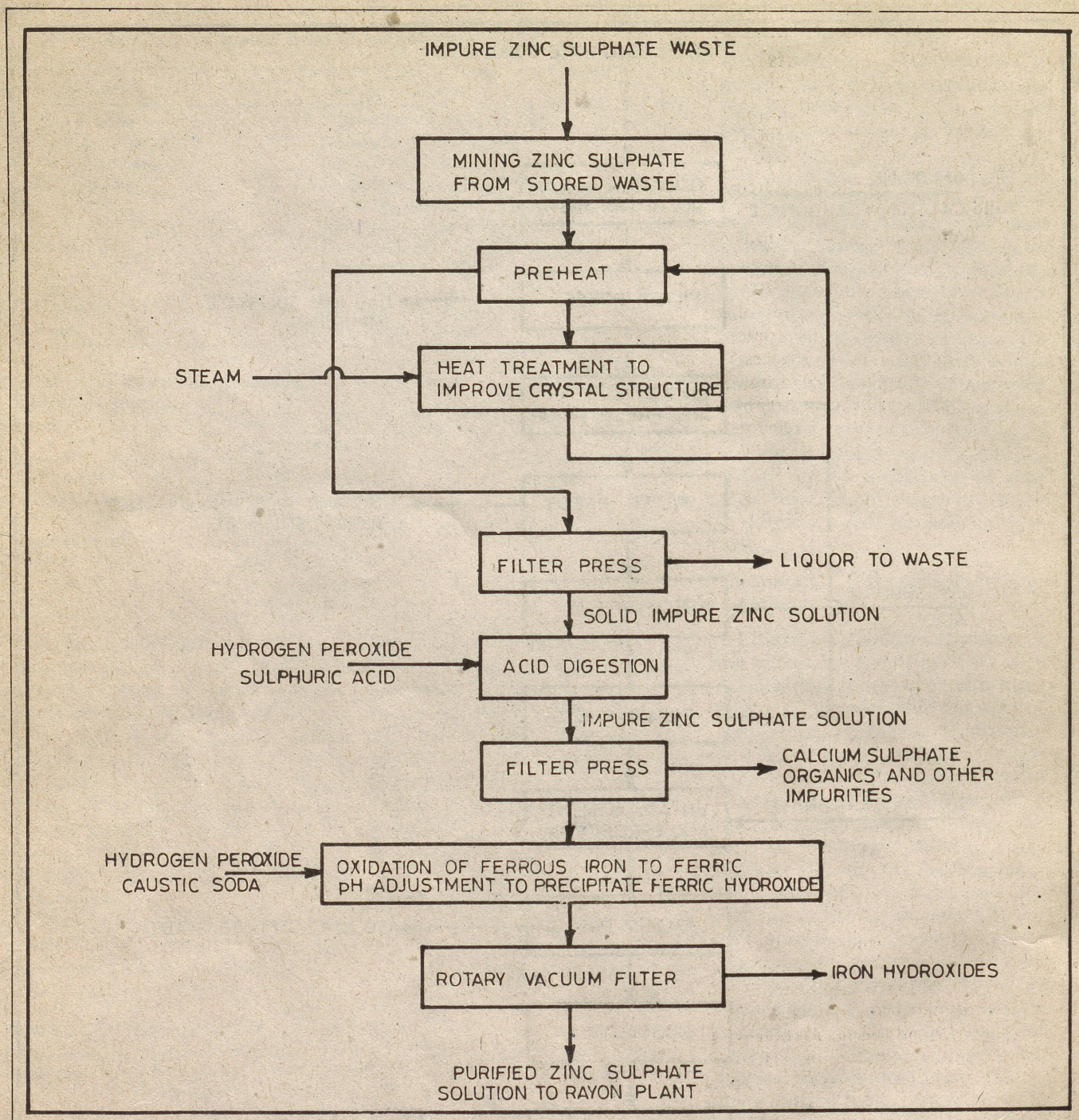

Fig. 4. Recycling of zinc sulphate in rayon manufacturing process

simple treatment process may be interposed between the processes. Water reuse is more economical if included at the design stage than it is by modification of an existing system.

Metal recovery from specific metal-bearing wastewater

Nickel can be extracted from aqueous effluent by a series of precipitative reactions to remove the impurities followed by electrolysis (Fig. 3). Another area which has attracted considerable attention is the recovery of zinc or zinc chemicals from the wastewater of rayon manufacturing industry (Fig. 4).

Recently hydrochloric acid pickling has been successfully introduced, and although the acid costs more, it is more readily recycled than sulphuric acid. A number of processes have been developed for regeneration of hydrochloric acid, all based on the hydrolysis of ferrous chloride at elevated temperature, according to the following equation:

$$4\ FeCl_2 + 4\ H_2O + O_2\ (air) \longrightarrow 2\ Fe_2O_3 + 8\ HCl$$

The iron oxide is returned to the

Regulatory requirements for recycle/reuse

IN the Water (Prevention and Control of Pollution) Act, 1974, the function of the State Pollution Control Boards are stated as follows:

- To evolve methods of utilization of sewage and suitable trade effluents in agriculture;
- to evolve efficient methods of disposal of sewage and trade effluents on land, as are necessary on account of the predominant conditions of scant stream flows that do not provide for major part of the year the minimum degree of dilution; and
- to evolve economical and reliable methods of treatment of sewage and trade effluents having regard to the peculiar conditions of soil, climate and water resources of different regions.

iron-making process and HCl gas is condensed to acid and returned to the pickle line (Fig. 5).

Recovery and reuse of organic solvents from the waste

In most of the organic chemical manufacturing industries, solvents are widely used either in the end products or as reagents. In-plant recovery and reuse is the common practice. But at the end when further reprocessing of the solvent is impossible, it goes as waste effluent. The commercial enterprises generally purchase such waste effluent (because conventional aqueous treatment is rarely possible) in order to recover the solvent for reuse. The solvent recovery is usually done by different kinds of distillation processes, e.g., simple, extractive, vacuum, semi-continuous and batch distillations.

Recovery of lignosulphonate from pulp and paper mill wastewater

Lignosulphonate is the most popular and versatile by-product produced in sulphite and bisulphite pulping (which is not done in India except in one or two industries). This chemical may be recovered and purified by the use of membrane techniques such as reverse osmosis (RO), ultrafiltration (UF), or electrodialysis (ED). Research is being conducted in India on membrane performance evaluation on long-range basis, on the feed pretreatment requirement, and on the separation, purification and recovery of lignosulphonates from spent sulphite liquor with the help of UF-coupled diafiltration process.

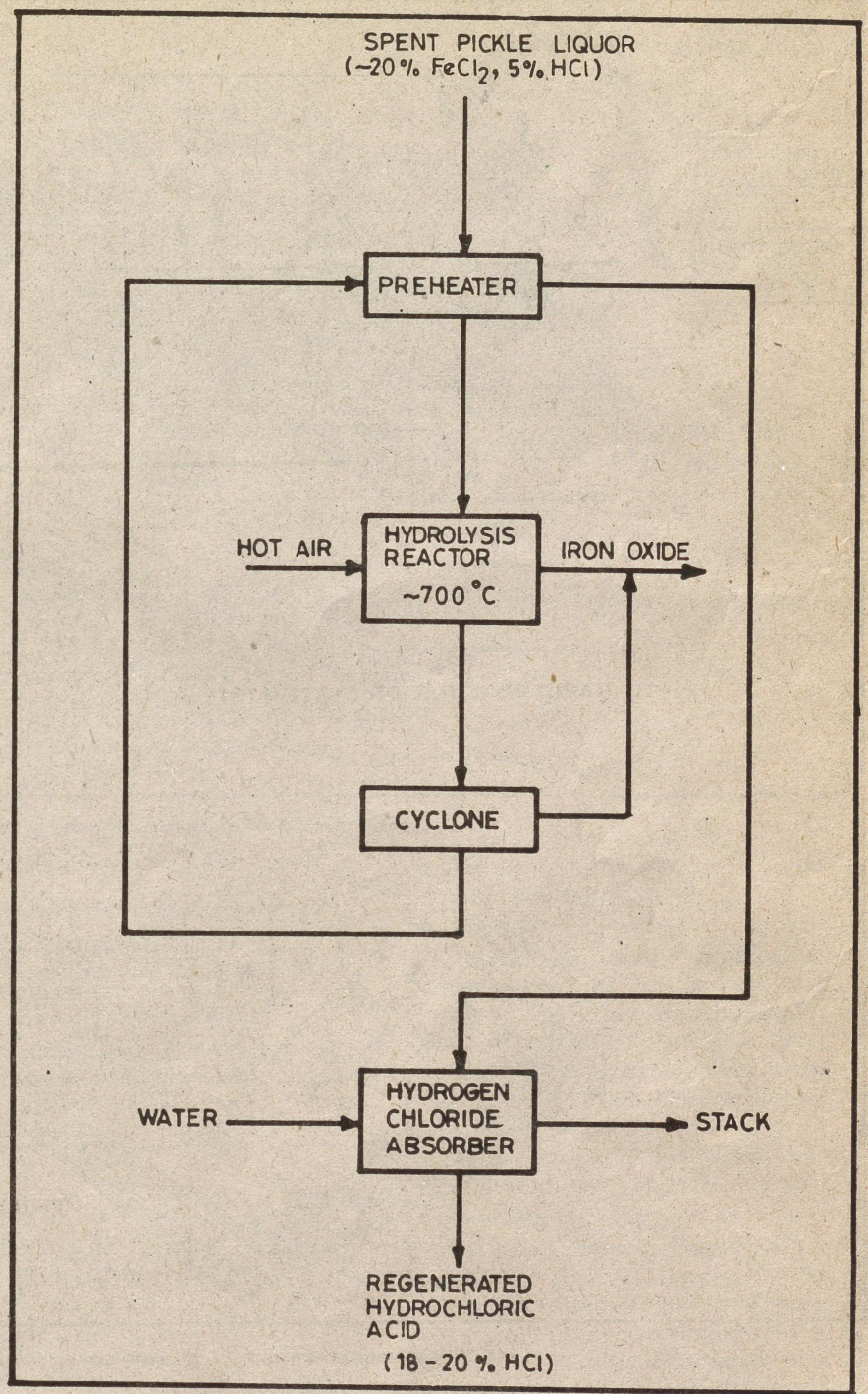

Fig. 5. Hydrochloric acid pickle liquor regeneration

The 4-R concept

In a wiser community, the waste-

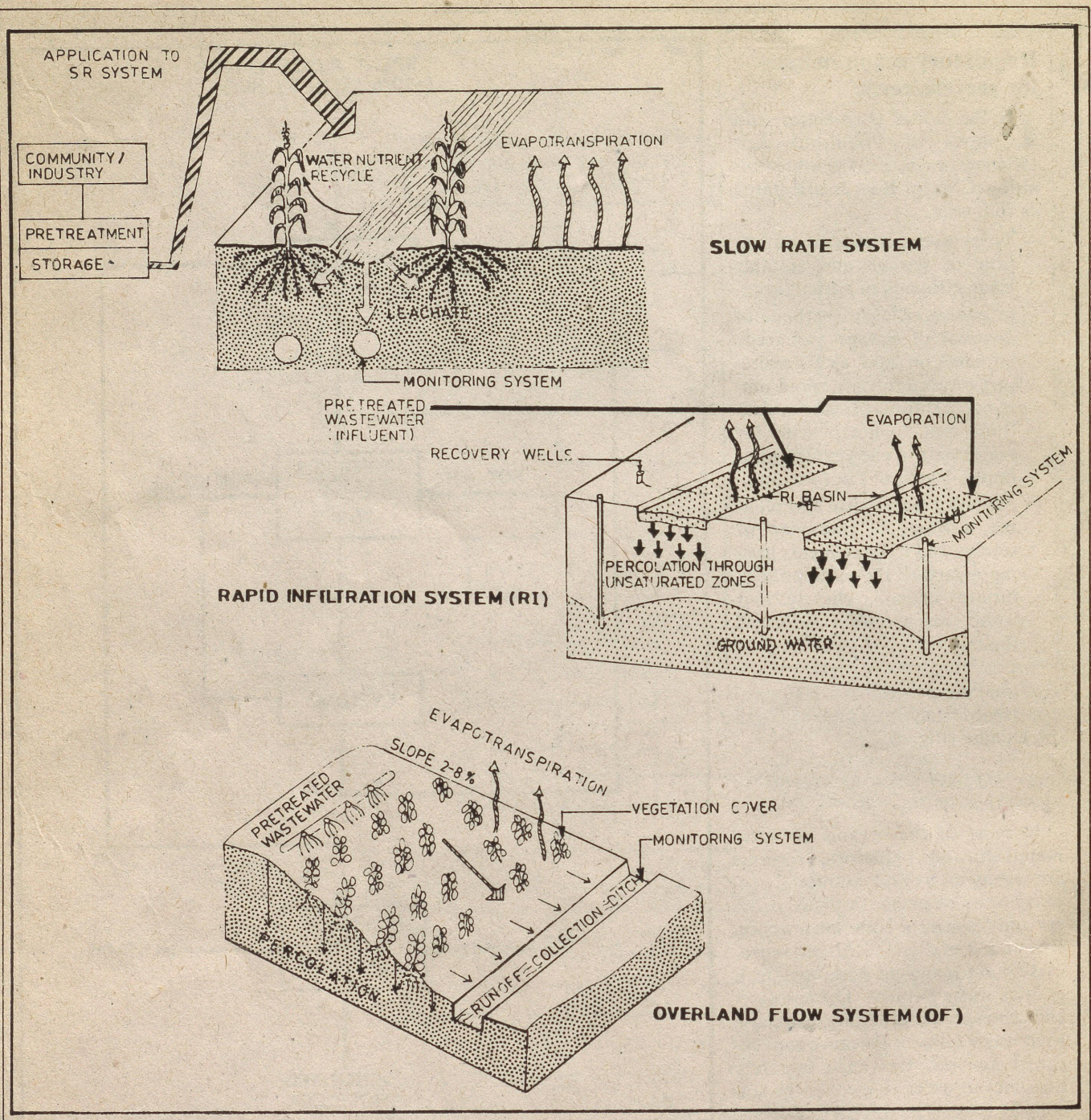

Fig. 6. Schematic presentation of different land application systems

waters receive some form of terminal treatment before application on land. The remaining nutrients, organics and water enter the natural system of recycling and used by plants and microbes of soil or retained by soil. In the process excess water percolates through the soil medium, gets renovated, and ultimately recharges the groundwater. This groundwater is again abstracted for reuse as water supply to the community. Recycling, renovation, recharge and reuse in the above process are collectively termed as the "4-R concept."

The principle of reuse/ recycling of wastewater differs from the age-old sewage farming practices as the present technology, called 'Land treatment', means "controlled application of pretreated wastewater on land surface to achieve a designed degree of treatment through natural biogeochemical process within the plant-soil-matrix." Three systems for this type of wastewater reuse are: (1) slow rate (SR), (2) rapid infiltration (RF), and (3) overland flow (OF). The conceptual diagram for the three systems are shown in Fig. 6.

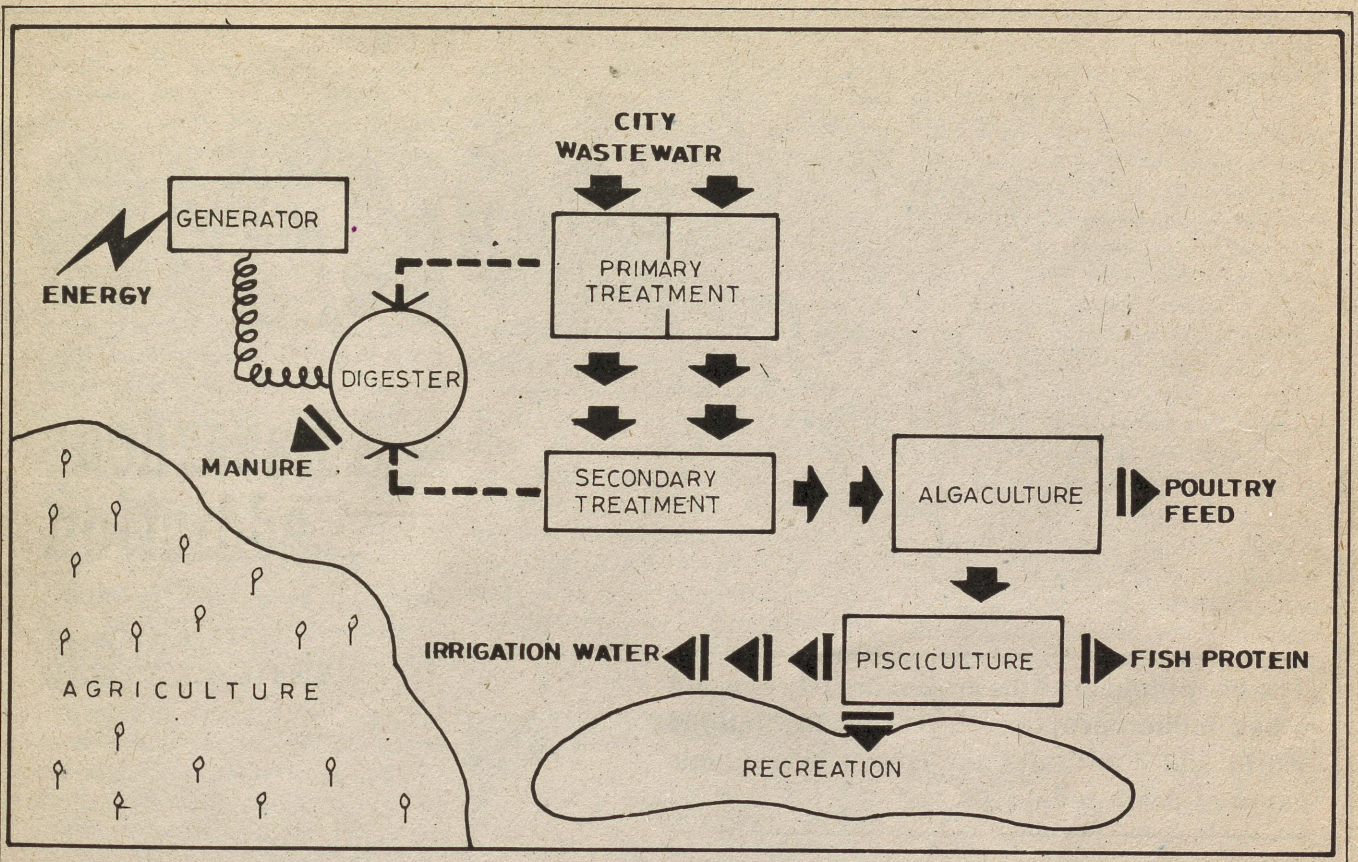

Fig. 7. Other alternatives of wastewater reuse

Objectives of the above systems are summarized as follows:

Slow rate system

- Treatment of applied wastewater based on assimilative capacity of soil;
- Economic return from reuse of water and nutrients to produce marketable crops; and
- Water conservation.

Rapid infiltration system

- Groundwater recharge;
- Recovery of renovated water.

Overland flow system

- Wastewater treatment with the help of low permeable and sloping land;
- Recycle of the renovated water from the system; and
- Crop production.

Recreation, energy production, aquaculture and pisciculture are some of the other alternatives for reuse of the treated wastewater (Fig. 7) which have been adopted in the Ganga Action Plan. The selection of technology, either in isolation or in combination, has to be made in consideration of local factors.

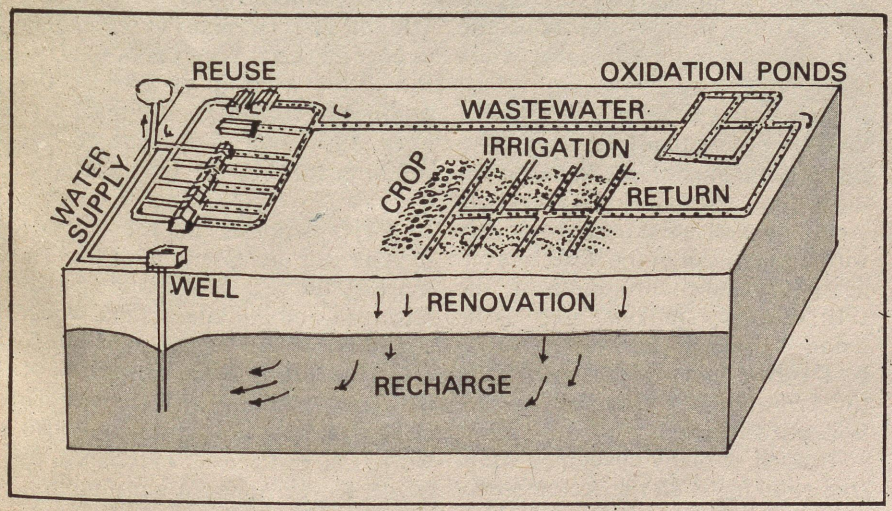

Fig. 8 The Four-R concept

Concluding remarks

With the advent of rapid industrialisation to keep pace with the developed countries, more and more industrial products/human utility items are being manufactured, and wastes and pollution problems are created in the process.

Industrial pollution can best be curbed by factory owners themselves (in their own interest) by complying with the pollution control regulations. It will also help them cut down cost of production in the competitive market through recycling/reuse/recovery of resources which are becom-

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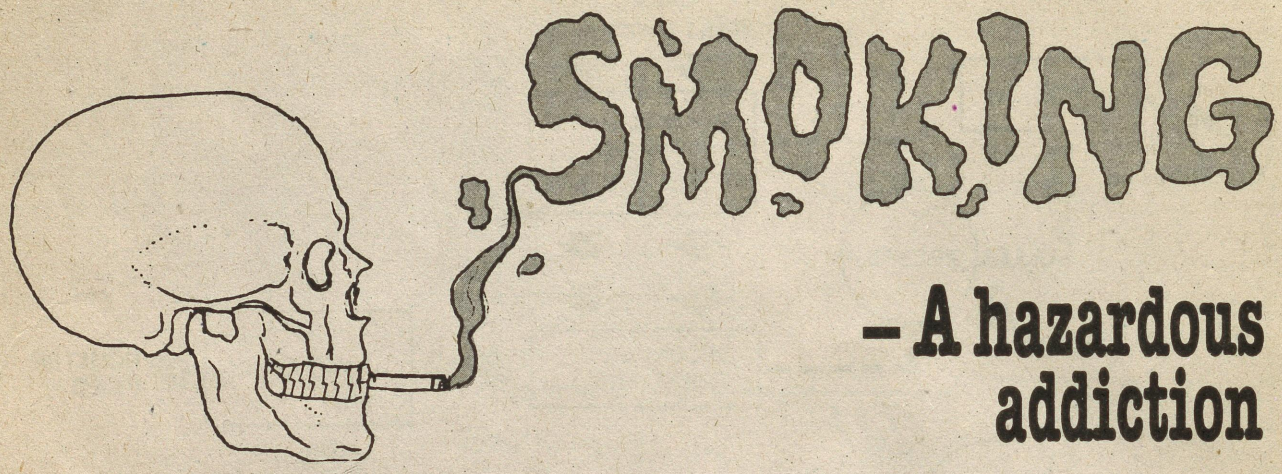

– A hazardous addiction

K.C. KANWAR
JYOTIKA KANWAR

The use of tobacco kills approximately two and a half million people each year throughout the world and constitutes the largest preventable cause of death today

SMOKING involves inhalation and exhalation of the fumes of burning tobacco of cigarettes, cigars, pipes or of the oriental 'hookah'. The use of tobacco is one of the foremost public health problems of the day—it kills approximately two and a half million people each year throughout the world and constitutes the largest preventable cause of death today. It causes many cancers, varied heart associated diseases, chronic bronchitis and emphysema, to list a few. Taken in whatever form, tobacco smoking is a dangerous and expensive addiction.

It is a common belief that smoking was first practised by the (Red) Indians of the Western hemisphere. Originally perhaps smoking started as a religious ritual though later the use of tobacco (both smoking and chewing) eventually became a world-wide vice. Today, smoking, which by far constitutes the most popular use of tobacco, has touched menacing proportions everywhere and hence is justifiably attracting attention of health planners. North Americans alone use about 50 billion cigarettes yearly. In North America alone, more than 25 million dollars a day are spent on cigarettes alone—a sum which could easily provide enough of food for almost 50 billion hungry people a day. Despite mounting evidence of the health hazards of tobacco as well as of smoking, and despite a complete ban on smoking by certain religious groups, world-wide production, manufacture and use of tobacco are increasing.

It is documented that 'by the end of the 5th century, the rulers of Andalusia (present day Spain) were aware of the hazards of tobacco and had prohibited its use, threatening smokers with amputation of the nose, or even death'. In Constantinopole, in the 17th century, smokers used to be paraded through the streets on donkeys before they were hanged. Still, tobacco addiction survived—in fact flourished then on.

Though in many developed countries smoking is on the decline somewhat, it is on the increase in the developing and underdeveloped countries where tobacco consumption has been increasing by about 5% annually. Rough estimates suggest that for every person who quits smoking in the United States or Europe, two start smoking in the developing world. Asian countries now account for about half of all US overseas tobacco sales, replacing the UK and West Germany as the leading export markets. Whereas in the UK, there was a drop of 27% in the number of cigarettes consumed between 1964 and 1975, tobacco use in China, for example, has doubled in the past 20 years. Further, according to WHO estimates, the tobacco sale in Asia will increase at least by 18% more by the year 2000 despite global efforts to stall smoking. China, which supports world's largest population, also holds the dubious distinction of being the country with the world's largest number of smokers and also world's largest grower of tobacco. In South Korea, tobacco consumption

Sh. Kanwar is with the Deptt. of Biophysics, Panjab University, Chandigarh; Ms Jyotika Kanwar is with Christian Medical College, Ludhiana (Punjab).

has increased by 45% in the past 20 years. India, the third largest tobacco producer in the world, though, has a low per capita cigarette consumption. But here 70% of the consumed tobacco is used by means other than cigarette smoking, for example, smoking as 'bidi', 'chutta', 'dhumati' and also in clay pipes and 'hookah', chewing as in betel quid with lime alone or mixed with areca nut, and as snuff (nasal application), all of which certainly are no less dangerous. A particularly distressing development in developing countries is the growing number of women and teenagers taking to smoking.

Tabacco—a dangerous drug

Tobacco deserves to be classed amongst dangerous drugs and smoking as a serious health hazard which has already taken a toll of millions of human lives. Almost 95 per cent of all cases of lung cancer, 75% of chronic bronchitis, and emphysema and 25% cases of ischemic heart diseases are caused by smoking alone. Death due to heart diseases among US men who smoke cigarettes is about 10 times higher than in men who do not smoke (US Surgeon General's Report 1979). Further, for all smokers risk of death increases progressively with the number of cigarettes smoked. On the basis of an average reduction in life expectancy for cigarette smokers of 5-8 years duration it has been estimated that an average of 5½ minutes of life is lost for each cigarette smoked. One recent analysis of mortality suggests that differences in the incidence of cigarette smoking between men and women over the age of 30 is the overwhelmin cause of overall male and female ongevity differences. According to WHO estimates, at least 2.5 million people die every year from tobacco related diseases. A recent survey conducted by WHO collaborating Centre for Oral Cancer Prevention, Tata Memorial Hospital, Bombay has shown that even by the most conservative estimates, 19% of all deaths among men and 4% among women can be attributed exclusively to tobacco. Using middle level estimates, according to this survey, 'almost one third of all deaths can be attributed to tobacco'. Tobacco related deaths in India, this survey estimates, could even be higher, approximating 1 million, since data from the rural areas do not reach statisticians. In addition, many more live on with 'crippled lungs and overstrained hearts' thereby leading subnormal lives. Health hazards apart, smoke in the environment is a nuisance; exposure to it brings discomfort to non-smokers.

It should be borne in mind that it does not take years for smoking to affect one's health. Even a few puffs now and then can hurt. Just one cigarette speeds up your heart, increases blood pressure and respiratory rate, upsets the flow of blood and air in your lungs and causes a marginal drop in skin temperature, especially on the extremities such as tips of fingers and toes. Cilliary

Fig. 1. Painting made by Van Gogh some 80 years ago highlighting tobacco health hazards

movement in the respiratory tract which normally works like brooms to sweep out germs, mucus and dirt from the lungs are adversely affected by smoking. Smoking of even one cigarette makes the cilia temporarily sluggish and impairs their brooming operation. Inhaling smoke for long paralyses cilia completely with serious resultant consequences.

Surveys done in the 50s and 60s in some of the developed countries have established that smoking accounted for a high incidence of deaths from lung cancer and other diseases such as pneumonia, coronary artery complications and even cirrhosis of liver. They have also revealed that pipe and cigar smokers, especially those who do not inhale deeply, are less prone to lung cancer than cigarette smokers, but they become more prone to lip cancer. Even those who do not smoke but chew tobacco, run a significantly higher risk of cancer of the oral cavity. Whatever be the mode of tobacco use, it is poisonous every way.

Nicotine ($C_{10}H_{14}N_2$)—the potent-killer in tobacco—is a liquid alkaloid extracted from the leaves of tobacco, *Nicotiana tabacum* and *Nicotiana rustica*. It is a colourless or feebly amber coloured compound which picks up moisture from air quickly. It has a strong tobacco odour and intensely bitter and burning taste. It has a boiling point of 123°-125°C under 15mm-20 mm Hg and a density of 1.0097 at 20°C. Nicotine is highly toxic; its toxicity can be judged from the fact that a very weak solution of nicotine is used as an agricultural insecticide. A fraction of a nicotine drop can kill a dog. Symptoms of nicotine toxicity in humans include extreme nausea, vomiting, evacuation of intestines and urinary bladder, mental confusion and convulsions. Nicotine gets absorbed through unbroken skin as across mucus membranes and hence free spilling of this compound on skin could be hazardous. The oral lethal dose of nicotine is around 50-60 mg/kg body wt.

Tobacco and health hazards

The contention that smoking is a health hazard is as old as the use of tobacco, but still, smoking flourished everywhere. The earliest report against tobacco perhaps was published in 1859 which mentioned that 68 patients in a hospital in Montpellier (France) who had cancer of the lips, tongue, tonsils or other parts of the mouth all used tobacco and that 66 of them smoked short-stemmed clay pipes. Not much was heard

about the bad effects of tobacco on health until cigarette smoking became widespread especially following the two World Wars. Soon thereafter, it was universally established that in countries where cigarette smoking was more popular, deaths from lung cancer and other respiratory distresses were significantly higher.

By early sixties, following many surveys primarily conducted by the American Cancer Society, the British Medical Council, Royal College of Physicians, London, and many similar establishments in other European countries, direct relationship of tobacco with many major and minor human ailments was established. Tobacco use was universally condemned as a major cause of human ill health. It also became evident that increase in death rate amongst smokers was directly proportional to the number of cigarettes consumed.

In 1964 was released one of the most exhaustive reports on the subject by the U.S. Surgeon General which concluded that cigarette smoking was associated with a 70% increase in the lung cancer death rate for American males during 1950-60. This report related smoking with not only lung cancer but also with coronary artery disease, chronic bronchitis and emphysema. Pipe smoking was linked to lip cancer. In the US, Federal legislation was passed in 1965 requiring all cigarette packages sold after January 1966 to carry health hazard warning labels. Cigarette advertising on television was banned beginning January 1, 1971, and thereafter various recognized societies, *viz.*, American Cancer Society and Heart Association mounted an intensive campaign against smoking. Many more studies were taken up on expanded basis to work out intensively the role of tobacco in various ailments. By this time, quite a few British reports had also concluded that cigarette smoking was the cause of lung cancer and bronchitis and probably contributed even to the development of the coronary heart diseases and other common diseases.

US Surgeon General's Advisory Committee report released in January 1969 concluded unequivocally that "Cigarette smoking is a health hazard of sufficient importance in the U.S. to warrant appropriate remedial action". This report also related smoking with cancers at sites other than lung including lip, larynx, esophagus, and urinary bladder.

Despite organized publicity against smoking in the wake of the many unfavourable reports and survey data, smoking, at least initially, dropped only marginally between 1965-1970. Per capita yearly consumption of cigarettes in the US fell from 4258 in 1965 to about 4000 by 1970. This was because simultaneously the tobacco industry had improvised new methods to check decline in sales. Filtered and extra-long cigarettes were introduced which were said to be 'less injurious'. The public continued to be cheated.

The tobacco industry disputed the conclusions arrived at by various surveys. According to it, tobacco has still to be proved as a health hazard. The industry questioned the reliability of the data linking smoking to varied illnesses and early death and pointed out inconsistencies in the data. According to the industry, relationship between smoking and illness and death was merely statistical and that the statistical analysis, at times, could be 'misleading'.

Mortality and morbidity

Many studies surveying hundreds of thousands of people have shown cigarette smoking to be statistically related to higher death rates. Some surveys have put the death rate amongst male smokers at twice that among non-smoker controls for a particular age group. It has been amply substantiated that cigarette smokers tend to die at an earlier age and have more days of disability than do non-smokers. Moreover, the mortality rates tend to increase proportionally with the number of cigarettes smoked per day and the degree of inhalation. Among women the differences were less striking, perhaps because less women smoke tobacco. As against 60% of Indian men who are tobacco addicts, only 15%-20% of Indian women consume tobacco. Many studies have also established a relationship between death rates and the age at which the deceased started smoking. The mortality rate for men who started smoking at the age of 15 was found to be almost double the

Fig. 2. The tobacco epidemic spreads every where: no country is free of it

rate for men who started in their thirties. Encouragingly though, damage done by smoking appeared to be reversible—those smokers who quit have lower death rates than those who continue to smoke. For those who have not smoked for 10 or more years, the death rates are close to those of non-smokers.

Smoking and diseases

Smoking is related to a host of diseases particularly those which occur more frequently in smokers than in non-smokers.

It is established now that smoking is the major cause of lung cancer in men. The rise of the disease has worked out but it is believed that the process is triggered by chronic irritation from some chemical substances present in the smoke. When a person draws on a lighted cigarette, the hot smoke assaults delicate tissues in his mouth, throat, breathing tubes and lungs. After the smoke is puffed out, the respiratory system retains 85% to 99% of the tobacco smoke pollutants such as carbon monoxide, nitrites, ammonia, nitrosamines, hydrogen cyanide, sulphur compounds, vinyl chloride, hydrocarbons, volatile alcohol, urethane, formaldehyde and hydrazine, many of which are known to be cancer causing agents.

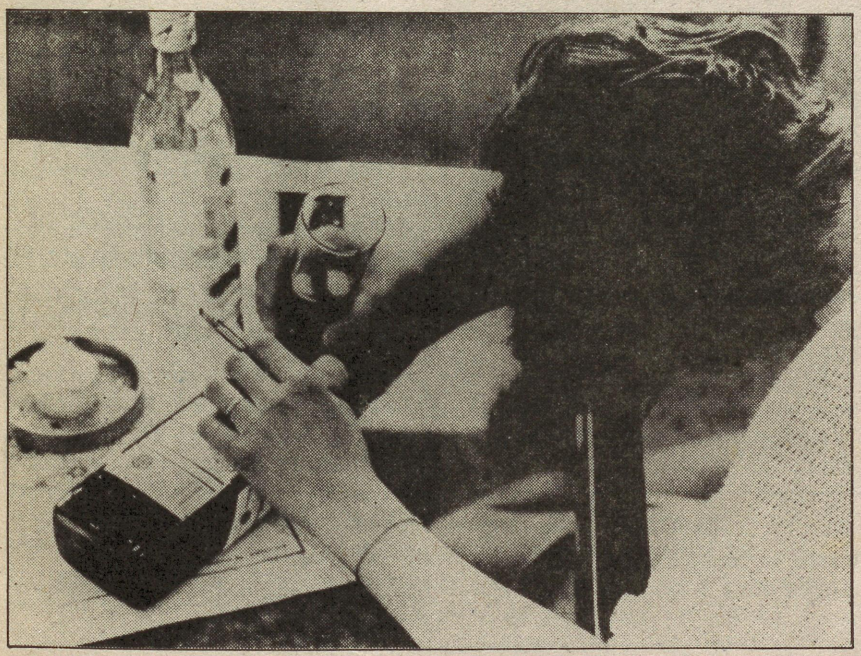

Fig. 3. Unhealthy life styles bring death closer. Smoking and alcohol potentiate each other deleterious effects

roughly gone along with the increased consumption of cigarettes. There is not only a direct relationship between smoking and lung cancer but also a dose-response effect; death rates increased proportionately with the average number of cigarettes smoked. Mortality ratio are, however, lower for pipe and cigarette smokers, for those who do not inhale deeply, and for those smoking filtered cigarettes only. For ex-smokers, tobacco risks diminish from the day they give up smoking.

How tobacco smoking causes cancer of the lung is not very well

Significant link of larynx cancer with smoking has been proved in males. Pipe smoking and tobacco chewing are also aggravating factors for this type of cancer. Risks of dying of cancer of the larynx, for example, are 6-10 times higher for cigarette smokers than for non-smokers. The damage in larynx epithelium also depends upon the number of cigarettes smoked per day and degree of changes in the laryngeal cells.

Lip cancer and pipe or cigar smoking also appear to be causally related. The reason possibly is the continuous irritation provided by tobacco tar in particular and the burning heat to the lip surface.

The risk of dying from esophagus cancer is 4-5 times greater for smokers than it is for non-smokers. Alcohol is said to be another important causative factor leading to esophageal cancers. If both are operative simultaneously, they seem to potentiate the action of each other.

Urinary bladder cancer is also associated with smoking. People who smoke one pack of cigarette a day have a death rate from bladder cancer twice that of non-smokers. Tobacco metabolites which are excreted via urine are said to be responsible for the cancer of urinary bladder which stores urine loaded with tobacco related carcinogens.

Respiratory diseases

Cigarette smoking is the most important cause of chronic bronchitis and it greatly increases the risk of death from chronic bronchitis and emphysema. It aggravates asthma too. Scientists postulate that smoking leads to emphysema by bringing about collapse of small airways in the lung. Tobacco smoke changes the fluid mucoid covering of the respiratory passage and impairs the ability of lungs and bronchial tubes to clear themselves of the mucus. Tobacco smoke also impairs the ciliary movements in the respiratory tract which are effective in clearing out the trapped mucus from the respiratory passages.

Heart diseases and circulatory impairment

Heart diseases constitute a major cause of death in the industrialized countries. Cigarette smokers have significantly higher rates of death from coronary heart disease than non-smokers. Also, risk for coronary ailment increases with the number of cigarettes smoked per day.

Among males the death rate from diseases of the coronary arteries which supply blood to heart itself average 70% higher for smokers than for non-smokers. With ages between 45-54 years, the risk for smokers vis-a-vis non-smokers is 300% more for men and 200% more for women. Hardening of arteries, including

aorta, is much more commonly reported amongst smokers. Nicotine and carbon monoxide of the smoke are said to be the main culprits for producing abnormalities in circulatory system.

Association exists between cigarette smoking and peptic ulcers. Delayed healing of peptic and duodenal ulcers is also reported amongst smokers. Even otherwise, smokers are much more likely than non-smokers to develop blockage of blood vessels in heart muscles, brain, and the limbs. Incidence of stroke is also significantly higher amongst smokers. Because smoking also depletes the body of vitamin C, smokers' skin wounds may heal less quickly. Smokers are more prone to coughs, colds, major and minor respiratory infections and to overall breathlessness. Above all, smokers have less effective immune system than non-smokers and this makes them more prone to all type of diseases. In addition, smokers take longer to recover from many diseases.

Tobacco smoking also affects the teeth, causing periodental disorders and gum diseases. Conditions such as dental caries, tartar or diseases of the gum stem to a large degree from the presence of sugar in the diet and inadequate oral hygiene, but these problems are more common, and severe too, amongst smokers than in non-smokers. Sometimes, smokers develop gingivitis—a severe inflammation of the gums which often leads to mouth ulcers and death of the tissues.

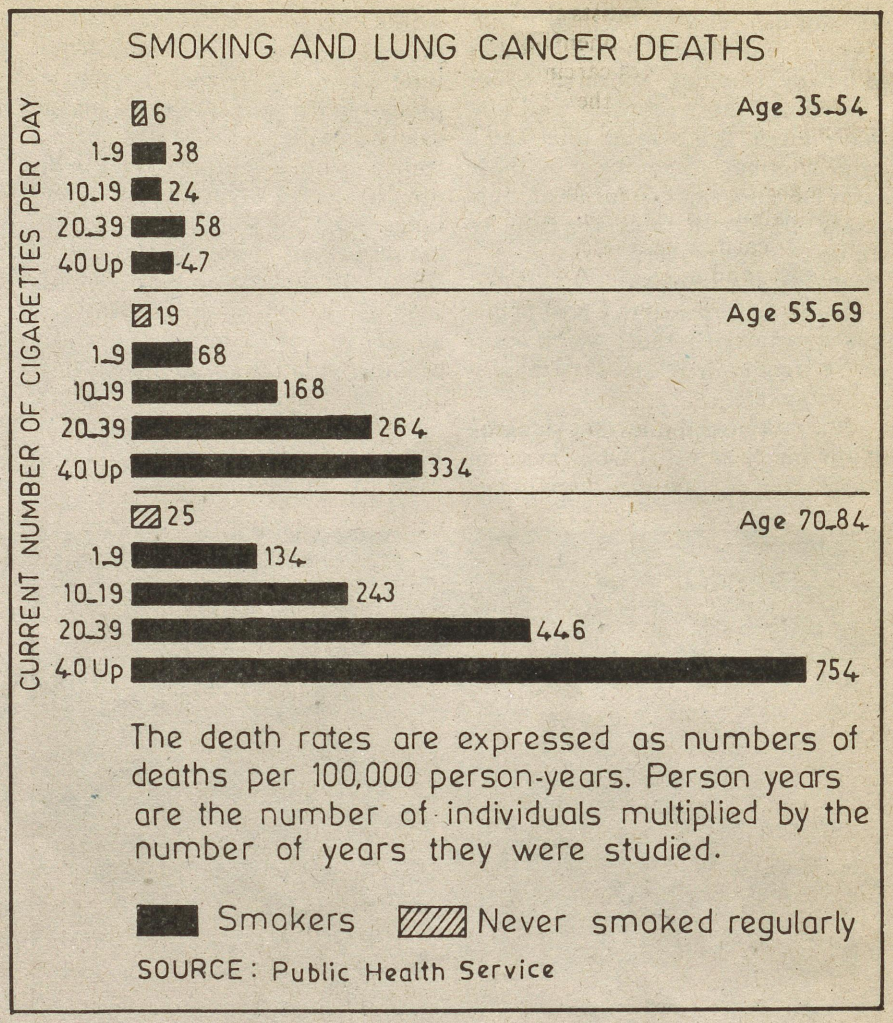

Fig. 4. Diagram depicting smoking and lung cancer deaths

Chemistry of smoking

Smoking habit is related to the varied social and psychological factors and is bolstered by the stimulating or sedating effects of nicotine. Tobacco leaf contains a complex mixture of chemical compounds like cellulosic products, starches, proteins, sugars, alkaloids including nicotine pectic substances, hydrocarbons, phenols, fatty acids, isoprenoids, sterol and inorganic minerals, and perhaps many more. Out of these, two unique groups of components, not found in other leaves are: (i) nicotine and its related substances, and (ii) isoprenoids.

Like tobacco leaf, cigarette smoke which is a mixture of 60% of gases and 40% liquid particulate matter contains several hundred substances including nicotine, carbon monoxide and tar containing carcinogens and mutagens such as benzo-(a)-pyrine, dimethyl-benz-(a)-anthracene, dimethylnitrosamine, naphthalene and methylnaphthalene. Not all constituents known have yet been evaluated for their toxicity, but all are suspected to be injurious and none is proved to be beneficial. Cigarette smoke enters the mouth of the smoker as an aerosol concentrate with millions or billions of microparticles per cubic centimeter. Inhalation of cigarette smoke leads to absorption of these substance through the pulmonary vasculature and blood-borne circulation throughout the body.

Smoking machines which simulate smoking habits enable scientists to trap particulate matter, a yellowish brown condensate known as tar. A single cigarette may have from 3mg-40 mg of tar depending upon the burning and condensing conditions, the length of cigarette, the use of filter and other factors. Over half a dozen compounds isolated so far from the particulate phase of cigarette smoke have been shown to be carcinogenic, i.e., capable of causing cancer. Two of the most potent compounds are formed in the burning process. Curiously, the overall carcinogenic potency of tobacco tar is many times greater than the combined carcinogenic potency of the substances iso-

lated from the tar. Scientists attribute this fact to other components of the smoke which, while not carcinogenic themselves, enhance the cancer-causing properties of the tar carcinogens.

The gas phase of cigarette smoke consists almost entirely of nitrogen, oxygen, carbon dioxide, carbon monoxide, and methane. About one per cent consists of at least 40 trace minerals.

Out of hundreds of active ingredients in tobacco smoke, the three main toxic compounds are (i) nicotine, (ii) tar, and (iii) carbon monoxide. Nicotine, a major toxin of tobacco smoke, is as addictive as cocain and morphine and creates dependence on tobacco. It raises the blood pressure and the heart rate thereby increasing the work load of the heart whose capacity is already weakened by reduced oxygen supply. Carbon monoxide combined with nicotine predisposes the smoker to a heart attack, paralysis or stroke. Carbon monoxide virtually drives the oxygen out of the red blood cells. The level of CO in smokers' blood is four times higher than in non-smokers'; in case of heavy smokers it may be as much as 15% higher than in non-smokers. Tar, on the other hand, damages many tissues, particularly lungs. The tiny particles present in cigarette smoke get stuck in lungs and give rise to a brown sticky mass containing chemicals which produce cancer; other chemicals in smoke produce emphysema and chronic bronchitis.

Cigarettes manufactured in India have more of nicotine, tar and carbon monoxide than those manufactured in the developed countries. Tobacco of *bidis*, too, is richer in these components. The tar content of cheap brands of Indian cigarettes approximates 19mg-27 mg and the nicotine content 1mg-1.4 mg—significantly higher than in cigarettes manufactured in the developed countries. Moreover, smokers in India, in order to get more value for the money spent, take longer and deeper puffs, thereby getting more nicotine, tar and carbon monoxide into their lungs.

Mode of smoking

Cigarette smoke inhibits the activity of ciliated cells in the respiratory tract. Cilia—small hair-like structures—move in a wave-like manner to expel mucus and foreign substances from the bronchial tubes. Some investigators believe that inhibition of the effectiveness of cilia enables environmental carcinogens, including those of tobacco smoke, to remain on the thin lining of the bronchial tubules from where they are absorbed and induce changes that lead to cancer.

Although filters can remove up to 40% of the tar in cigarette smoke, they are ineffective in removing components of the gas phase that impede ciliary activity. Since cigarette smoke has more than 2000 components, it will be a long time before all the harmful components are pinpointed and eliminated from smoke. However, with respect to tar and nicotine, cigarettes have become undoubtedly safer. Present day cigarettes contain only 2/3 of these components compared to cigarettes marketed 10 years ago, but this advance has been offset by longer-sized cigarettes with added tobacco. Longer, effective and safer filters can be devised but they would eliminate most of the 'taste' for which smokers are crazy.

Smoking and reproduction

The adverse effects of smoking on reproduction, though serious, have not been prominently publicized so far. The adverse effects can be discussed under two major categories viz., (i) female fertility and pregnancy, and (ii) male fertility.

Female fertility

Habitual female smokers show 21% higher frequency of infertility than non-smokers. Fertility, however, is speedily restored more or less completely amongst subjects who give up smoking. In one recent survey it was found that even those women smokers who were physiologically fertile showed diminished fecundity (ability to conceive). The overall mean pregnancy rate per cycle for smokers was 22% as against 32% per cycle for non-smokers.

A number of human studies have associated cigarette smoking with early onset of menopause; in fact, there exists inverse dose response relationship between smoking and age at menopause. Like-wise human menstrual cycle—vital for optimal female reproductive functioning—too, is disturbed by smoking. Menstrual disorders, viz., frequency of secondary amenorrohea, abnormal vaginal bleeding and irregularity in menstrual rhythm are significantly higher amongst smokers. Association between maternal smoking and spontaneous abortion has also been established. There is an almost doubling of premature births in smokers compared to non-smokers. Likewise incidence of still-births, neonatal and postnatal deaths is higher among smokers.

Male fertility

There is increasing evidence now available which proves unequivocally that smoking adversely affects not only male fertility but also impairs his libido (the sexual drive or urge). Smoking also adversely affects sperm concentration in semen and spermatozoal motility, and pushes up the incidence of abnormal spermatozoa in semen, all of which are related to spermatozoa viability. All these adverse effects, however, are reversible and normalcy is restored within 6 months after smoking is stopped.

Epidemiological data has revealed that incidence of natural infertility amongst male smokers is significantly higher than their non-smoker counterparts. Further, heavy smoking leads to testicular atrophy. It also stalls sperm formation and impairs testosterone synthesis—the hormone which regulates male libido.

Non-smoking smokers

'Non-smoking smokers' constitute a category of persons who are forced to breathe tobacco smoke as a result of 'enforced smoking' or 'involuntary smoking'. Neither their number nor the consequences of smoking on them is insignificant. Recent WHO reports on tobacco and health have underscored the health hazards from smoking that is inflicted upon non-

smokers. One report in the *British Medical Journal* in 1981 established that the risk of lung cancer was higher among wives of smokers than of non-smokers. A child whose parents smoke 10 cigarettes a day each, stands a 40% higher risk of contracting bronchitis, 27% greater chance of getting persistent cough and 60% higher risk of having a wheezing chest than a child of non-smoking parents. "Passive smoking gives rise to higher risk of cancer" concludes International Agency of Research on Cancer in Lyn (France) in one of their latest reports. Passive smoking can also trigger attacks of asthma in hypersensitive subjects. Health hazards apart, smoke in the environment is a nuisance indeed. According to the World Health Assembly which met in Geneva in May 1985, passive, enforced or involuntary smoking violates the right to health of non-smokers who must be protected against such environmental pollution.

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WASTEWATER *(Contd. from p. 201)*

ing dearer day by day.

The most neglected factor in the field of pollution control in India is the discharge of municipal wastewaters into streams and rivers. The '4-R concept', highlighted in the article, will prove to be useful in handling municipal and industrial wastewaters.

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STARS AND PLANETS

(Contd. from p. 189)

Saturn *(Sani),* visible in the morning sky rises about two hours after sunset during the first half of the month and about half an hour after it during the second half. It is in Sagittarius *(Dhanus).* Its visual magnitude is about +0.1.

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

In recent years, the modification of jute fibres by different chemical techniques has opened up innumerable new fields of applications

NEW USES OF JUTE

AMAR K. MOHANTY

JUTE fiber is an agricultural product. Jute industry has special importance in the economy of India and continues to be a major traditional earner of foreign exchange. However, it is facing tough competition from the synthetic fibers as the latter often offer certain advantages in terms of physical properties, durability and production economics. Therefore it has become necessary to boost the outlet of jute. At present, the bulk uses of jute are in the manufacture of packaging materials such as hessian and sacking, and of carpet backing cloth, due to its inherent high strength and relatively low price. Jute fiber now also finds use in sophisticated fields like decorative and furnishing materials such as lamp shades, wall covers, curtains, upholsteries, etc. However, the diversified uses of jute fibers depend upon the chemical modification of the fiber since the raw jute is generally brown in colour. In recent years the modification of jute fibers by different chemical techniques has opened up new possibilities for innumerable applications of chemically modified jute fibers.

Origin of jute

Jute is a fiber obtained from the bast of various species of corchorous plants growing principally in India and East Indian Islands.There are mainly two species of corchorous plants namely, *Corchorous capsularies* (white jute) and *Corchorous olitorius* (Tossa). However, in recent years the increasing use has been made of the fiber from Hibiscus plant family, commonly known as mesta, bimli, or kenaf. The fiber, which forms only a small portion of the jute plant, is located between the outer bark and the central pith or stick. The fiber is extracted from the jute plant by steeping in water (retting). Due to retting the cementing materials undergo decomposition which loosens the fiber from the surrounding cortical tissue thereby enabling its separation from the plant.

Chemical composition of jute fiber

Jute fiber is a natural fiber and has a very complex chemical structure unlike other natural fibers such as cellulose, silk, wool, etc.

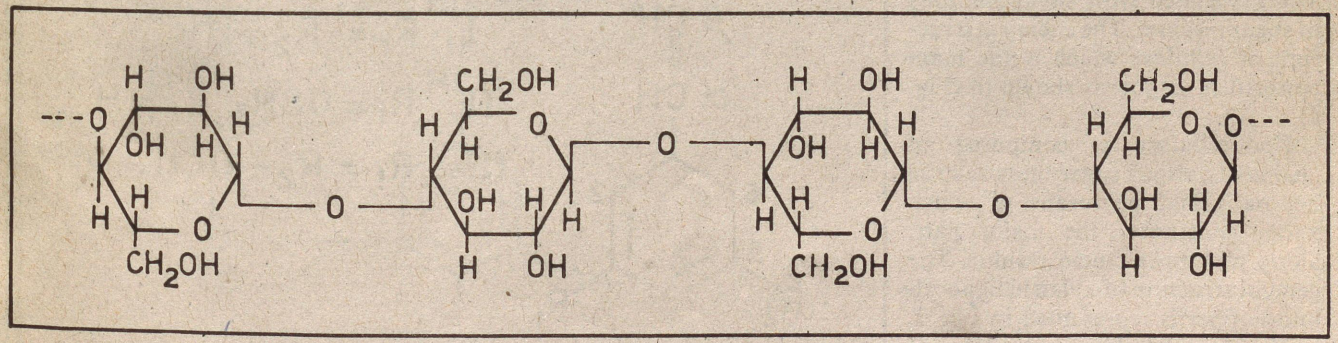

Fig. 1. Structure of cellulose

Dr. Mohanty is with the Post Graduate Department of Chemistry, Utkal University, Bhubaneswar-751004 (Orissa)

Chemically, jute is a lignocellulosic fiber. Compared to cotton, jute is not uniform in chemical composition as shown by the multicellular structure of the fiber. It is made up of a bundle of ultimate cells cemented together with non-cellulosic substances such as hemicelluloses and lignin. Thus cellulose, the main structural element of the fiber, is held entirely within the cell units and lignin and hemicelluloses are distributed throughout the entire body of the fiber serving as a cementing material. Jute differs from cotton in chemical composition in that it contains lignin and hollocellulose, the latter being a comlex mixture of carbohydrates. The hollocellulose component of jute may be subdivided into two main groups namely alpha or true cellulose and hemicellulose. The alpha-cellulose component, although consisting mainly of cellulosic chains,is also associated with small amounts of sugar residues. The chemical structure of cellulose which is the main constituent of jute is shown in (Fig. 1).

Hemicellulose is composed of chains of various sugar units such as hexosans and pentosans of which xylan constitutes the major part, along with uronic acid residue. The general structure of xylan in lignocellulosic fiber is represented in Fig. 2.

The hemicellulose consisting of hexosans, pentosans and polyuronides is intimately associated with lignin. Due to the presence of numerous hydrogen bonds and different types of chemical linkages, stabilisation of the chains is made possible.

Although the exact mode of linkage in jute is not well-known, lignin is believed to be linked with carbohydrate moiety through two types of linkages, one being alkali sensitive and other being alkali resistant. The alkali sensitive linkage forms an ester type of combination between the lignin hydroxyl and carboxyls of hemicellulose uronic acid. The ether type of linkage occurs through the lignin hydroxyls combining with hydroxyl group of the cellulose. The lignin, being polyfunctional, exists in combination with more than one neighbouring chain molecule of cellulose making a cross-linked structure.

Despite a large volume of research work, the exact chemical nature of the principal component of jute—lignin—still remains obscure. The main difficulty in lignin chemistry is that no method has so far been established whereby it is possible to isolate lignin in native state from jute. Although the structural formula of lignin in jute has not yet been established, the functional groups and units which make up the molecule have been mostly identified. The high carbon and low hydrogen content of jute suggests that it is highly unsaturated or aromatic in character. The lignin is characterized by its associated hydroxyl and methoxyl

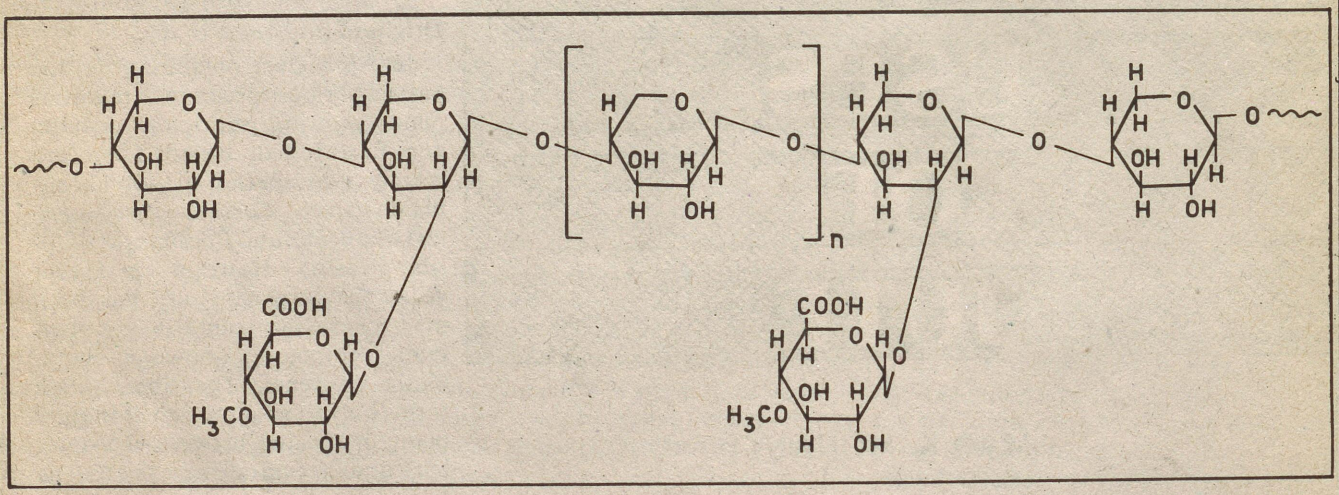

Fig. 2. General structure of xylan in lignocellulosic fiber

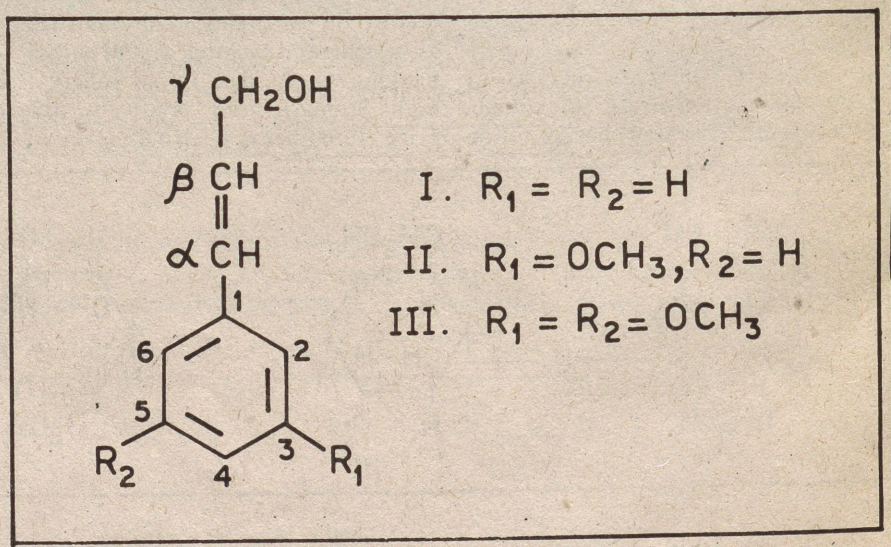

Fig. 3 Structure of p-hydroxycinnamyl alcohols

groups and jute lignin has been found to contain five hydroxyl and five methoxyl groups per building unit, corresponding to a molecular weight of 830.

The chemical nature of lignin in lignocellulosic materials like grass, wood, wood pulp, etc., has been an important aspect of studies in recent years. It has been found that lignins are polymers formed by dehydrogenation of *p*-hydroxyl-cinnamyl alcohols such as, *p*-coumaryl (a), coniferyl (b) and (c) sinapyl alcohols. Gymnosperm lignin is formed from coniferyl alcohols, angiosperm lignin from mixtures of coniferyl and sinapyl alcohols, and grass lignin from mixtures of coniferyl, sinapyl and *p*-coumaryl alcohols. The general structure of *p*-hydroxy-cinnamyl alcohol is represented in Fig. 3 and that of lignin in Fig. 4.

Besides cellulose and lignin, additional minor substances such as fats and waxes, pectinious materials, inorganic salts, nitrogenous substances, vitamins, colouring matter, etc., are also present in jute fiber. Studies on the minor constituents which may be present in small amounts or even only in traces are more limited compared to those on major constituents of jute fiber. The wax material which is present in jute fiber to the extent of 0.5%-0.8% has been found to consist essentially of higher alcohols (47%), fatty acids (33%), sterols (7%) and hydrocarbons (10%) along with small amounts of other substances. This small amount of wax is responsible for the characteristic odour of jute.

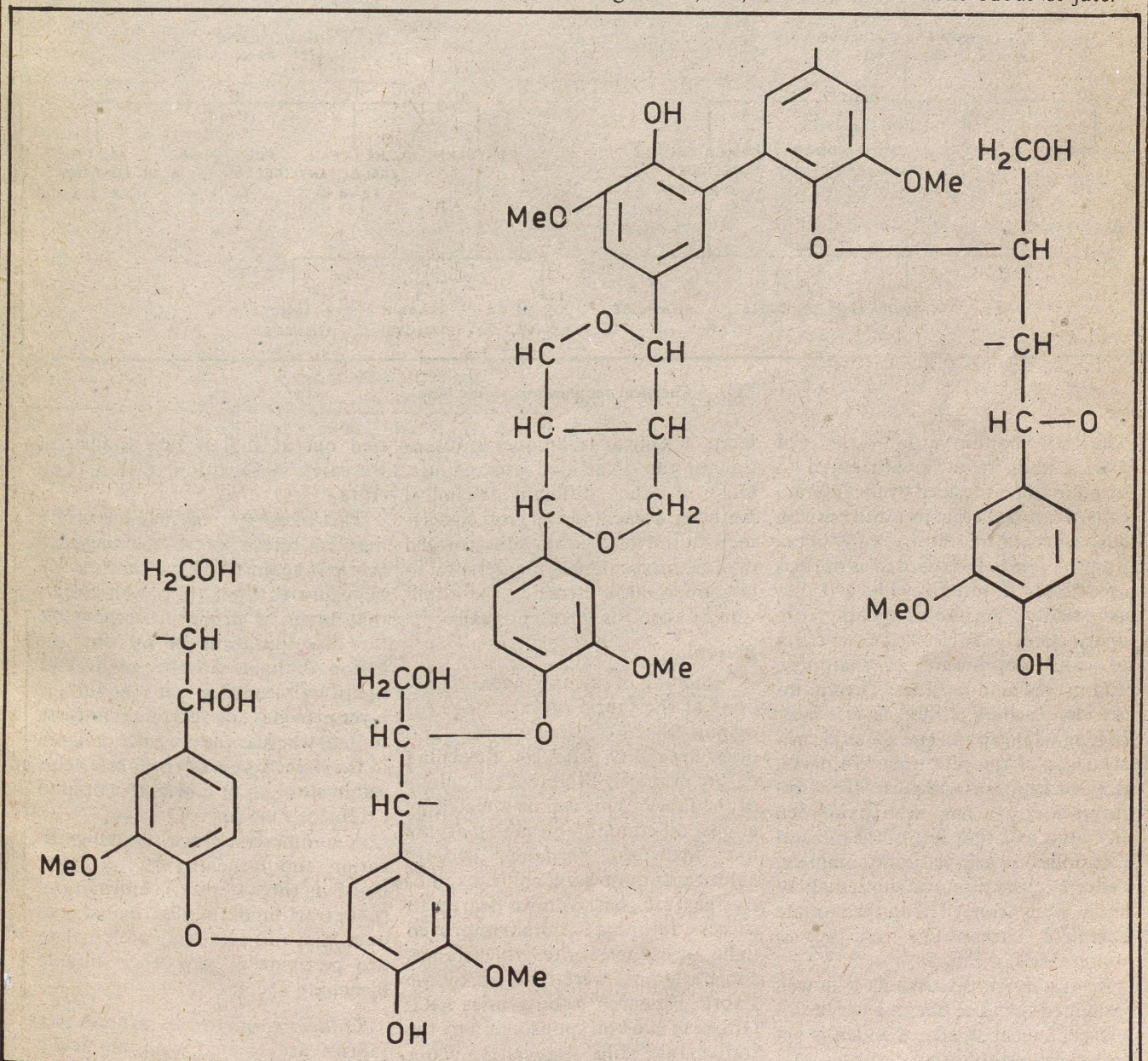

Fig. 4. Structure of lignin

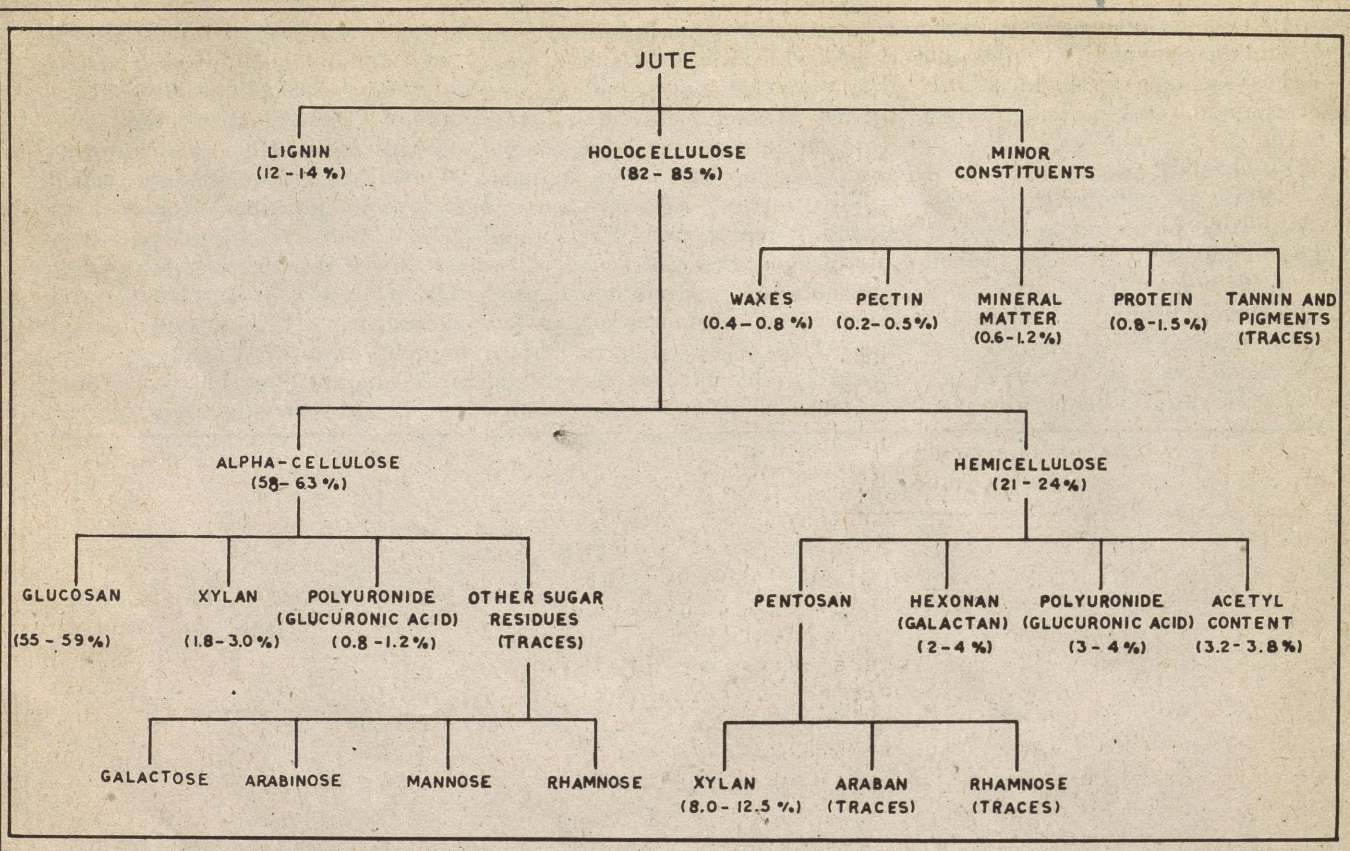

Fig. 5. Chemical composition of jute fibre

The dark colour in certain varieties of jute, usually tossa, is attributed to iron tannate produced by the interaction of tannin in the fiber and the iron derived from the retting water. Pectin, which may be regarded as normal constituent of jute fiber (0.3%-0.72% as calcium pectate) appears from analysis to be composed essentially of galactose, arabinose, rhamnose and uronic acid residues. The vitamins identified as present in jute fiber belong to B group. The mineral constituents of the jute fiber are partly derived from soil and partly from retting water. It has been examined from jute ash, that 70% of the mineral components are cationic, namely, sodium, potassium, calcium, magnesium and iron. The approximate chemical composition of jute is represented in Fig. 5.

From above discussions it is well imagined that jute fiber is a very complex chemical structure which is yet to be well established.

Chemical modification of jute fiber

Modification of jute fiber by different chemical techniques is essential for the diversified uses of jute. Out of the different chemical methods, bleaching and graft copolymerization of certain unsaturated organic molecules (monomers) on to jute fibers have attracted the attention of chemists in recent years.

Bleaching

Bleaching of jute is conventionally done at the fabric or yarn stage for manufacture of decoratives and other speciality products. Bleaching of jute primarily brightens the colour of the fabric. This can be effected by almost all common bleaching agents like hydrogen peroxide, sodium chlorite, sodium hypochlorite, chlorine gas, etc., with various degrees of success. In order to obtain improved light resistance after bleachings, some attempts were initiated by the Fabric Research Laboratories FRL (USA) in 1967 on sponsorship by the Indian Jute Mills' Association. Considerable research works on bleaching of jute fibers for improved light resistance of the fiber have been carried out at Indian Jute Industries' Research Association, IJIRA (Calcutta).

The bleaching of jute imparts a marked resistance to the bleached fabrics against discolouration on exposure to light. It is well-known that lignin is primarily responsible for discolouration of jute by the action of light. So the removal of lignin by bleaching from the surface layer provides adequate light fastness to jute, whereas the presence of lignin in the inner layers of the fabric helps retain strength of fabrics to a desired extent.

A commercial process of delignification and bleaching of jute takes place via three steps: (i) chlorination, (ii) extraction of the chlorinated product, and (iii) bleaching with hydrogen peroxide or any other suitable bleaching agent.

Chlorination. In this process jute fabrics are treated with an acidic solution of sodium hypochlorite by addition of hydrochloric acid to alkaline sodium hypochlorite. Sodium

hypochlorite under acid conditions decomposes to give nascent chlorine:

$$NaOCl + HCl \rightarrow NaCl + HOCl$$
$$HOCl + HCl \rightarrow H_2O + Cl_2$$

The chlorine thus formed reacts with phenolic groups of lignin of the jute thereby forming chlorolignin.

Extraction of chlorinated product. The compounds of chlorinated lignin are generally soluble in aqueous sodium sulphite, alkalies or sodium bisulphite, out of which sodium sulphite has been found quite effective. After the removal of chlorolignin by sodium sulphite treatment, the fabrics are washed. Such fabrics are extremely resistant to discolouration on exposure to sunlight/daylight and have specific end uses.

Bleaching with hydrogen peroxide. The chlorolignin-free jute fibers can be bleached by common bleaching agents. The varying processing concentrations of the bleaching agents have marked influence on the light fastness of the fabric. Generally, bleaching with 1 volume of hydrogen peroxide gives improved colour resistance to the fiber. By bleaching, the fabric attains a reasonable degree of whiteness with a high resistance to discolouration on sunlight exposure.

Graft copolymerization

Graft copolymerization is a novel technique for the development of some of the important useful properties of jute fibers. Graft copolymers of natural polymers like cellulose, silk, jute, etc., exhibit excellent properties besides exhibiting their original properties.

A graft copolymer is a high polymer whose molecules consist of two or more polymeric parts of different composition chemically united together. It is a process of copolymerization of one kind of monomer in its polymeric state with another polymer which may be either synthetic or natural. In a graft copolymer, sequences of one monomer are grafted onto the backbone chain having other monomer (Fig. 6).

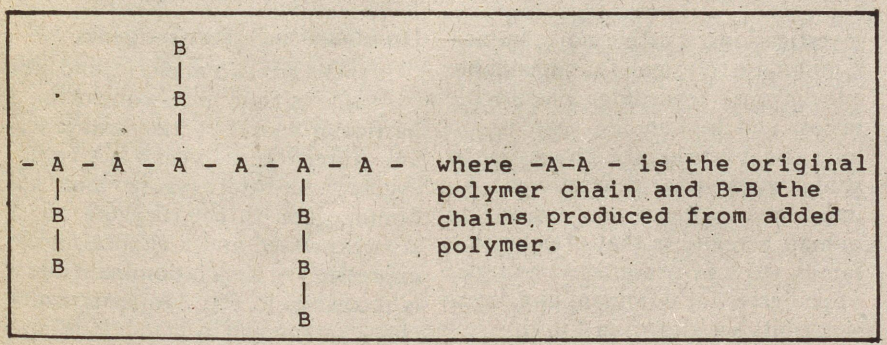

Fig. 6. Graft copolymer

Graft copolymerization provides additional desirable properties through the added polymer without destroying the base properties of the original fiber or polymer.

Important properties like tensile strength, thermal stability, light fastness, resistance to bacterial decomposition of jute fabrics have been shown to be enhanced by grafting suitable monomers onto the jute fibers. Some of the important monomers, which have been successfully grafted onto delignified, bleached or different chemically modified jute fibers thereby improving certain useful properties of jute fabrics, are represented in Table 1.

Table 1

Monomer	*Chemical formula*
Methyl methacrylate	$CH_2 = \underset{\displaystyle CH_3}{\overset{|}{C}}-COOCH_3$
Acrylonitrile	$CH_2 = \underset{\displaystyle CN}{\overset{|}{C}}H$
Styrene	$C_6H_5-CH = CH_2$
Vinyl acetate	$CH_2 = CH-O-\overset{\displaystyle O}{\overset{\|\|}{C}}-CH_3$

There has been considerable amount of research on graft copolymerization of various monomers onto jute fibers. But inspite of all these efforts, there has been little commercialization of the grafting process.

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HUMAN GENETIC DISORDERS

A number of disorders in human beings have been found to be associated with numerical and structural changes in chromosomes

B. N. SINGH

IN 1908, Sir A. Garrod delivered an amazing series of lectures at the Royal College of Physicians, London, on "Inborn errors of metabolism". He described certain genetic diseases that produce defects in metabolism. He also mentioned Gregor Mendel's laws of heredity to account for such phenomenon. Since then many diseases have been reported which are caused due to point mutations (an abrupt inheritable change in the genetic constitution of living organisms). These mutations may be dominant or recessive. There are other abnormalities which are genetic in origin but do not fit the expectations of Mendelian laws. After the establishment of chromosome number (diploid) of 46 by J.H. Tjio and A. Levan of the University of Lund, Sweden in 1956, a number of disorders have been found to be associated with numerical and structural changes in chromosomes. These genetic changes have occurred spontaneously in human populations. However, they may be induced also by different agents such as radiations and chemicals (known as mutagens) present in the environment.

Genetic principles were laid down through experiments on different species of animals, plants and microorganisms. Such experiments are not possible in human beings. Mating and reproduction in man are intimate personal matters and cannot be directed to suit the convenience of experimenters. This makes man unsuitable for conventional genetic investigations. Furthermore, human families are too small for dependable conclusions regarding phenotypic ratios; and human life span is too long and it would take a long time to study even few generations. An important method of studying human heredity is that of collecting family trees or pedigrees. Examples of pedigrees for dominant and recessive traits are shown in Fig. 1.

In pedigrees, females are symbolised by circles and males by squares. The symbols of parents are joined by a marriage line and symbols of their children are placed below a horizontal line which is joined to the marriage line by a short vertical line. The presence of a trait is shown by a black symbol.

Dominant and recessive genes

If there are two alleles A and a of the same genetic locus controlling a particular character, they will generate three geno-types—AA-homozygote, Aa-heterozygote and aa-homozygote. In heterozygote Aa, if A is expressed and it suppresses the expression of a, A is dominant and a is recessive. In Fig. 1A, a particular character (shown by black circles and squares) is present in all the three generations and the individuals showing the character may be homozygous or heterozygous for the dominant gene controlling the character. On the other hand, in Fig. 1B only one individual in the third generation shows the specific character and is homozygous for the recessive

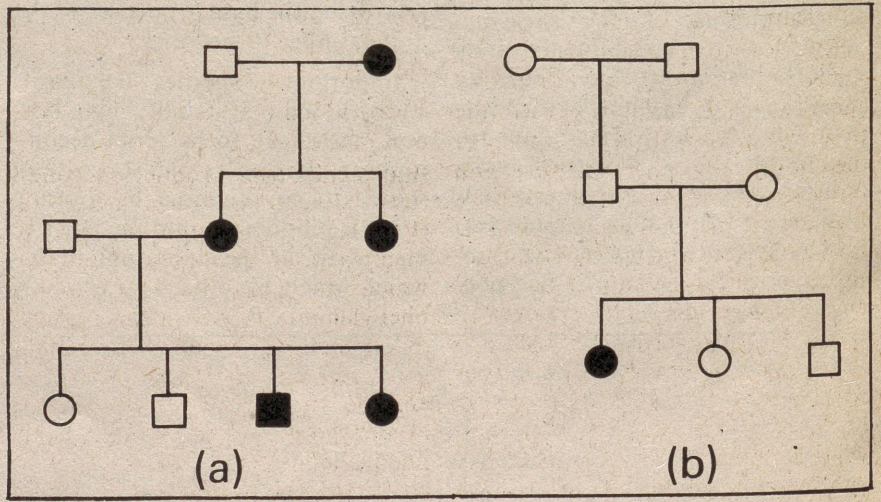

Fig. 1 (a) A pedigree of dominant character, and 1 (b)-a pedigree of recessive character. In both pedigrees, squares represent males and circles females. Open symbols represent persons not showing the trait in question; black symbols, persons showing the trait

Dr. Singh is Reader in Zoology Department, Banaras Hindu University, Varanasi-221005

gene controlling the character in question. A recessive gene (autosomal) will be expressed only in homozygous condition. A sex-linked recessive gene will be expressed in homozygous females. But it will be expressed in males carrying the gene because they are hemizygous (i.e. they have only one X chromosome).

Single gene disorders

There are numerous diseases in human beings which are caused due to single genes produced by mutation. The mutant genes producing diseases may be recessive or dominant. Furthermore, mutant genes may be autosomal (occurring on autosomes) or sex-linked (occurring on sex chromosomes). A number of disorders caused due to single genes and the mode of their inheritance has been clearly understood, some of which are described here.

Alkaptonuria

This disease suggests a relationship between a gene and a specific biochemical reaction and is caused due to a recessive autosomal gene. In metabolism of phenylalanine and tyrosine, one of the end points is the breakdown of homogentisic acid to carbon dioxide and water. This reaction is accomplished under the influence of an enzyme that is present in the liver. The disorder is caused due to the defect in the enzyme homogentisic acid oxidase that normally mediates the breakdown of homogentisic acid. When the defective enzyme is produced due to the mutant gene, a large amount of homogentisic acid is excreted in the urine which turns black upon exposure to air. Homogentisic acid also accumulates in the body and becomes attached to the collagen of cartilage and other connective tissues. This leads to a darkening of the cartilaginous regions. In joints, the accumulation can lead to arthritis. Alkaptonuria is inherited as an autosomal recessive trait and is an example of genetic enzyme block.

Albinism

An autosomal recessive gene in homozygous condition produces an albino individual who is sensitive to bright light and whose skin is easily sunburned. An albino individual shows complete absence of melanin (colour pigment) in skin, hair and eyes due to which he or she appears white. The mutant gene is associated with faulty utilization of phenylalanine. In albinos the tyrosinase enzyme which catalyses the conversion of tyrosine to DOPA (3, 4-dihydroxyphenylalanine) is not produced. As a result melanin is also not produced. Fig. 2 depicts a pedigree of albinism.

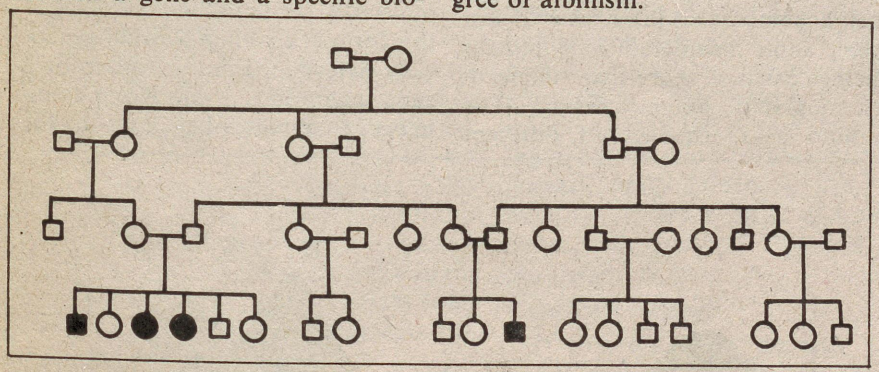

Fig. 2. A pedigree of albinism

Phenylketonuria

A block in phenylalanine and tyrosine metabolism produces a condition known as phenylketonuria (PKU). It is caused due to a defect in phenylalanine hydroxylase enzyme which mediates the oxidation of phenylalanine to tyrosine in the liver of normal individuals. The mutant gene responsible for the defective enzyme is autosomal recessive. In the homozygotes for the mutant gene, phenylalanine accumulates and is converted to phenylpyruvic acid which is excreted in urine. Some of this is concentrated in the cerebrospinal fluid. Persons with a deficiency of the enzyme are feeble minded and have light pigmentation.

Tyrosinosis

This results from an excess of tyrosine which is excreted in the urine. Individuals homozygous for the mutant recessive gene fail to produce the enzyme liver-tyrosine-transaminase and thus the conversion of tyrosine to parahydroxyphenylpyruvic acid is blocked. However, no serious symptoms associated with tyrosinosis have been reported.

Tyrosinemia

It is a rare disorder. Persons homozygous for a recessive mutant gene are unable to produce the enzyme parahydroxyphenylpyruvate oxidase. In this condition a large amount of parahydroxyphenylpyruvic acid and derivatives of lactic and acetic acids are excreted in the urine. If the person is not kept on low tyrosine diets, it leads to serious liver problems which may result in early death.

Genetic goitrous cretinism

This condition is also associated with phenylalanine and tyrosine metabolism. One of the pathways involved in this metabolism leads to the production of thyroxine. An autosomal recessive gene in homozygous condition causes an enzyme block at this point which produces genetic goitrous cretinism accompanied by a considerable degree of physical and mental retardation.

Sickle-cell anaemia

Red blood cells, RBC or erythrocytes, contain haemoglobin which is a conjugated protein whose prosthetic (nonaminoacid) portion consists of iron-containing heme groups and the protein portion consists of four polypeptide chains—two identical alpha and two identical beta-chains. One heme group is associated with each polypeptide chain. Oxygen atoms are loosely bound to the iron atom present in the heme group. However, the functional efficiency of heme groups is determined by the protein portion.

Sickle-cell anaemia is produced due to a change in the hemoglobin molecule which lowers the oxygen carrying efficiency of heme groups. Patients with sickle-cell anaemia nor-

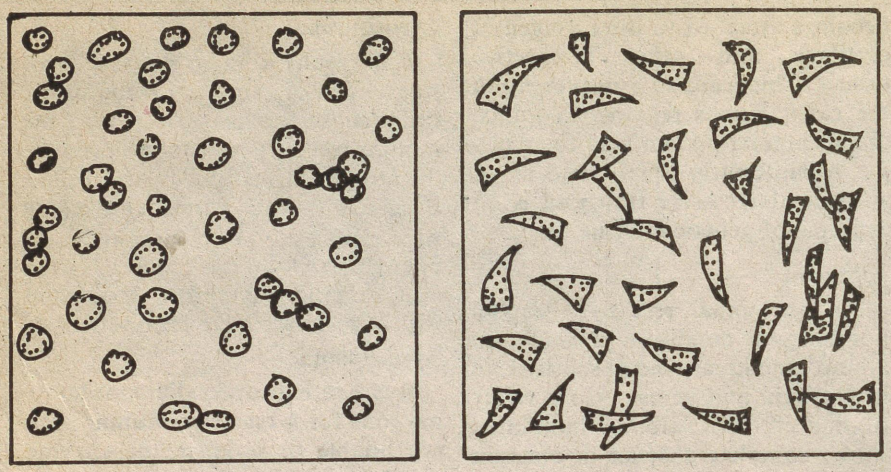

Fig. 3. Normal and sickled red blood cells

mally show only moderate anaemia. However, there is a hemolytic crisis due to sudden decrease in red blood cells following acute infections. As a result of rapidly developing severe anaemia, death may occur.

In persons with sickle-cell anaemia, there is no reduction of hemoglobin content within the cells in most cases. The red blood cells change their shape from biconcave (normal) to sickle shape (crescentric) when oxygen tension around the cells is lowered. Fig. 3 shows normal and sickled red blood cells. In sickle-cell trait, there is moderate sickling under reduced oxygen tension. Persons with sickle-cell trait appear otherwise to be healthy.

Sickle-cell anaemia occurs due to a mutation and individuals showing this disease are homozygous for the mutant gene. The heterozygous individuals (possessing normal and mutant genes) show sickle-cell trait. On electrophoresis the hemoglobins from normal individuals, from persons with sickle-cell anaemia and from those with sickle cell trait produce different patterns which are depicted in Fig. 4. The heterozygotes (sickle-cell trait) show the electrophoretic characteristics of both types of hemoglobins—normal and sickle cell anaemia. This provides evidence that adult hemoglobin of human beings exists in more than one form (hemoglobin polymorphism). The amino acid sequence of different forms of hemoglobin has been determined. It has been found that normal hemoglobin has glutamic acid in the sixth position in beta-chain while the sickle-cell anaemia hemoglobin has valine in the same position. The amino acid sequences of beta-chain of various hemoglobin are shown in Fig. 5. Normal hemoglobin is called as Hb A and Sickle-cell as Hb S. The substitution of one amino acid by another in the beta-chain is the cause of lowered oxygen carrying capacity of sickle-cell anaemia hemoglobin. This substitution is caused due to mutation in genetic code. In some African populations, the sickle-cell gene is maintained at considerable frequency because of advantages that the heterozygotes possess in resisting malarial infection.

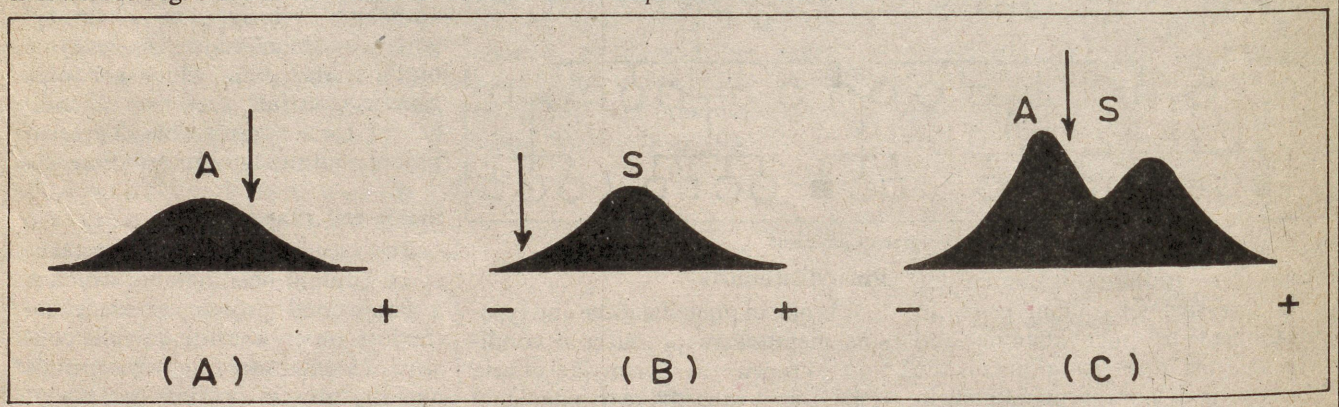

Fig. 4 Electrophoretic patterns of hemoglobin of different individuals: (A)—Normal individual (hemoglobin A); (B)—Individual with sickle cell anaemia (hemoglobin S); (C)—Individual with sickle cell trait

Hemoglobin Canaemia

This is another type of anaemia caused due to mutation. In the beta-chain of hemoglobin there is lysine in the sixth position (normal hemoglobin contains glutamic acid in the same position). This new type of hemoglobin is labeled Hb C. The genes determining A, S and C types of hemoglobin are alleles (different forms of the same genetic locus) since their amino acid differences occur within the same cistron.

Thalassemia

Insufficient number of hemoglobin molecules per red blood cell leads to this form of anaemia which is genetically determined and is caused by a gene exhibiting incomplete dominance. Individuals heterozygous for the mutant gene show mild anaemia—thalassemia minor—and usually survive to the age of sexual maturity. Persons homozygous for the mutant gene are characterised by severe anaemia thalassemia major and they are unable to cope with infections. Such persons die before reaching puberty. In this form of anaemia, hemoglobin content in erythrocytes is reduced due to less pro-

		Amino acid sequence							
		1	2	3	4	5	6	7	8
Hemoglobin	A	valine	histidine	leucine	threonine	proline	glutamic acid	glutamic acid	lysine
Hemoglobin	S	valine	histidine	leucine	threonine	proline	valine	glutamic acid	lysine
Hemoglobin	C	valine	histidine	leucine	threonine	proline	lysine	glutamic acid	lysine

Fig. 5. Amino acid sequence of beta chain of different hemoglobins showing difference in the sixth amino acid

duction of beta-chains. This is known as beta-thalassemia. Alpha thalassemia has also been reported in patients with reduced synthesis of alpha chains.

Cystinuria

It is a rare autosomal recessive disorder. Individuals homozygous for the mutant gene suffer from defective reabsorption of cystine, lysine, ornithine and arginine in the renal tubules. This leads to accumulation of these substances in urine. In the bladder, calculus formation takes place due to crystals of cystine as it precipitates out of the solution.

Galactosemia

This disorder is caused by an autosomal recessive gene which is rare in the population. The gene is responsible for the loss of activity of the enzyme galactose-l-phosphate uridyl transferase which catalyses the transformation of galactose into glucose. There is an excess of galactose in the liver and urine. Galactosemia leads to liver enlargement, cataracts and mental deficiency.

Tay-Sachs disease

This is the best known lysosomal storage disease. The mutant gene producing the disorder is autosomal recessive. In individuals showing the disease (homozygous for the recessive gene), there is loss of activity of the enzyme which cleaves the terminal residue from brain lipid (ganglioside). The homozygotes appear normal at birth and after a few months they begin to show signs of central nervous system deterioration which leads to progressive mental retardation, blindness, and loss of neuromuscular control. Death occurs usually by 2 to 4 years of age.

Retinoblastoma

A dominant mutant gene causes malignant tumours in eyes and leads to death in early childhood. The gene arises due to mutation and is lethal.

Huntington's chorea

This disease occurring around 25-40 years of age, is associated with the loss of enzyme activity. The main symptom is progressive mental deterioration. It is caused by a rare dominant gene.

Cystic fibrosis

This is a hereditary metabolic disorder in children that is caused by an autosomal recessive gene. In individuals homozygous for the mutant gene, a unique glycoprotein specified by the gene, is produced. This glycoprotein produces mucous with abnormally high viscosity which interferes with the normal functioning of several exocrine glands in skin (sweat), lungs (mucous), liver and pancreas. Patients suffer with bronchitis and defective digestion and absorption of food.

Gaucher's disease

It is a lysosomal disorder associated with loss of enzyme activity and is caused by a recessive gene. Presence of Gaucher's cells causes enlargement and destruction of many tissues particularly spleen, liver, bone marrow and brain.

Hemophilia

This is a sex-linked disease which manifests itself chiefly in the absence of ability of the blood to clot when exposed to air. In persons with hemophilia, a small skin injury can lead to death due to loss of blood. The disease is caused by a sex-linked recessive gene. Female hemophiliacs have also been reported but they are rare. Hemophilic men, when they survive and reach the reproductive age, produce daughters who are normal but carriers (heterozygous) of hemophilia. Heterozygous females transmit hemophilia to their sons (half). Two types of hemophilia, A and B, have been reported which are caused due to recessive loci separated from each other on the X chromosome.

Red-green colour blindness

This is the commonest sex-linked human trait caused due to a recessive gene on the X chromosome. Individuals with this disorder are unable to discriminate between red and green colours. Both types, viz., defect in green sensitive cones as well as defect in red sensitive cones, are known. It occurs more frequently in males because they have only one X chromosome (hemizygous). In females (they possess two X chromosomes) the trait is expressed only in homozygous condition. Heterozygous females (having normal and mutant genes) are said to be carriers. All sons of a colour blind mother are colour blind irrespective of the kind of colour vision her husband may have. However, all the daughters of a husband with normal vision, will have normal vision but they are carriers (heterozygous) of the gene for colour blindness.

G 6 P D deficiency

The deficiency of glucose-6-phosphate dehydrogenase enzyme results from the action of a sex-linked recessive gene and a large number of persons are affected by this disorder. The enzyme is involved in glycolysis pathway in red blood cells. When certain drugs are administered, persons develop severe anaemia due to destruction of erythrocytes. These drugs and incitants include primaquine (antimalarial drug), phenacetin, naphthalene (mothballs accidently taken by children), sulphoxone (antileprosy drugs), nitrofuratoin (urinary antiseptic), para-amino salicylic

acid, and sulphonamides. Inhalation of pollen or ingestion of seeds of broad bean *(Vicia faba)* produces the same result. In the absence of these drugs and incitants, the persons with G6PD deficiency do not suffer ill effects.

Lesch-nyhan syndrome

This is a sex-linked neurological disorder characterised by mental retardation and destructive self mutilating behaviour with a tendency to bite fingers and lips. The syndrome is associated with a loss of enzyme that participates in purine metabolism. The production of excessive uric acid in these persons indicates that the enzyme is involved in the normal regulation of purine biosynthesis. The sex-linked pattern of inheritance suggests that the gene responsible for this disease is located on the X chromosome.

Chromosomal disorders

Every species has a characteristic number of chromosomes. For sexually reproducing forms one can designate two basic numbers: (i) haploid (n) which is found in gametes, and (ii) diploid (2n) which is found in somatic cells. In humans *(Homo sapiens)* the diploid number of chromosomes is 46 (44A+XX in females and 44A+XY in males). In gametes the number is reduced to half (22A+X or 22A+Y). Out of 46 chromosomes, 44 are autosomes (A) and the rest two sex chromosomes (XX in females and XY in males). Chromosomes have been numbered (1-22 pair autosomes + XY) and arranged in groups according to their size and position of centromere. Chromosomal aberrations due to structural and numerical changes involving both autosomes and sex chromosomes are known in human beings. With the advancement of techniques for studying human chromosomes, a number of genetic disorders have been found to be associated with structural and numerical alterations in chromosomes. Some disorders for which chromosomal aberrations have been well studied, are described here.

Down's syndrome (Mongolism). This was first reported in 1866 by a British physician J.L. Down. Individuals showing the syndrome are characterised by numerous abnormalities which include: mental retardation (I.Q. very low), below average height, peculiarity of the upper eye lids, sloping forehead, flattened nose bridge, short broad hands, usually open mouth with protruding tongue and cardiac malformations. Life expectancy is reduced. Sexual maturity is generally not attained. Males with Down's syndrome are sterile but a few females have been reported to have borne children.

Choromosomal studies of persons with mongolism have revealed the presence of an extra chromosome which makes the total number of chromosomes 47. The extra chromosome is 21 autosome. This condition is known as trisomy (triplo-21). The frequency of Down's syndrome in the population is roughly one in 600 live births. The occurrence of Down's syndrome is closely associated with maternal age. Trisomy (triplo-21) arises due to non-disjunction (failure of separation of homologous chromosomes during meiosis) of chromosomes during oogenesis.

Edwards' syndrome. It is characterized by several abnormalities some of which are; malformed low set ears, small receding lower jaw, flexed fingers, cardiac malformations, deformities of skull, face and feet. Death takes place usually around 3 to 4 months of age but sometimes it may be delayed for nearly two years. One mentally retarded female of 15 years age has been reported. Pronounced maternal age effect has been found to be associated with this syndrome. The individuals showing this syndrome have an additional chromosome and thus the total chromosome number is 47. The extra chromosome is autosome 18 (trisomy, triplo-18).

Patau's syndrome. This is also a case of trisomy (triplo-13) resulting from an extra autosome taking the total chromosome number to 47. The individuals with Patau's syndrome exhibit many abnormal characteristics: mental retardation, sloping forehead, deformed face, polydactyly of hands and feet, deformed hands and feet, cardiac and other internal defects. Death occurs within hours or days but may abort spontaneously. However, one individual with triplo-13 of 5 years of age has been reported.

Turner syndrome. Individuals showing Turner syndrome present a general female phenotype and are characterised by several abnormalities: short stature, webbing of the neck, broad shield-shaped chest. Slight mental retardation is often found in these individuals. Secondary sexual characters do not develop. Breast development is either absent or very slight. Pubic hairs are either absent or reduced. Axillary hairs do not develop and genitalia remain infantile.

Normal females are sex-chromatin positive due to the presence of Barr body (one of the two X chromosomes which is darkly stained). However, Turners are sex-chromatin negative even though they show a general female phenotype. This suggests that there is only one X chromosome in Turner individuals. They have only 45 chromosomes (44A+XO). Thus abnormalities are caused due to the loss of one of the two X chromosomes. Individuals showing Turner syndrome are usually sterile. However, one normal birth and some pregnancies have been reported. The general female phenotype of Turners indicates that the absence of Y chromosome produces female phenotype.

Klinefelter syndrome. Persons showing Klinefelter syndrome have a general male phenotype and are characterized by mental retardation. The external genitalia are normal in gross morphology. Testes are small and sperms are not produced. Some degree of breast development has been observed. Arms are longer than average. Voice is higher pitched as compared to normal males.

Individuals with this syndrome are sex-chromatin positive suggesting the presence of two X chromosomes although they show a general male phenotype. Cytological studies have demonstrated the presence of 47 chromosomes (44 A+XXY). The abnormal chromosome number arises through nondisjunction of sex chromosomes during gametogenesis.

The general male phenotype of these individuals suggests that Y chromosome produces maleness even in the presence of two X chromosomes. Thus in human beings Y chromosome determines maleness and X chromosome in the absence of Y determines femaleness.

Besides these syndromes produced due to numerical changes in chromosomes, some abnormalities have been found to be associated with structural changes in chromosomes particularly deletion (when a segment of chromosome is lost) and translocation (when a chromosome or its part is translocated to another chromosome). In the case of Down's syndrome, an extra chromosome 21 is translocated to chromosome 14. The chromosome number is 46 but an individual with translocation shows all the symptoms of Down's syndrome (triplo-21). In addition to this a few other cases of translocation in human beings have been reported. In these cases, there are numerous phenotypic abnormalities and spontaneous abortion or death may occur within a few months after birth. Those who live longer always exhibit mental retardation. Chromosomal segments are present in triplicate in these individuals.

Deletion (loss of a chromosomal segment) also leads to abnormalities in human beings. The best known disorder associated with a deletion in humans is cri du chat (cat cry) syndrome. Persons with this syndrome have a characteristic high pitched cry similar to that of a kitten in distress caused due to malformation of larynx. In addition to this, malformation of head, face and mental retardation have also been observed. However, individuals affected with these abnormalities may attain sexual maturity. There is no change in the chromosome number. But chromosomal studies have shown that a large part of the smaller arm of one of the number 5 autosomes is deleted. Patients with chronic myelocytic leukemia show deletion of a segment of number 22 autosome. This deleted part is usually seen to be translocated to one of other autosomes. Abnormalities due to deletion of a segment of sex chromosomes are also known.

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SCIENCE SPECTRUM *(Contd. from p. 226)*

Usually the sperms persist in the vagina upto 72 hrs after intercourse. But in rare cases they may persist up to 17 days. In case of a dead woman sperms can persist in the vagina even upto 3-4 months. However, complete sperms with head and tail do not persist as long as the heads. Sperms usually retain the tail from 16 hrs to 72 hrs after intercourse. Tail is also lost during preparation of the slides for microscopic identification of sperms from the vaginal swabs. The reasonable conclusions from the findings of sperms in a vaginal swab may be drawn only after getting useful information if the victim has had sexual intercourse, apart from the alleged offense, within the previous week and to know about how long after the alleged offence the vaginal swab was taken. Ostensibly, the sperms are the most unequivocal and the longest surviving seminal constituents and are the most valuable forensic indicators of the presence of semen in the vagina. In cases involving aspermic (without sperms), oligospermic (few sperms) and vasectomised offenders, semen detection will be difficult should the swab be taken at any prolonged interval of time after intercourse. Many cases of rape remain unreported because most of the victims feel shame, embarrassment and fear of revenge by the offender if she goes to police, or fear of being rebuffed by the parents if they learn of the incident. The unfortunate and disturbing point is that only a small percentage of sexual offenders is punished.

Santosh Toor
Research Fellow, BPR & D
Forensic Science Laboratory
Madhuban, (Haryana)

Electrochemically induced nuclear fusion

ANY scientific discovery that promises to solve the energy problem is bound to receive world-wide attention. If, in addition, the results obtained are unexpected and unexplainable on the basis of currently accepted theories, the attention is bound to turn into a scientific furore. The results reported jointly by Dr. Martin Fleischmann of the University of Southampton, UK, and Dr. Stanley Pons of the University of Utah, USA, have generated enough furore—accompanied, however, by feverish activity—in the world scientific community. In their article published in the April 1989 issue of the *Journal of Electroanalytical Chemistry* (261 (1989) 301-308), Fleischmann and Pons have claimed success in inducing electrochemically generated deuterium to undergo nuclear fusion reaction at room temperature. The discovery of "cold fusion", if substantiated, may turn out to be a scientific revolution which may place unlimited energy at the disposal of mankind.

It is well known that nuclear reactions are accompanied by very large changes in energy due to the conversion of a part of the mass of the reactants into energy according to Einstein's equation $E=mc^2$. Thus, the law of conservation of mass does not hold in the case of nuclear reactions. In contrast to energy changes of upto 400 kJ mol^{-1} in the chemical reactions, where this law holds, the energy changes in nuclear reactions are millions of times greater. A common driving force for the nuclear reactions is the tendency of the different nuclei to attain higher stability. It has been found experimentally that the chemical elements with highest stabilities are those that have mass numbers around 60 (see Fig. 1).

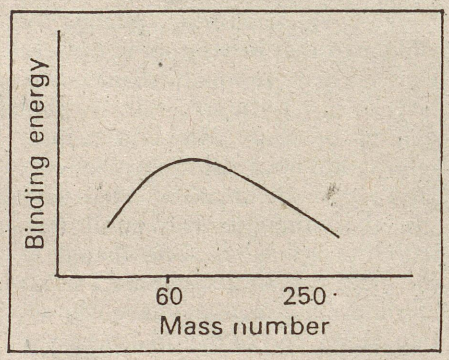


Fig. 1. Variation of binding energy with mass number

Theoretically, a lighter element with mass number less than 60 can acquire greater stability by increasing its mass number through fusion with another light element, while a heavier element with mass number greater than 60 can achieve greater stability by fission into elements of smaller mass numbers. Both these nuclear reactions, fusion and fission, generate vast amounts of energy. While controlled fission reactions have been successfully commercialised to produce usable energy, similar success has not been achieved in the case of fusion reactions. The strong repulsive forces between the reactant nuclei prevent their close contact, a pre-requisite for a successful fusion reaction. So far, the efforts have been directed towards mimicking the fusion reactions occurring in the sun and other stars. At high temperatures, of the order of a few hundred of million degrees centigrade, the gaseous reactants lose electrons and become ionized. In this positively charged gas mass, called plasma, nuclei collide with each other at sufficiently high speeds to overcome the repulsion barrier. Such controlled fusion reactions involve elaborate experimental arrangements and are prohibitively expensive.

Therefore, the significance of the work of Fleischmann and Pons lies in the simplicity of the experimental set-up used to achieve the nuclear fusion reaction of deuterium ($D = {}^{2}_{1}H$). Deuterium was obtained by the electrolysis of heavy water (D_2O) containing 0.1 M LiOD in an electrolytic cell equipped with a palladium cathode and platinum anode (Fig. 2).

The following reactions are expected to occur during the

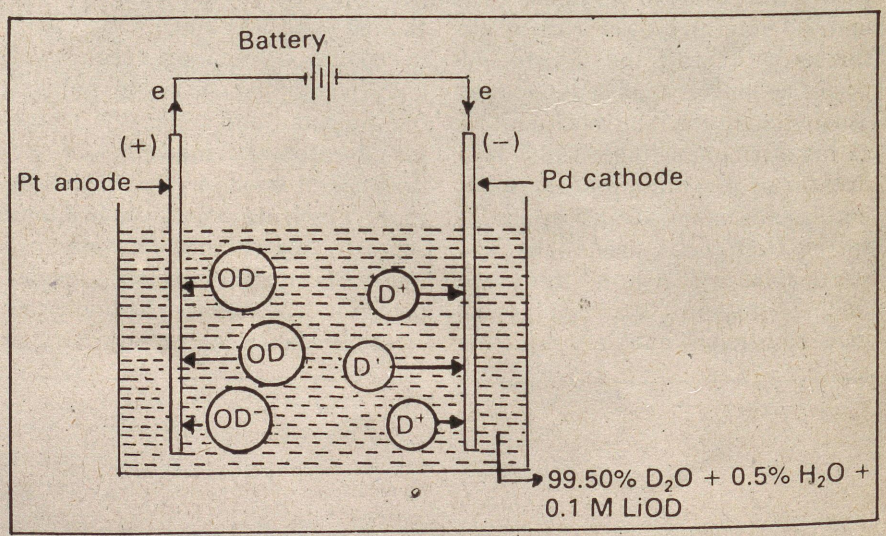


Fig. 2. Electrolytic cell

electrolysis of heavy water.

$D_2O \rightarrow D^+ + OD^-$

$D^+ + e \rightarrow D_{ads}$ (at cathode)

$4OD^- \rightarrow 2D_2O + O_2 + 4e$ (at anode)

However, the surprising observation that led Fleischmann and Pons to propose the occurrence of nuclear fusion was the generation of abnormal amounts of heat during the course of electrolysis. During electrolysis, heat is expected to be produced due to the passage of electric current through the electrolyte (Joule heating), but the heat produced in different experiments carried out by Fleischmann and Pons was much more ($\sim 4 \times 10^6$ J cm^{-3} of electrode volume) than expected. In one particular experiment, so much heat was produced that the palladium cathode melted (melting point 1554° C), and a part of it vaporized. In the words of Fleischmann and Pons, "It is inconceivable that this could be due to anything but nuclear processes."

The nuclear processes that Fleischmann and Pons propose to be taking place at the palladium cathode are:

$^2D + {}^2D \rightarrow {}^3T + {}^1H$ ..... (1)

and $^2D + {}^2D \rightarrow {}^3He + n$ ..... (2)

where D = deuterium (^2_1H), T = tritium (^3_1H), (^1H = proton and n = neutron.

According to Fleischmann and Pons, fusion of "electrochemically compressed" D^+ occurs at the octahedral sites of the palladium lattice. The chemical potential of dissolved D^+ corresponds to pressures of the order of 10^{26} atm and, further, the D^+ ions in the cathode lattice behave as delocalised species. It is the combination of very high compression and mobility that leads to a significant number of close collisions among deuterium nuclei and finally to the fusion reaction.

Many objections have been put forward to this explanation. for example, many scientists have pointed out that the radiation accompanying the reported reaction is expected to be so massive as to kill the persons doing the experiment. Therefore, the heat-producing reaction may not be nuclear reaction at all buy some chemical reaction. Fleischmann and Pons agree that the quantities of tritium and neutrons detected by them are much less than those expected according to the amount of heat produced. They suggest, however, that reactions (1) and (2) are only a small part of the overall reaction scheme and the major part of the energy produced is due to some yet unknown nuclear processes.

Support for this view has come from Dr. Peter Hagelstein of the Massachusetts Institute of Technology, USA, who is reported to have already submitted papers explaining the mode of fusion reaction occurring at the palladium cathode. He proposes that a free flow of energy exists between the palladium lattice and the deuterium nuclei. The fusion reaction occurring at the Pd cathode, according to Dr. Hagelstein, follows equation (3) instead of Eqs 1 and 2.

$^2D + {}^2D \rightarrow {}^4_2He + \gamma$ — rays..... (3)

The energy released in the form of gamma-rays is absorbed by the cathode lattice and is spent in starting another fusion reaction at an adjacent site thus leading to a chain reaction. Sometimes, ^4_2He produced in reaction (3) is unable to transfer energy to the lattice and decomposes to produce tritium or ^3He [$^4_2He \rightarrow {}^3_1T + {}^1_1H$; $^4_2He \rightarrow {}^3_2He + n$]. According to Dr. Hagelstein, these are the neutrons which have been observed by some of the experimenters. This view also explains the much lower flux of neutrons observed than that expected on the basis of heat produced in the reaction.

However, the experiment of Fleischmann and Pons is being meticulously repeated all over the world and only time will tell whether it is a historic discovery or a wild goose chase like the polywater of a decade and half ago.

B. C. Sharma
Editor
Indian Journal of Chemistry
P.I.D., N. Delhi—110012

Transition metal cluster compounds— a fascinating field

IN early sixties F.A. Cotton and his co-workers at Massachusetts Institute of Technology, U.S.A. began a systematic study of a new branch of transition metal compounds known as metal cluster compounds, a class of compounds different from the classical polynuclear complexes. A metal atom cluster may be defined as a group of two or more metal atoms in which there are substantial and direct bonds between the metal atoms. A typical compound is structurally represented in Fig. 1.

Although these compounds were synthesized as early as 1920, their behaviour could not be explained in terms of coordination theory as experimental tools for the elucidation of structure were not available. With the advent of techniques like X-ray crystallography, this class of compounds could be investigated in detail. They are now known as 'metal atom clusters'. The first metal atom cluster compound was a molybdenum (II) compound containing six Mo atoms in an octahedral environment with direct Mo-Mo bonds.

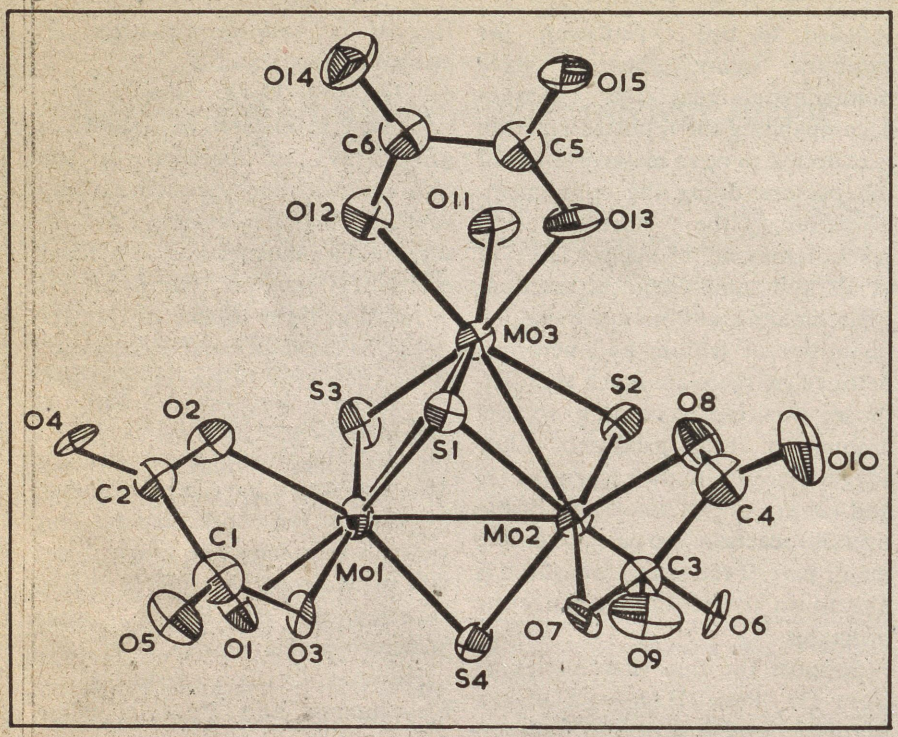


Fig. 1. Structure of $(Mo_3S_4C_2O_4)H_2O_3$ ion in the cesium salt

Another typical example of a metal cluster is $K_3W_2Cl_9$ in which the metal-metal (W-W) distance is 2.4 Å only, which is far less than the distance in tungsten metal (2.74 Å). One of the interesting aspects about the metal atom clusters is that there is a direct bonding between metal atoms without any bridge. Transition metals have varying tendencies to form metal-metal bonds. A fairly large number of metal atom cluster compounds have been reported with Mo, Rh, Re, Cr, W, Nb, Ta, Tc, and Ru. The tendency of these metals to retain clusters arises due to large energies of atomization, i.e., their very high boiling and melting points. There are today compounds containing M-M bonds virtually for all the transition block of elements with the exception of group (IV).

Two important conclusions can be drawn from the work on metal-metal bonding. The M-M bond formation is most likely when the metal atoms are in their low oxidation states usually +2 or +3. Secondly, the tendency to form M-M bonds is usually greater with the heavier elements. At present, techniques are available to demonstrate the existence of metal-metal bonds. They are X-ray crystallography, photoelectron spectroscopy and powerful theoretical techniques. As the bond order increases the metal-metal distance decreases and the bond strength increases; for instance, the single bond in $Mn_2(CO)_{10}$ is weak (20 Kcal/mole) and Mn-Mn distance is 2.92 Å whereas in $[Re_2Cl_8]^{2-}$ ion Re-Re bond is quite strong (100 Kcal/mole) and the Re-Re distance is 2.24 Å. Theoretically the bonding in these compounds can be explained in terms of interaction of the 'd' orbitals of the two metal atoms involved in bonding. The σ overlap between the d_{z^2} orbitals is the largest, the next is π overlap of d_{yz} and d_{xz} orbitals and the smallest is δ overlap between the d_{xy} and $d_{x^2-y^2}$ orbitals. The δ component of the overlap is crucial in the understanding of the stereochemistry of metal cluster compounds. The overlap between the two sets of 'd' orbitals of

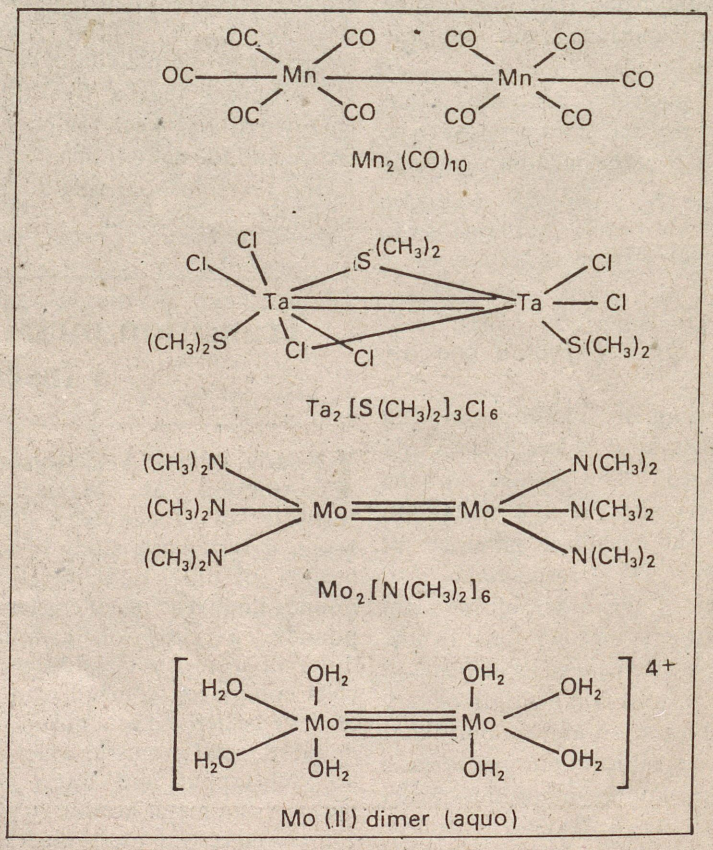


Fig.2

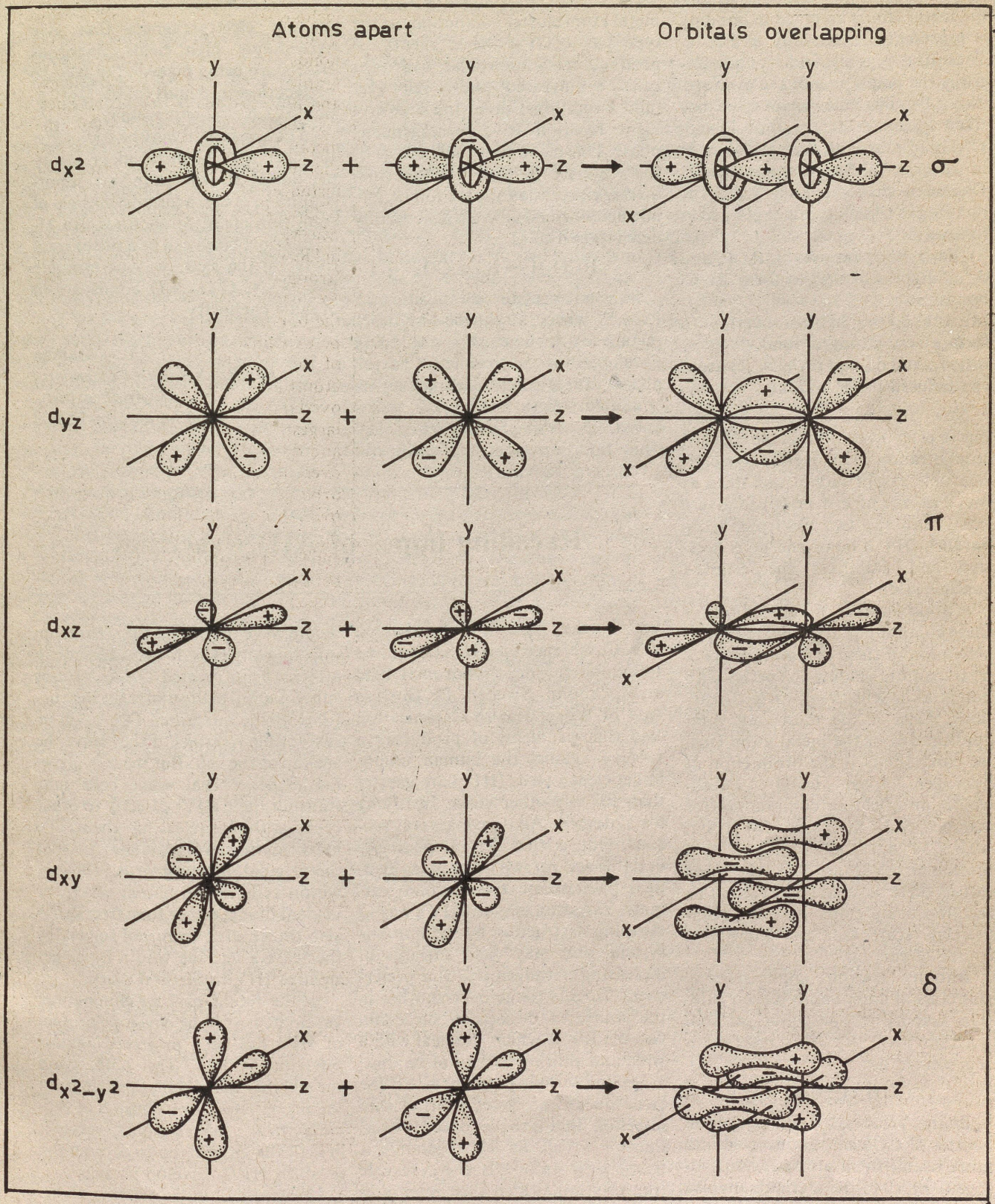


Fig. 3. Interaction of the 'd' orbitals of the metal atoms involved in metal-metal bonding

the metal atoms involved in bonding is represented pictorially in Fig. 3. These drawings also indicate qualitatively the magnitude of the overlaps. Now, for instance, an overlap between a square set of four ligands (X_4) placed around each metal atom in the two X_4M units is considered. One such cluster is $[Re_2Cl_8]^{2-}$. The bonding in this cluster is explained as follows :

(i) Each Re atom uses S, P_x, P_y and $d_{x^2-y^2}$ hybrid orbital to form Re-Cl bonds.

(ii) The $d_{z^2}-p_z$ hybrids overlap to form a very strong σ bond.

(iii) d_{xz} and d_{yz} pair on each Re atom can be used for π bonding.

Now only two electrons are left, one in each d_{xy} orbital. In the eclipsed configuration these overlap to a considerable extent (about one third as much as one of π overlap) to give δ bond with the two electrons being parallel. The δ bond energy is decisive and stabilizes the eclipsed configuration.

A good number of applications of these compounds arise due to photoactivation of these compounds via δ-δ^* transition, leading to species with potential in sensitizing various reactions. One of the most important applications of the metal atom cluster compounds is the production of hydrogen from water. Photoexcitation of cluster compounds, for instance, $Mo_2(SO_4)_4^{4-}$ in 5M H_2SO_4 with 254 nm radiation, produces molecular hydrogen. In the near future there is a possibility of this reaction being employed on a commercial scale—as an alternative source of energy.

Another notable application of this class of compounds is their catalytic activity on the water gas shift reaction (WGSR). This reaction is represented as :

$$CO + H_2O \rightleftharpoons CO_2 + H_2$$

By this process, the reducing equivalents of CO can be converted into more usable form of molecular hydrogen. Most of the methods involve the use of heterogeneous catalysts at high temperatures. By employing metal atom cluster compounds of the type $[Ru_3(CO)_{12}]$ the efficiency of production of molecular hydrogen can be enhanced under relatively mild conditions, involving a convenient reaction in a homogeneous phase. One more added advantage of this catalyst is that, the intermediates, either the formate ion or formic acid formed in WGSR, is readily decomposed to H_2.

$$HCO_2H \rightarrow H_2 + CO_2$$

Substances of the composition M Mo_6 S_8 where M can be any other metal, for instance Pb, are being developed for the so called 'Chevrel' phases. These compounds are superconductors with remarkable resistance to quenching by magnetic fields. They find important applications in making electromagnets that give exceedingly high fields. Vigorous efforts are being made in the West to perfect these methods for the fabrication of Chevrel compounds.

In conclusion, it may be stated that the chemistry of metal-metal multiple bonds affords abundant opportunities to create a fascinating field of transition metal compounds. An M-M multiple bond can be a site of reactivity, in the same way as multiple C-C, C-N, C-O, N-O bonds are in organic chemistry.

V.A. Raman
Reader, School of Chemistry
Andhra Univ.
Visakhapatnam-530003

Receding hopes of AIDS vaccines

At the Fourth International Conference on AIDS (Acquired Immunodeficiency Syndrome) held at Stockholm, Sweden, Dr Gordon Ada of World Health Organization said that problems of producing a vaccine against the human immunodeficiency virus (HIV) are greater than for any other virus. Justifying his statement Ada gave several reasons. One is that HIV is generally variable and no two isolates are identical. Each isolate contains many variants. Variation may be HIV's way of escaping destruction by the immune system, and may yield variants of increasing pathogenicity and preferences for one tissue over another in the course of disease. A successful vaccine is one which can deal with a wide and shifting variety of strains.

Second serious problem is that the virus ducks for cover shortly after infection, that is to say, once HIV has infected a cell, its RNA genome is transcribed into DNA by reverse transcription, which then integrates into the chromosomal DNA of the infected cell. An effective vaccine would have to prevent the virus from infecting any cells, for no vaccine can attack the integrated DNA. Viruses subsequently made under the instructions of the integrated DNA will be susceptible to attack if they leave the shelter of the cell. But there is growing evidence that some cells may transmit their HIVs directly to other cells, without releasing them. To make matters worse, it may be that the original infecting virus is largely within cells in the blood, semen or vaginal fluids, rather than free, and is also transmitted from cell to cell. In that case a vaccine would never get sight of HIV in the first place.

In the recent past no chimpanzee vaccinated with the envelope protein of HIV has been protected against infection by HIV. This holds good for whether the vaccine is made from the protein itself or it consists of vaccinia virus, the smallpox vaccine, genetically engineered to contain the gene for HIV's envelop protein.

Unsuccessful initial trials in chimpanzees and rhesus monkeys cast a dark shadow over prospects that

there will soon be an effective vaccine against HIV.

Chimpanzees were infused with large quantities of immunoglobulin purified from the blood of AIDS patients. As a result they were well armed not only with antibodies against a range of HIV proteins, but also with antibodies that neutralize the virus and antibodies that prevent the rivus from fusing cells together. Yet, when challenged 24 hr later with HIV, they were found to be infected. Owing to the shortage of chimpanzees, the search for an alternate animal model is going on intensely. Since some similar immunodeficiency viruses (SIV) produce AIDS in rhesus monkeys, this is a promising but inexact model. Unfortunately, the first attempt to vaccinate rhesus monkeys against SIV infection has failed. Another hope is that HIV-2, the predominant AIDS virus in Western Africa, will infect rhesus monkeys and produce AIDS, even though HIV-I can do neither.

Another vaccine uses both an engineered vaccinia virus and cells taken from the vaccinated subject infected with virus, killed and given back by slow infusion. Daniel Zagury who has used guinea pig for this complex procedure is now seeking a simplified version.

Despite these failures, vaccination of human beings has begun. In one trial, the envelop protein alone has been given in four different doses to homosexual volunteers, some of whom received a booster shot one month later. The higher doses sometimes (but not reliably) induced antibody production and a positive lymphocyte blast transformation test. In another trial, two patients in the UK have been given an (anti-idiotype) antibody designed to prevent infection by HIV. In the third trial, killed and purified viruses were given to nine people with AIDS related complex—the condition that precedes full-blown AIDS. Some success has been achieved from this group till now.

In the absence of a simple and reliable animal model for AIDS, it is inevitable that pressures will mount for more human trials of AIDS vaccines. Such trials need close observation before approval and should not be implemented without consent as they are not beyond risk.

Madhu Aggarwal
Senior Res. Fellow
Publications & Information Dte.
New Delhi-110012

Proteinase inhibitors and protection against proteolysis

THE term proteinase (peptidase) is routinely used to refer to proteolytic (i.e., protein-breaking) enzyme that catalyses the cleavage of peptide bonds in other proteins. They are classified into two categories. Endopeptidases cleave the protein chain anywhere except the end terminal amino acid residues and cannot remove amino acid residues from amino or carboxyl terminals. Exopeptidases on the other hand cleave the polypeptide chain from either end and can remove one or two amino acid residues at a time either from the amino or carboxyl end. The active sites (place for actual catalysis) on both endo-and exopeptidases serve the dual role of binding the substrate (peptide) and catalysing the hydrolysis of a specific peptide bond.

Proteinases are found in cell both in soluble and in particulate fractions. Among the particulate ones, the importance of lysosomal (i.e., found in lysosome) cysteine (a sulphur-containing amino acid) proteinases in physiology and clinical biochemistry has long been recognized. Their importance lies in their involvement in intracellular and extracellular protein catabolism (Barrett, 1977). The cysteine proteinases (known previously as thiol proteinases) constitute the group of endopeptidases whose members rely for catalytic activity on the presence of a thiol (-SH) group of a cysteine residue in the enzyme molecule. The other three main classes of endopeptidases are the serine proteinases, aspartic proteinases and metalloproteinases whose catalytic groups in the active site of the enzymes are respectively, serine, aspartic acid and metal ion.

Cysteine proteinases have been isolated from a large number of biological sources (plants, animals and bacteria) include papain, actinidin, ficin, clostripain and cathepsins. The best-known and most thoroughly investigated enzyme of lysosomal cysteine proteinases is cathepsin B. The term cathepsin (meaning 'to digest') is usually reserved for those proteolytic enzymes which are lysosomal in origin. Under certain conditions these proteinases are secreted into the extracellular space where they are presumably active. Because of the potency of the cysteine proteinases, it is meaningful to understand how these enzymes are controlled and/or regulated.

During the past decade, increasing attention has been given to protein-proteinase inhibitors. The driving force behind this current interest is the awareness that proteinases exercise many control functions in the organism. Outside of cells, the proteinases encounter protein inhibitors present in plasma or serum. The discovery of endogenous protein inhibitors of cysteine proteinases in mammals afford a new insight into the processes in which they participate. For example, these inhibitors might protect the cells from inappropriate endogenous or external proteolysis by participating in the control mechanism responsible for intracellular or extracellular protein breakdown. According their size, these inhibitors can be divided into two groups. One group is high molec-

ular weight inhibitors in the range from 60,000-175,000, mainly present in the plasma which include α_2-macroglobulin, haptoglobin and three α-cysteine proteinase inhibitors (α-CPI) or α-thiol proteinase inhibitors (α-TPI). The other group consists of low molecular weight inhibitors having mol. wt. from 11,000 to 16,000. These inhibitors have been isolated mainly from mammalian tissues. A new class of inhibitors has been identified as the peptide diazomethyl ketones. They act only on cysteine proteinases and not on serine proteinases.

Protein degradation in mammalian cells is thought to occur via two major pathways: the lysosomal pathway, which may degrade the majority of cellular proteins non-selectively, and the non-lysosomal pathway, which preferentially degrades abnormal and short-lived proteins. Enough evidence is available that cathepsin B and most likely other thiol proteinases play an important role in the degradation of proteins. Discovery of endogenous proteinase inhibitors indicated their possible regulatory role under pathological conditions.

When a cysteine proteinase enters the blood stream, it forms a complex with cysteine proteinase inhibitors having the greatest affinity for that enzyme. In the case of serine proteinase inhibitors of plasma, there is evidence that complexed proteinases are transferred to α_2-macroglobulin and this complex is promptly removed from the blood stream by the reticuloendothelial system. This sequence of events probably also occurs in cysteine proteinases. Proteinases are also detectable in extracellular spaces as a result of cell death, inflammation, trauma, bone resorption or pathological conditions such as malignancy. In view of the large number of lysosomal cysteine proteinases possible, it is likely that the plasma-derived inhibitors of these powerful enzymes play a protective role. It has also been discovered that a cathepsin B-like proteinase is selectively secreted by malignant cells but not by their normal counterparts. This proteinase plays a role in the invasiveness of cancer cells; the plasma inhibitors of cysteine proteinases exert a protective effect against this enzyme.

There is considerable evidence that the activity of thiol-dependent cathepsins is altered in several diseased states. In muscular dystrophy, the concentration of cysteine proteinases particularly cathepsins B or H and muscle calcium-activated neutral proteinase is elevated. All these thiol proteinases are inhibited by the plasma inhibitors. Leupeptin, a powerful inhibitor of cysteine proteinases, markedly retards the muscle tissue breakdown that occurs in genetically dystrophic animals. Various forms of cancer cells have also been shown to have significantly increased cathepsin B activity. In general, it is agreed that tissue destruction and other pathological consequences result when the proteinase-proteinase inhibitor balance is upset in favour of the enzymes. Nowadays inhibitor proteins are used as model systems to elucidate the mechanism of inhibition of proteinases as well as to study the protein-protein association. These protein inhibitors are also being used as valuable tools in medical research because of their unique pharmacological properties.

Sudhir K. Agarwal
Department of Biochemistry
School of Life Sciences
North-Eastern Hill University
Shillong-793014

Forensic investigation of semen

RAPE is the worst of crimes against women and is becoming more and more a subject of serious concern for both the society and law-enforcement agencies. Generally there are two essential requirements for establishing the crime of rape. Firstly, the lack of consent of alleged victim and secondly penetration by the male organ. In rape cases circumstantial evidence is not an adequate proof and, as such, the physician and the forensic scientists are required to play significant role in providing objective information. The physician describes whatever injuries and related medical evidences are there. The forensic scientist shows presence of semen in the swab collected from the victim's vagina—a proof that indicates past intercourse.

Semen is usually identified by the presence of sperms which constitute about 5% of the volume of seminal fluid. Microscopical identification of sperms in the vagina is an adequate proof of recent intercourse. However, the problem of availability of sufficient material for semen analysis from the vaginal vault is very acute. Swabbings from the post coitus vagina will contain vaginal secretions, seminal plasma, vaginal epithelium cells, mucosa and sperm cells. The exact composition of the vaginal material varies from individual to individual. Also, both the seminal plasma and sperm contain a number of enzymes (proteases, peptidases, etc.) which contribute considerably to the degradation of seminal constituents. If the victim runs for a distance after being raped, much of the seminal fluid may drip out of her vagina destroying a vital evidence. The effect of drainage is enhanced by menstruation and sometimes by bathing. In contrast to the women who are mobile after intercourse, high estimates for all seminal constituents are obtained from dead victims who have been raped immediately before or after death.

(Contd on p. 219)

By **Hasan Jawaid Khan**

Aspirin cream replaces tablet

ASPIRIN brings relief to sufferers of arthritis, lumbago, rheumatism and general muscle soreness. But when taken internally in form of tablets it also causes stomach disorders in some people. Ian Tindall, an Australian pharmacist, has now devised a way of applying aspirin in a new cream form which allows the drug to pass into the blood stream through the skin. As opposed to alcohol-based creams that do not get through the skin quickly, give off unpleasant smells and makes the skin dry, Tindall has devised a way of stabilising aspirin in a water-based cream. The new product is called Ease.

Wasp fights insect pests

THE Chinese are using a wasp small enough to fit on a pinhead to wipe out insect pests that harm crops. The trichogramma wasps are released at the peak of pregnancy. They lay their eggs directly into the eggs of more than 400 insect species. The developing parasites consume the host egg leaving the crops undamaged. The Chinese are using the wasps to fight two main insect pests: the Asian corn borer and the sugarcane stem borer.

The advantage of trichogramma is that once applied it does not itself become an agricultural pest. In fact, loads of trichogramma must be airdropped each year to target fields. Presently millions of wasps are being reared in China. But this technology can be used with only three of the 19 trichogramma species found in China Research is underway to use new trichogramma strains on a wider range of vegetable and orchard pests.

Useful fungus from dirty cup

THE next time you drink coffee try leaving your cup unwashed. After a few days you might come across a fungus in the cup whose utilitarian aspect could make headlines. In fact, that is how Professor Margalith Galun, a botanist at Tel Aviv University in Israel, discovered a fungus that could be put to clean industrial waste water. She noticed a fungus growing in the residue of an unwashed coffee cup. She decided to experiment with it. It has so far shown the potential for filtering waste water.

The fungus can absorb heavy metals including mercury, uranium, lead, zinc, cadmium, nickel, silver, copper and chromium. It also thrives on waste products from food and beverage industry. Scientists now hope to utilise this property of the fungus to clean industrial waste water which can then be recycled for other uses.

Pollution reduces egglaying in birds

AS a result of the pollution of surface waters with such substances as polychlorobiphenyls (PCBs) and pesticides, birds lay fewer eggs and fewer young than normal are hatched. Researchers of the Applied Marine Research Laboratory in the Netherlands reached this conclusion after more than six years of research with tufted ducks. Tufted ducks feed on zebra mussels found in the waters of Netherland. But in some polluted underwater beds the mussels accumulate the pollutants in their tissues and such polluted mussels are also eaten by some ducks.

The researchers fed one group of tufted ducks on mussels from polluted waters and one group on mussels from relatively clean water. The ducks fed on mussels from polluted waters showed an increased concentration of pollutants in their tissues. They also had smaller kidneys and sexual organs. These ducks exhibited nervous behaviour patterns. Many of the females died at the beginning of the breeding season and those that survived spent less time brooding their eggs or ignored them.

Consequently, tufted ducks fed on the heavily polluted mussels lay fewer eggs than the ducks which were given relatively clean food. The eggs are much smaller. Moreover, only 39 per cent of the eggs hatched, whereas 97 per cent of the eggs from ducks fed on clean mussels produced ducklings. According to the researchers the percentage of eggs that hatch depends on the PCB and pesticide content of the egg yolk.

Glued to the spot

INSECT pests of potato are in for a hard time. Robert Plaisted and his colleagues at Cornell University in the USA are developing a species of potato whose leaves would trap any insect that happens to alight on them. Such a species if developed would keep away the insect pests and thus dramatically reduce the need for chemical insecticides. The researchers have been crossbreeding domestic potatoes with a wild species from the mountains of Bolivia. The leaves of these plants are covered with two types of spiky glands called trichomes.

One type of trichomes coats the leaves with a sticky chemical that traps any hapless insect. As the poor insect struggles to break free it brushes against trichomes of the second type. The very fragile balls rupture releasing an enzyme that mixes with the first substance and hardens it. With its legs firmly encased in the stuff, the insect gets immobilized. Those that manage to get free die of starvation as their mouth parts get clogged with glue.

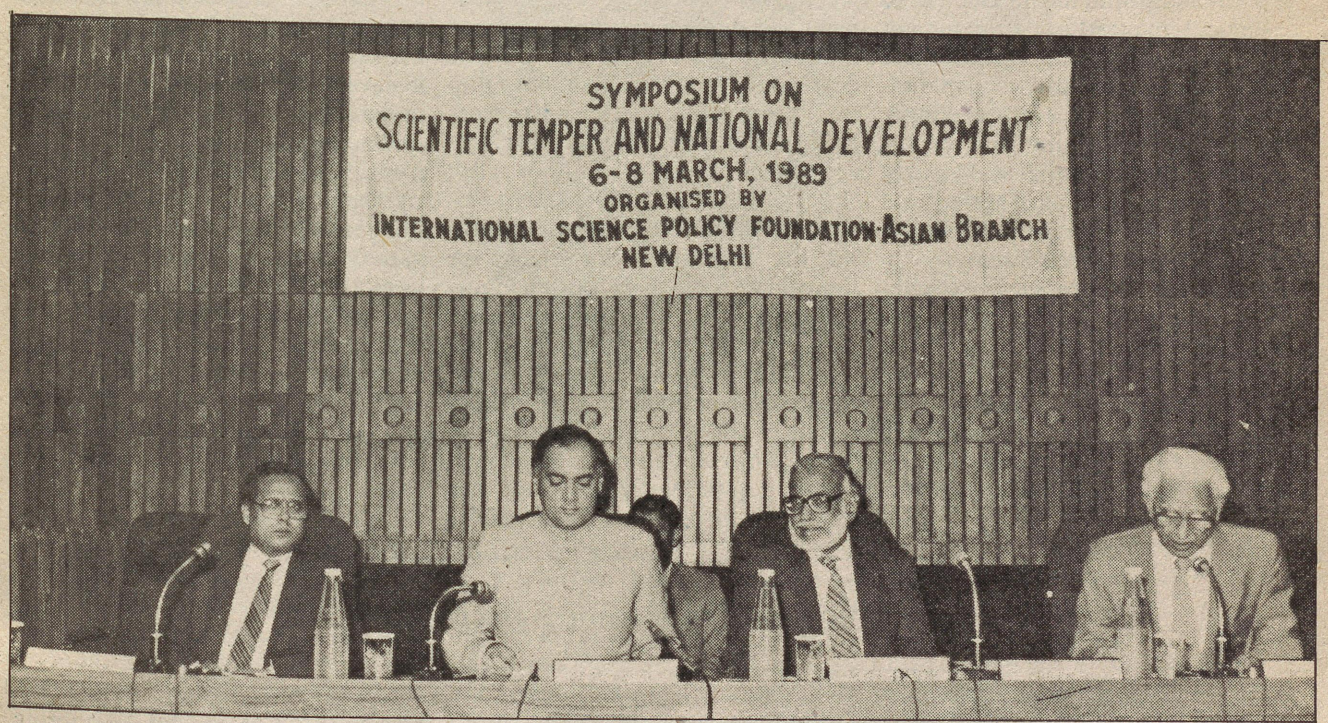
Symposium on Scientific Temper and National Development

THE promotion of scientific temper, which involves the use of available knowledge to guide individual and social behaviour, is more important today, when dogmatism and fanatism are destroying the very fabric of civilized life than ever before. Pandit Jawaharlal Nehru, the first Prime Minister of India, coined the word 'scientific temper' and considered it as a vital input to national development. During the Nehru Centenary year, the International Science Policy Foundation—Asian Branch organized a symposium on 'Scientific Temper and National Development', from 6 to 8 March, 1989 in New Delhi as a tribute to Nehru. The Symposium was attended by both foreign and Indian participants.

The Symposium was inaugurated by the Prime Minister Shri Rajiv Gandhi. He also delivered the Foundation lecture on Scientific Temper and National Development. In his lecture Shri Gandhi cautioned scientists against destroying the traditional values in their quest for modernization. He asked them to use science and technology for social change and not equate technological development with gross materialism. Scientists, he said, had an added responsibility of creating scientific temper in society. He further added that people should be trained to cope with emerging technologies and not to become their slaves.

Prof. A. Rahman, Former Director, NISTADS, New Delhi welcomed the Prime Minister and announced the creation of Triennial Nehru Prize by the Asian Branch of the Foundation for promotion of scientific temper. The inaugural function was chaired by Professor M. G. K. Menon, Scientific Adviser to Prime Minister and Member, Planning Commission. In his remarks he said that the Nehru era witnessed a renaissance of Indian science and Indian society getting liberated from the clutches of colonialism. The Foundation Medal, which was given third time in 25 years, was awarded to Jawaharlal Nehru posthumously and was received by Shri Rajiv Gandhi.

In the first session on 'Scientific Temper and National Devlopment' it was brought out that there was a confusion as to what actions and thinking processes were circumscribed by scientific temper. It was, therefore, essential to know the meaning of scientific temper in our social and national interest. Prof. M.G.K. Menon in his keynote address highlighted three issues which relate science and technology to the people. Firstly, the artifacts of science provide a connection between science and the people. Secondly, science operates in a framework of axioms and options, therefore, those who



talk of science and its application without taking into account its impact are not helping science. Thirdly, the popularization of science becomes an empty structure if promotion of scientific temper is not included in it.

In the second session on 'Culture and Science', the participants expressed concern at the adoption of western model of development by the developing countries alongwith the modern science. Referring to the civilizations which had different knowledge systems because they moved through different historical trajectories, they said each knowledge system would correspond to the culture in which it was nurtured. The contemporary sciences in Asian countries on the contrary are both dependent and less productive. Science, it was argued, could only be an element in the evolution of culture. It should not be allowed to dominate culture and used as an instrument of exploitation. The crucial issue was to temper science and technology by ethical values provided by religion, ideology or other value systems of society and by adopting a code of conduct for individual and community.

In the third session on 'Sustainable/unsustainable Development', the discussion was focussed on unsustainability of natural resources, impact of development programmes on environment, and equity and development of indigenous scientific and technological capability for sustainable development. It was observed that in many development actions complementary policies were not adopted. Also, all the elements of sustainability were diluted in development programmes through reckless use of natural resources, unrestrained widening of consumerism and subjugation to market forces. The sustainable development strategy required a set of criteria for each ecosystem. Decentralized sustainable development could contribute to global sustainability. However, the main problems were how to make operational the concept of sustainable development and use effectively freshly acquired environmental awareness, and translate the global concern into local actions.

In the fourth session on 'Emerging Futures', the impact of science and technology on life-styles and employment was discussed. It was suggested that for future development the developing countries should stop thinking in terms of mechanistic lines of industrial organizations of eighteenth and nineteenth centuries. They should adopt sophisticated technologies in terms of cybernatics and automation. The future cities may have limited use in view of fast changing communication technology. Therefore, rural areas in developing countries must receive adequate priority in development planning based on a vision of society. Scientific research must be directed towards implementation of a strategy which would give equal priority to consumption sector relating to basic needs and capital goods sector. Demand in the latter should be complemented through recycling of its products within that sector. One of the greatest areas of growth in research and implementation was the entire area of biotechnology. It was feared that biotechnology might intervene more and more in human reproductive system unless appropriate legislations are introduced. The new reproductive technology was already being misused against women.

In the fifth session on 'Science and Technology Policy for Development' there was unanimity among the participants that policy and planning for science and technology for development must work for meeting the basic needs of the people, reduce social inequality and maintain a desirable balance between the human activities and ecology. This would be possible if developmental planning decision-making systems were decentralized in such a way that people could participate in the implementation of development programmes. Such a possibility can only be created through the activities of the socially conscious strong local pressure groups as watch-dogs.

M. A. Qureshi
Scientist
NISTADS
Pusa, New Delhi—110012

Biological Oxidation Systems

AN International Symposium on "Biological Oxidation Systems" will be held at the Indian Institute of Science, Bangalore, on October 23-26, 1989. It is being organized by the College of Agriculture and Environmental Resources Research Institute, Penn State University, University Park, PA, USA, and the Indian Institute of Science, Bangalore. The symposium will focus on discussions pertaining to the molecular mechanisms by which O_2 and it's reduction products, superoxide and peroxides, react in biological systems. The symposium will include a keynote address by Prof. Bengt Samuelsson (Nobel Laureate), plenary lectures by leading scientists, sectional lectures by invited speakers, and contributed papers (both short oral and poster presentations).

Further details can be had from:

The Organizing Secretariat
International Symposium on
Biological Oxidation Systems
Department of Organic Chemistry
Indian Institute of Science
Bangalore-560012 (India)

The trek to the South Pole

WHEN Roald Amundsen became the first man to reach the South Pole in 1911, he felt he had attained something opposite to the calling of his heart. From the childhood he had a strong desire to be the first man to reach the North Pole but before he could even make preparations for the journey, Robert E. Peary (see *S.R.*, March'89) had reached it. He was then left with no option but to make an attempt for the South Pole and join in the race for the Pole with the British team led by Robert Falcon Scott. Apart from favourable weather that helped him to win the race to the Pole, Amundsen had some qualities that few polar explorers had. Tall, fair, and with piercing eyes and equiline nose, he was a born leader. He had a good judgement of both men and animals, was a keen student of nature and history, and was a meticulous planner. Having thoroughly read all the travelogues of previous explorers he knew where each one had made a mistake and how to rectify it. It was his single-minded purpose and secretive nature that eventually helped him to reach the South Pole before the British team could. However, unlike Robert E. Peary, Amundsen made a detailed survey of the South Pole and even pinpointed its exact location which was found hardly some meters away from the mathematically estimated position of the South Pole!

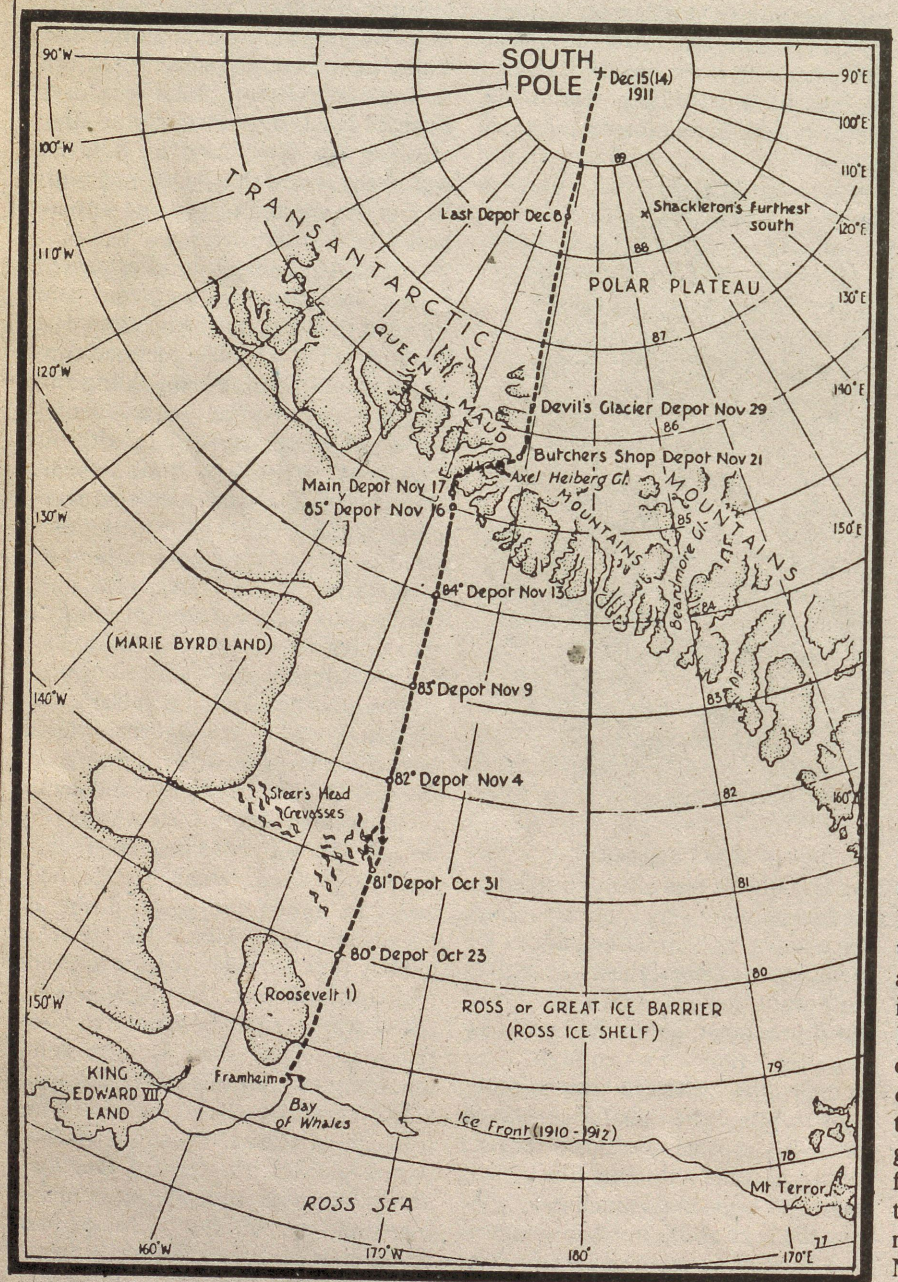
Amundsen originally belonged to a family of fishermen and sailors who lived in the islands at the mouth of Christiania Fjord, Norway. His father and uncles were however businessmen and shipowners. He was born on July 16, 1872, at Christiania, Norway. His house was the last one in the village adjacent to the woods. In fact, Norway being a country of fjords and mountains with the frequent occurrence of violent storms and snow, every Norwegian is a wee bit of a nature observer and tries to adapt himself to the natural elements. Amundsen was also a born nature observer and was interested in outdoor activities from the childhood. No sooner he started walking than he took to skis, the most popular sports in the country. During winters when the rivers would freeze he and his friends would go for skiing. He also took active interest in gymnastics. But he was always bullied by his friends who were older than him. Once when he complained about his friends to his father, the latter said, "I don't want you to get into any fights. But if you must, get in the first blow and see that it's enough". In studies, he showed consistently poor results. When his father passed away, his mother was keen that he should become a doctor. But he had disgraced himself so much in studies that the school did not allow him to take final examinations! Amundsen therefore took the final examination as a private candidate, passed it and joined a medical college. But his heart was not in studies. His heart lay in exploration and adventures. When he was 15 he stumbled upon the voyage and explorations of Sir John Franklin. His tales of suffering, murders and cannibalism fascinated him. He wanted to experience them himself and set his heart on becoming a polar explorer. He used to read books on polar expeditions, attend lectures of polar explorers, and used to go on long skiing expeditions and walks in the countryside. When the famous Norwegian polar explorer Fridtjof Nansen returned home after crossing the Greenland in 1888 he was in the crowd that welcomed him. In fact, he wanted to become a polar hero like Nansen.

Roald Amundsen

When Amundsen's mother passed away, he gave up medicine and decided to strike out on his own. His reading of polar travelogues had convinced him that mountain-skiing and dog-driving were two prerequisites for a polar explorer. Along with his friends he went on a skiing expedition to cross the nearby ice-clad Hardangervidda, an open, treeless, windswept and hummocked land as formidable as Antarctica. He also tried to join some expedition going to the Northern seas but nobody was ready to hire a raw hand like him. Eventually, he secured a sailor's job aboard a sealer *Magdalena* which intended to spend winter amidst ice floes in the Arctic region and hunt seals and wild animals. He was rather horrified to see the massacre of seals on a large scale. When he returned home he joined duty aboard one of his uncle's ships. Meanwhile he religiously took exercises to keep himself trim and healthy so that he would be ready when the opportunity to visit the polar region came. He also went on skiing expeditions to Hardangervidda regularly. But howsoever he tried, he could not cross that backyard region of his country. Once he and his brother were reported missing and on another occasion he would have lost several fingers due to frostbite. Nevertheless Hardangervidda taught him several lessons which came in handy during his

future polar expeditions. The first opportunity for a polar adventure came his way when Lt. Adrien de Gerlache selected him as a second mate aboard his *Belgica* which was visiting the southern seas and Antarctica.

The thirteen-month life aboard *Belgica,* when the ship cruised to the southern seas and spent winter for the first time in Antarctic region, provided first hand lessons to Amundsen. He patiently observed his shipmates, tested and improved equipment especially during the four month long night of the Antarctic winter when most of his mates were losing their sense of balance. For instance, scurvy disease, which took a heavy toll of sailors in those days due to lack of vitamin C in their diet, also plagued the men aboard *Belgica.* Amundsen learnt that the flesh and blood of freshly killed seals and penguins could keep the disease at bay. He observed that to haul things in the cold region of Antarctica was an extremely tiresome and exhausting task. He also experimented with skis on the icy continent and found them to be an effective means of transport. These lessons made the difference between his victory and Scott's defeat in the race for the South Pole later. Besides, he kept a sharp eye on all aspects of life on the icy continent. He tried to improve sleeping bags, tents, sledges and clothing and tested them there because the conditions are similar to those found in the neighbourhood of the North Pole. In fact, all this time he was secretly making preparations for his expedition to the North Pole. He had also mellowed after seeing the suffering aboard *Belgica.* He felt that it could have been avoided had the correct information been available in advance and the expedition more carefully planned. He returned home a mature explorer and seaman ready to embark on his own adventure.



Roald Amundsen's route to the South Pole

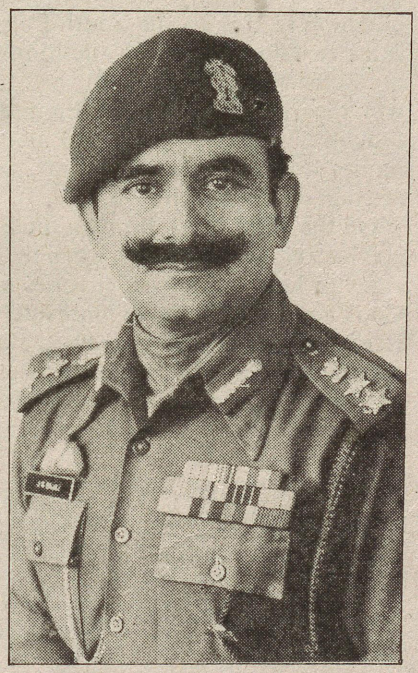
It was when Amundsen was wintering at 72° South the idea of a fresh search for the magnetic North Pole occurred to him. In 1831, James Clark Ross had located the magnetic North Pole but at that time a controversy raged whether it was stationary or it migrated. Amundsen had the idea of locating the magnetic North Pole again so that it could be decided once for all whether it was stationary or migratory. Moreover, he knew that such an expedition would also give him the much needed experience for the trek to the North Pole which till then lay unconquered. On his return from Antarctica he met Nansen and convinced him of the scientific importance of such an expedition. Nansen liked the idea and did his best to obtain money for

the expedition from businessmen and even from the then reigning monarch. Amundsen bought a small sloop Gjøa and fitted it with a motor. He also picked up men for his expedition. He was rather choosy about men. Even if he found a minor hesitancy in a man in performing a task he did not select him for the expedition. He did not want anyone who just wanted to seek escape from civilization. However, he did not select a scientist for conducting magnetic surveys. He himself learnt the basics of magnetic surveys and trained his men in the science. After much uncertainty due to lack of money, Amundsen eventually set sail with a small party of men under his command.

During his expedition to Bootha Felix where Ross had located the magnetic North Pole, Amundsen learnt several lessons. He befriended Eskimos and learnt their language so that he could know how to travel in the polar region. He observed that Eskimos were never in a hurry, not because they were lazy but because they avoided sweat. For travelling in cold region sweat affected the stamina of a person. He also found that Alaskan dogs were far better than Siberian dogs. One polar explorer told him that it is important to understand the psychology of dogs because the relation between a dog and a human being is not that between a master and his servant but one between equals. Moreover, their meat is edible if an emergency arises. One lesson he took to heart was that the pace of travelling through the polar region should be such that both body and spirit of man and animals could easily bear it. Amundsen could reach Bootha Felix but the magnetic North Pole had moved further north. When he went in its search bad weather dogged him and forced him to give up his quest. He missed the magnetic North Pole by at least 50 km. However, he took the opportunity of returning home via the famous unconquerable North-West Passage, a journey which was dear to him from his school days. When he returned home he was welcomed as a hero and

In the footsteps of Amundsen

"JOURNEY through a pipeline of hell" is how Colonel J.K. Bajaj, the first Indian to reach the South Pole, describes his trek to that point at the bottom of the earth. 47-year old Colonel Bajaj, who is Principal, Nehru Institute of Mountaineering, Uttarkashi, Uttar Pradesh, was part of a private expedition team of eleven persons belonging to different parts of the world. He and his team reached the South Pole on January 17, 1989, exactly 77 years after the British team leader Robert Falcon Scott set his foot on the same spot. Today, the Amundsen-Scott station is located at the pole in the memory of the two gallant trekkers.



Col. J. K. Bajaj

Col. Bajaj is an Indian Army Officer with interests as diverse as engineering, photography, golf and skiing. Earlier in 1984-85 he was part of the Indian Scientific Reconnaissance Expedition to Antarctica. By virtue of his feat he joins the exclusive club of 22 persons who have trekked to the pole. He and his other team members entered Antarctica from Chile and started their trek from Hercules Inlet near Weddell Sea. The entire journey of 1,200 kilometers over the icy terrain was covered in 50 days. During the expedition some scientific experiments, such as effect of the polar conditions on human body, were conducted and samples of rocks and ice were also collected.

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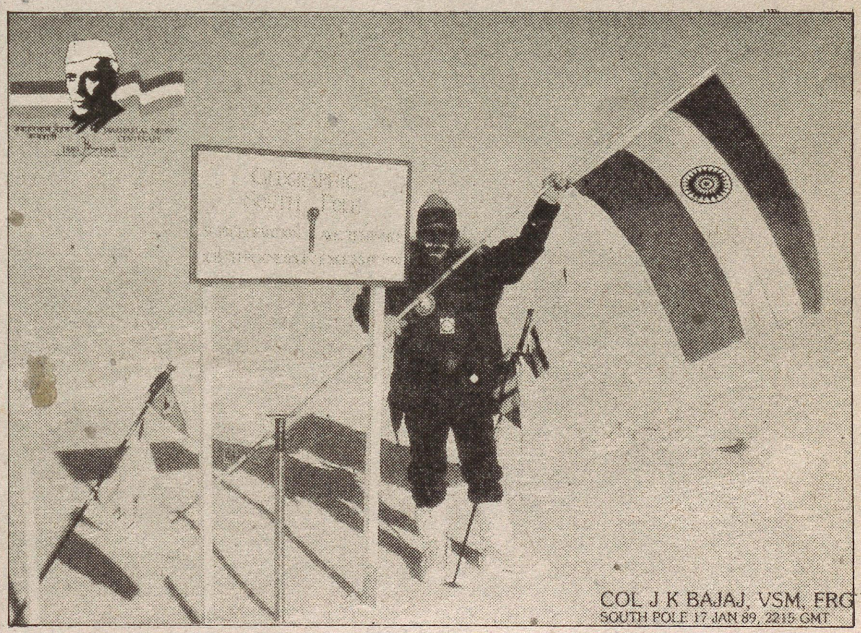
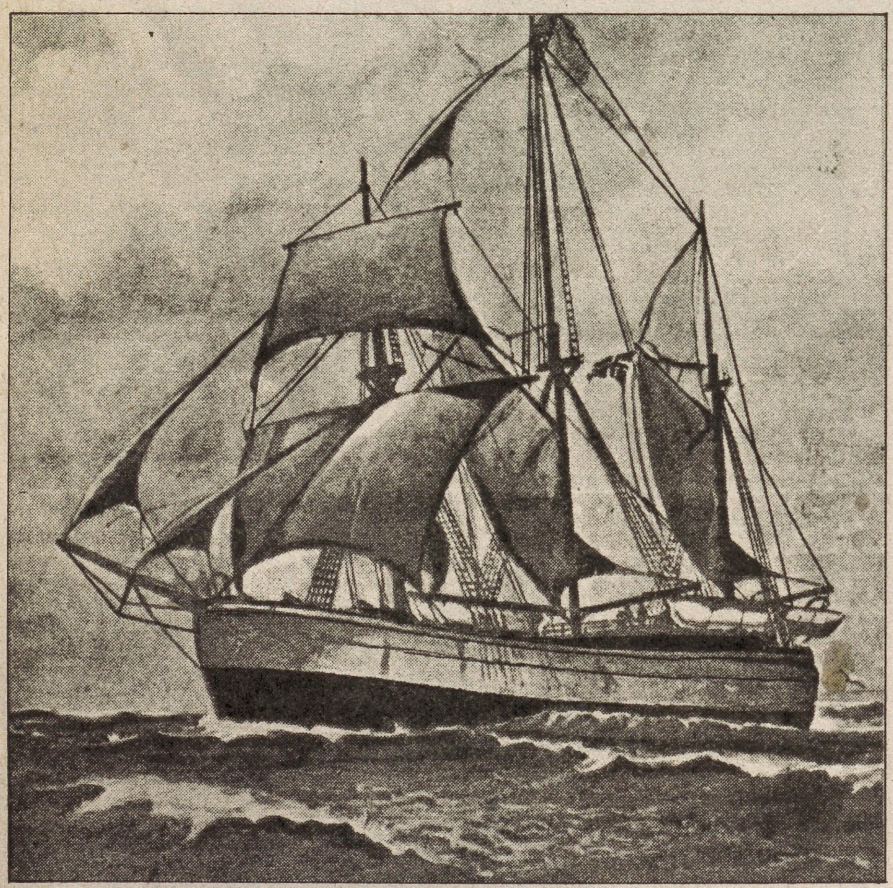


was much applauded and acclaimed. Even the reigning King Haakon VII met him because it was the first major feat attained by a Norwegian after the country had gained Independence.

As soon as Amundsen returned from the North-West Passage, he decided to make a bid for the North Pole and began to make preparations accordingly. He wrote a book on his journey, went around the country and the U.S.A. giving lectures and collecting money for the trek to the North Pole. Nansen also agreed to give him on loan his famous ship *Fram* for the journey to the Pole. But, then, suddenly, came the bolt from the blue. News arrived that Frederick A. Cook, his companion during the Antarctic winter aboard *Belgica,* had reached the North Pole! It was soon followed by Robert E. Peary's news of the conquest of the Pole. Amundsen immediately changed his mind because he knew the maiden credit for the Pole had gone. There was no point in doing the same thing again. He decided then and there to make an attempt for the South Pole but did not tell any body about it, not even Nansen. He knew that if the British team, which was planning to trek to the South Pole, came to know about his ambitions, no stone would be left unturned to win the race. The British Empire, though in decline then, had both money and resources to thwart his attempt at the South Pole.

On the other hand, his own financial backers and creditors, when they came to know about the victories of Cook and Peary, were no more interested to finance his journey to the North Pole. Nevertheless, Amundsen continued to pretend that he was going north for the exploration of the North polar basin. Meanwhile he started making preparations for the South Pole. He built one stout hut containing a kitchen, a table and 11 bunks, which, to deceive the press, he claimed, was to function like an observation hut for studying the Arctic pack ice. Basically, he had built the hut, called "Framheim" later, for the stay of his team on Antarctica during the winter season before he would trek to the South Pole. He also designed new snow goggles and special 2.75 meter long skis. He decided to land at the Bay of Whales on the Ross Ice Barrier of the Antarctic continent because it was the most easily accessible point nearest the South Pole. Though creditors were after him, Amundsen knew he had to take the chance. If he returned after conquering the South Pole, all his crimes would be forgiven!



The *Fram*

On June 7, 1910, the third anniversary of Norway's Independence, Amundsen set sail aboard *Fram* from the coast of Norway without any ceremony or celebration. There were only 19 men, including one ski champion, accompanying him to the Pole. It was only when the ship reached Madeira and picked up from a local dealer 97 Alaskan dogs which had been bought in advance that the suspicions of the team were aroused. After all, if they were going to the North Pole, what was the hurry to have the dogs aboard the ship? The dogs could have been bought in Greenland. At this juncture Amundsen disclosed his secret ambition of reaching the South Pole instead of the North. He openly discussed and displayed his plans and gave the entire team the option to return home. He had planned his trek to the Pole in such a manner that he would reach it at least 15 days before the British team which was already on its way to Antarctica. After initial hesitation, the entire team welcomed Amundsen's decision and was rather jubilant to think that it would be the first at the South Pole.

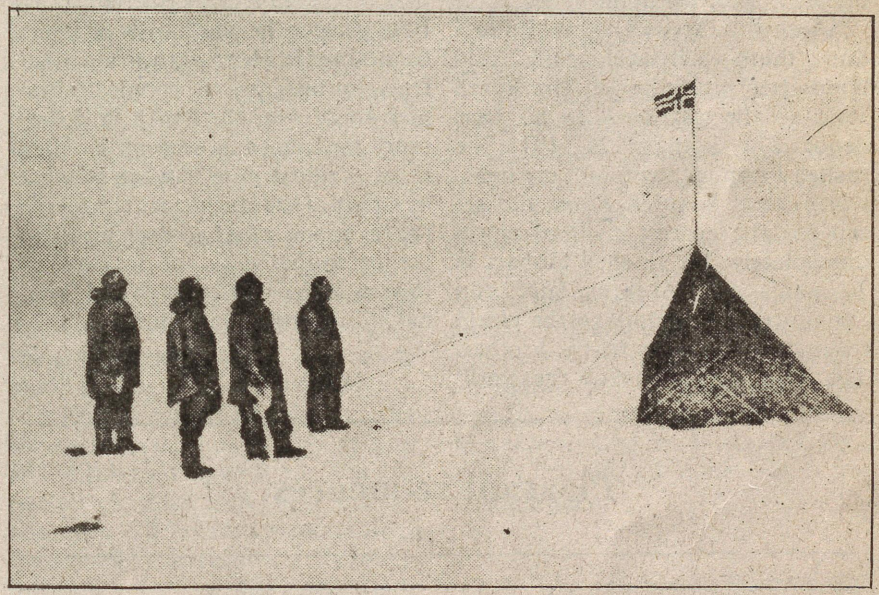
Amundsen and his team reached the Bay of Whales on January 15, 1911, ten days after the British team

had reached McMurdo Sound in Antractica. The pre-fabricated hut Framheim was installed and no time was lost to make preparations for the trek to the Pole. Some depots with food and equipment were laid every two degrees of latitude on the pre-planned route to the South Pole before winter would set in. The party then returned and began to wait for the winter to end. Meanwhile, Amundsen had informed the British team about his intentions. Some members of the British team came to the Bay of Whales and tried to find out how Amundsen and his men were likely to trek to the Pole. They returned unimpressed when they came to know that Amundsen and his team intended to take the assistance of dog-driven sledges and skis. On the other hand, Amundsen, though confident of winning the race, had second thoughts when he came to know that the British team intended to use motor sledges. But he never showed his apprehensions to his team members and began to wait eagerly on the winter to end.

Before the summer season would start in Antarctica, Amundsen and his team of four men and 52 dogs left Framheim on October 19, 1911. The four men were Oscar Wisting, Sverre Hassel, Helmer Hansen and Olav Bjaaland. Two men were sidetracked and sent to explore the King Edward VII land as punishment for their mutinous behaviour. Carrying no scientific equipment and wearing warm, loose-fitting lightweight fur garments of the Eskimos, the men were on skis as well as sledges. All the way to the Pole the team marked its trail with dried fish. Though blizzards, whiteouts and mists appeared off and on, the weather in general was favourable and did not create any problem. On an average the team trekked only for about 5 to 6 hours every day and covered about 32 kilometers daily. The remaining time was spent in resting, eating and sleeping. When some team members suggested Amundsen that they should move faster he did not agree. Twice, skiers were caught in the traces of the sledges and would have fallen into crevasses but for their presence of mind. Sometimes, when a dog misbehaved it was shot and its fresh meat fed to its companions to keep scurvy at bay. On the way to the Pole, the team made several geological discoveries. For instance, it discovered the high mountain range which was named Queen Maud mountain range after the Norwegian Queen. Once a loud continuous roaring sound was heard which was correctly attributed to tides that occurred in the nearby Bay.

The trekking and skiing skills of Amundsen and his team underwent rigorous tests when they encountered what is today known as the Devil's glacier. However, without any loss of human or animal life the team managed to cross it at its narrowest and most difficult point. Some dogs were totally exhausted in the effort and so were killed and their meat fed to others! This place was named the Butcher's Shop. Amundsen felt sad that he had to kill the dogs because they had served him well. But no option was left for him. He had to be the first not only to reach the Pole but also to reach the press in the civilized world. If the announcement of his victory appeared in the press after the British team's, he knew he would have as good as lost the race and his creditors would hound him throughout the life. After the team crossed 86 degree South, the fear of being beaten by the British team was uppermost in the mind of the team members. Mirages of approaching persons and the flag of Union Jack were seen off and on!

On December 15, 1911, Amundsen and his team reached the South Pole which lies on an ice-laden King Haakon VII plateau named after the reigning Norwegian monarch. To make sure that he had not missed the Pole and also to bring home a convincing proof of his victory he conducted a series of exercises. Four men were sent on skis in four directions. About 16 kilometers away each installed a sledge runner, and a black flag, and kept a letter addressed to Robert Falcon Scott, the leader of the British team. Observations of the position of the respective location were conducted and its details mentioned in the letter. Six hours later all four returned, signed each other's navigation books, and then calculated the exact location of the South Pole on the basis of their observations. Amundsen gave the honour of leading the team to that estimated



Roald Amundsen and his team at the South Pole

location of the Pole to the ski champion Olav Bjaaland. Here a tent was installed, the pennent of *Fram* and the Norwegian flag were hoisted, and some discarded equipment was left behind along with a letter addressed to King Haakon VII for delivery to him by the British team if Amundsen and his team did not return home. This location of the South Pole estimated on the basis of a crude instrument like sextant is hardly 2,250 meters away from the mathematically calculated exact location of the Pole on the surface of the earth. The British team reached the Pole after tremendous suffering and strain. However, it succumbed to the elements of nature, and Amundsen and his team returned home safely.

"And so, farewell, dear Pole, I don't think we'll meet again," said Amundsen when he left the South Pole on the way back to his base depot. On January 26, 1912, he rached Framheim without any untoward event, boarded *Fram* and set sail for the nearest civilized world immediately. He reached Hobart in Tasmania two Months later and announced his victory to the world through a telegram to his brother. The news did not reach the world until March 7, 1912. 50 years later, a journalist took hardly three hours in an aircraft to fly from the Bay of Whales to the King Haakon VII plateau. And it took hardly 20 minutes for this news to reach Oslo, Norway, and a few hours later the feat was announced to the world! On his return, Amundsen was applauded the worldover for his feat. With only a select group of men and meagre resources Amundsen could achieve what the Britishers could not with the plentiful men and resources at their command. In 1927, Amundsen wrote *My life as an Explorer* about his experiences as a polar explorer.

Amundsen however could not stay satisfied with the simple yet immortal title of the first man on the South Pole because he was hardly 39 when he attained it. He tried to attain other feats, for instance, to become the first man to fly over the North Pole, but every time he came second. He died in an accident in 1928 when he went as a part of the rescue team to search for his friend who had been given up for lost in the Arctic region. He slept forever in the region which had fascinated him from the childhood.

Dilip M. Salwi

Pleasant sequences

EVERY one has encountered a question such as "Give the next number in the sequence 2, 4, 6, 8, 10, ..." in mental ability tests. A simple question, isn't it? Ponder over that a little more. Does the question imply that there is only one number that can fill the blank (be the next number)?

A sequence is a collection of numbers such that for every natural number (positive integer) n, there is one and only one number in the collection. For example, in the sequence 2, 4, 6, 8, 10, ...(2n),.....; 2 is for natural number 1 (2 is the first number); 4 is for natural number 2 (4 is the second number); 6 is for natural number 3 (6 is the third number); 2n is for any natural number n. Suppose that the first few numbers of a sequence are given in order, then can the next number of the sequence be given? If yes, will it be unique (one and only one)?

For example, will the answer to the question "Give the next number in the sequence, 2, 4, 6, 8,....." be unique? It appears to be unique, doesn't it? But, will it be so for every sequence? As an example, take the population of India from 1881 to 1981 for which data is available at 10 year interval, and form a sequence. From the available data for the sequence, can we give the population of India in 1991 by some mathematical rule? If it can be given, will it be unique?

Consider another interesting problem related to sequences. Petroleum reserves in the world are dwindling and our consumption rate is increasing. It is desirable to take some measures to reduce the consumption rate and save petroleum at least till an alternative energy source is found. The following question is concerned directly with a solution to the crisis. Suppose that there are a total of 10 units of petroleum in the world today and it is desired that the consumption rate is gradually reduced to retain petroleum till at least another alternative energy source is found. When an alternative energy source may be found is not yet known. Therefore, the plan should be to retain the fuel for ever. To that end, a plan suggested is as follows. In the first year, we consume only one unit of petroleum. In the second year, we will consume only 1/2 unit of petroleum. In the third year, only 1/3 unit of petroleum will be consumed. In the n^{th} year only 1/n unit of petroleum will be consumed. Will the petroleum last for ever if the plan is followed strictly? Verify your solutions with the answers.

Answers

(1) The blank in any sequence can be filled by any number by an infinite number of mathematical rules, i.e., there exist an infinite number of mathematical rules and solutions to the question "Give the next number in the sequence 2, 4, 6, 8, 10, ...". This can be shown using a more general question: "What is the next number in the sequence a, b, —.....?" As already said above, the next number in the sequence can be any number. Suppose that we want to fill the blank with a number x. To this end, all that is to be done is to find a mathematical rule which gives a and b for n= 1 and 2, respectively and x for n=3.

Such mathematical rule can easily

be written. Consider the following mathematical rule: $f(n)=(a/2)(n-2)(n-3)-b(n-1)(n-3)+(x/2)(n-1)(n-2)$. Check that the mathematical rule given above satisfies all the required conditions, i.e., $f(n)=a$ for $n=1$, b for $n=2$ and x for $n=3$ (By choosing any arbitrary x we can find a mathematical rule which will make the third number of the sequence to be x, the chosen arbitrary number). So it is not sufficient to give any number of numbers of a sequence to define a sequence, but it is necessary that we specify the exact mathematical rule. The 'mathematical rule' technique given above can be generalised. Observe that the first term in the sequence is 'a' for $n=1$ and every other term in the mathematical rule given above is zero for $n=1$. So the total is a for $n=1$. Observe similarly for $n=2, 3$.

So, when the next number of a sequence is to be given, like in population prediction, it is not just sufficient to find a mathematical rule satisfying all previous conditions but care should be taken to choose a mathematical rule that is more realistic to the situation in hand.

(2) Even if one can follow the plan strictly, petroleum will not last for more than 2,62,144 years. This will be shown below.

By the end of the first year, if the plan is adhered to, we would have consumed 1 unit of petroleum. By the end of the second year, we would have consumed $(1+1/2)$ units of petroleum. By the end of the third year, we would have consumed $(1+1/2+1/3)$ units of petroleum. Similarly, by the end of the n^{th} year, we would have consumed $(1+1/2+1/3+\ldots+1/n)$ units of petroleum. Then our question is: for any n does $(1+1/2+1/3+1/4+\ldots+1/n)$ exceed 10? It can be shown that at least by $n=2,62,144$ the sum exceeds 10.

First, it will be shown that the above sum exceeds any number for sufficiently large n. The following groups (bracketed terms) $(1/3+1/4)>1/4+1/4=1/2$, $(1/5+1/6+1/7+1/8)>1/8+1/8+1/8+1/8=1/2$, $(1/9+1/10+1/11+1/12+\ldots.1/16)>1/16+1/16+1/16+1/16+1/16+1/16+1/16+1/16=1/2$ can be formed from the sum $(1+1/2+1/3+\ldots.1/16+\ldots.1/n)$. By choosing n sufficiently large, any number of such groups, each being greater than $1/2$, can be formed form the sum $(1+1/2+\ldots.1/n)$. The sum of m such groups is greater than $m/2$. If n is chosen such that the sum $(1+1/2+1/3+\ldots.1/n)$ contains m groups such as $(1/3+1/4)$, $(1/5+1/6+\ldots.1/8)$, then $1+1/2+1/3\ldots.1/n$ is greater than $3/2+m/2$ ($3/2$ accounts for $1+1/2$, the sum of the first two terms, 1 and $1/2$, which were not included in any of the groups). By choosing sufficiently large n to contain sufficiently large number of groups, it is easy to see that the sum $1+1/2+\ldots.1/n$ can be made greater than any number.

As the sum exceeds 10 for sufficiently large n, let us calculate a n for which the sum exceeds 10. The first two terms of the sum i.e., 1 and $1/2$ add up to $3/2$. So, for the total sum to exceed 10, it is sufficient if we can find n for which the sum $(1/3+1/4+1/5+1/6+\ldots.1/n)$ exceeds $17/2$. From the above group formation, we conclude that 17 groups are sufficient to make the sum exceed $17/2$. The first group contains two terms. The second group contains four terms, the third group contains eight terms, and the n^{th} group contains 2^n terms. So the number terms in the successive groups form a geometric progression. From this observation it is simple to calculate the total number of terms in the first 17 groups. It is $2^{18}-2=2,62,142$. When we account for the first two terms i.e., 1 and $1/2$, the total number of terms in the sum $(1+1/2+1/3+\ldots.+1/n)$ such that the sum is greater than 10 becomes 2,62,144. So $n=2,62,144$. Hence our conclusion about petroleum conservation.

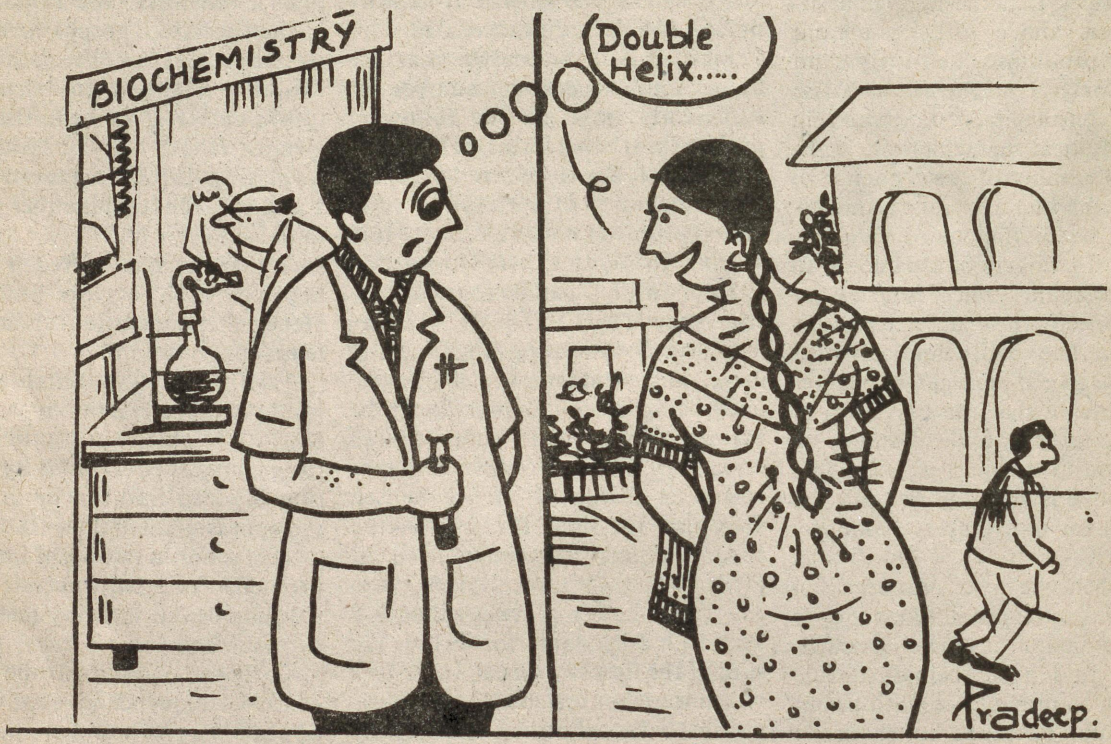
This is a rough estimate as every group exceeds $1/2$ rather than being equal to $1/2$ while it is sufficient that the group just equals $1/2$. By calculation one can find that by $n=12369$, the sum is greater than 10.

This is only a sample of interesting problems from sequences. The topic is fundamental in many mathematical problems. The second problem given here is related to the convergence of a sequence. The convergence of sequences of numbers and functions is important in mathematics. In fact, the integral of a function which we often come across is nothing but summation and the existence of the integral is closely associated with convergence and the symbol of integral $\int$ (distorted S) came only from 'summation'.

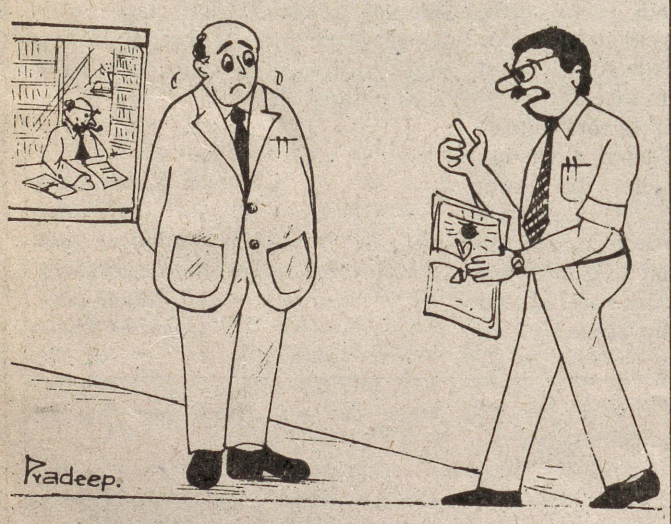
S. Seetha Rama Raju
Scientist
Naval Physical & Oceanographic Laboratory
Naval Base
Cochin-682004

CARTOONS

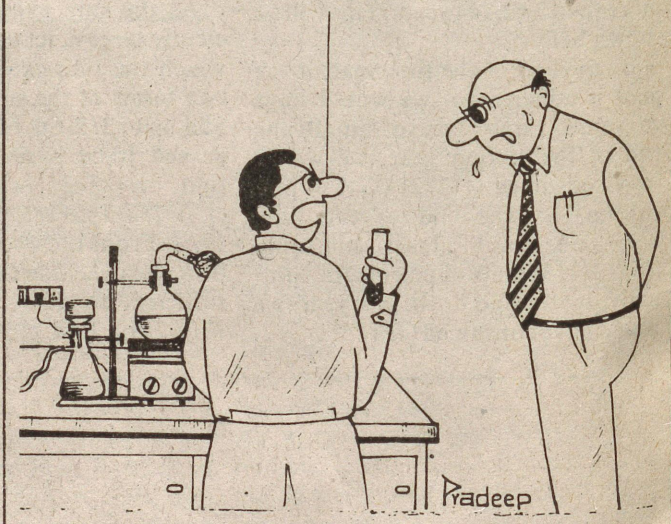
By Pradeep K. Srivastava



"I liked your lecture on DNA so much that I changed my hair-style accordingly"



"Last time I could not get research grants because my file could not be traced, so I am taking no chance now, I have put a 'radioactive tracer' on it"



"What are the best conditions for recrystallisation? Why should I bother? That is for the crystals to know"

Plants to monitor metal pollution

METALS are natural constituents of the earth's crust and are ever present in soil, water and living matter. Several metals are essential to the functions of living organisms and yet many interact with living matter and cause toxicosis. Above certain concentrations metals such as arsenic, boron, cadmium, copper, lead, mercury, molybdenum, nickel, selenium and zinc have been proved to be toxic to plants and/or animals and have also been reported to impair the quality of human foodstuffs. The main sources of metal contaminants in the soil are metalliferous mining and smelting activities, industrial emissions and effluents, urban development, vehicle emissions, dumped waste materials, sewage sludge, composted town refuse, fertilizers and pesticides. Aerial contamination of metals occurs through atmospheric emissions from coal-fired generating plants, automobiles and municipal incinerators. The problem due to metal contaminants is essentially long-term, since additions are cumulative and may reach damaging proportions in the biota much later. Any irreversible effect, either within an ecosystem or on a whole ecosystem is bound to affect man either directly, as increased metal concentration in his foodstuff, or indirectly in terms of degradation in the quality of his environment. It is essential that the metal menace is curbed.

Successful pollution abatement depends on efficient monitoring of the general environment so that it is known for sure when control measures are needed and whether those in operation are working. Physico-chemical methods provide data on specified pollutants measured at a particular time and location with calibrated instruments. Such data can demonstrate levels of contamination but cannot give a direct indication that organisms will be affected. On the other hand, data from monitoring living organisms would yield useful information on the effects and distribution of metal contaminants in actual components therein. Biological monitoring technique using plants is a cost-effective and useful approach since plants are excellent receptors and collectors of heavy metals and dusts and provide continuous but integrated monitoring.

Bioavailability of metals

The total metal content of the soil and/or air is not fully "available" to a

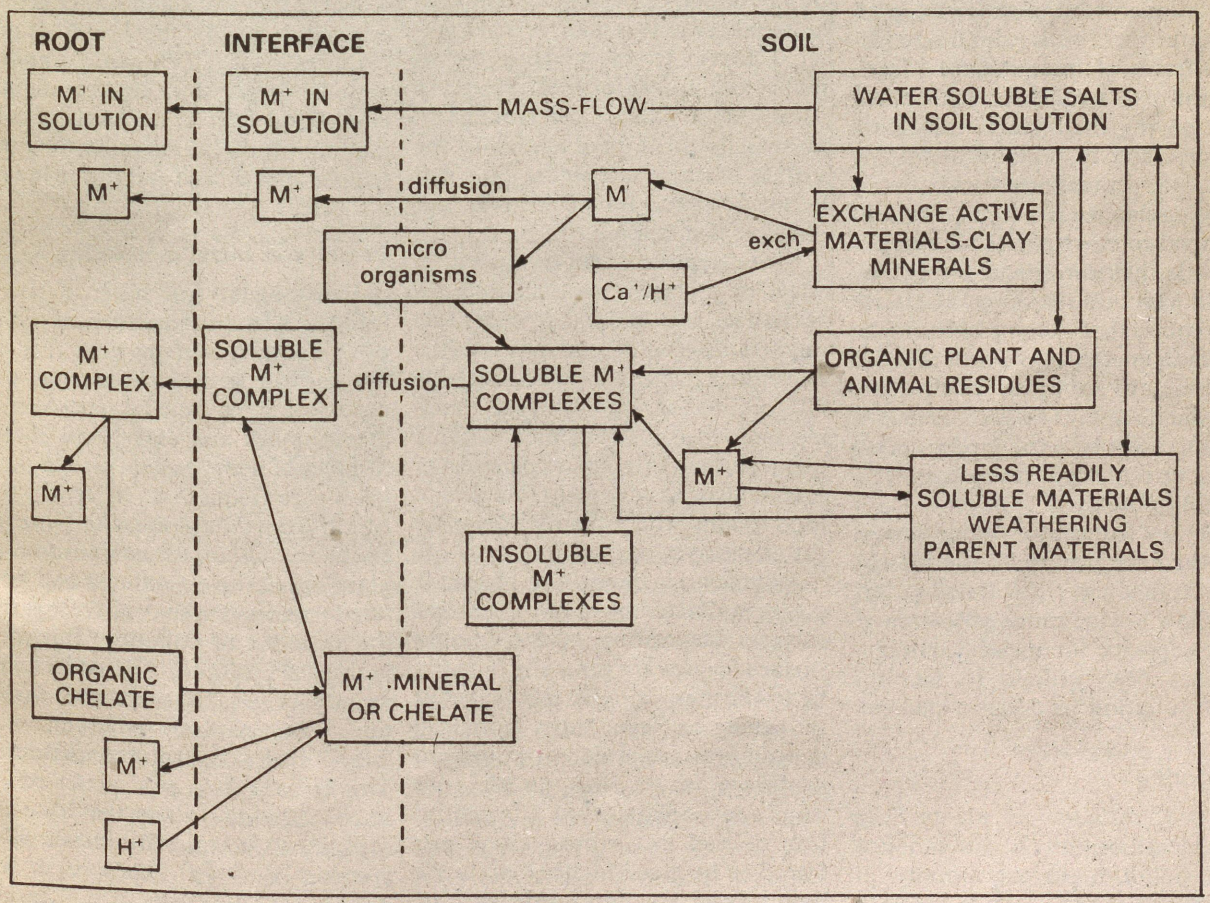


Fig. 1. Some processes and Factors affecting the availability of metal ions (M+) in soils and their uptake by plants

plant. The entry of metals into plants depends upon their extractability or the ease of exchange at the root-soil interface (Fig. 1). So each metal will have a different degree of "availability" depending upon various factors like the nature of the metal compound, conditions of the soil such as pH, presence of competing ions, chelating agents and also microorganisms. Trace metals may be captured via aerial parts of plants particularly leaves, as roots absorb the metallic compounds but in a somewhat less complicated way. The metal incorporation into the vegetation of a locality do not necessarily reflect the actual physical load of contaminant (s). But such a study provides a key to the understanding of impact on the ecosystem.

Metal tolerance

A number of plants have evolved populations with the ability to grow and flourish in soils containing elevated levels of trace metals. Metal-tolerant plants resist the toxic effect by removing the metallic ions from the metabolism, or by rendering them into innocuous form, or by changing enzyme structures. Some of the metal-tolerant plants accumulate metals in their roots from where they do not pass into the shoot. There are also reports that in some of the tolerant plants metals in the root cells are dumped into vacuoles which make them ineffective. The mechanism of tolerance can be explained in other ways but no single theory is universally acceptable.

In the freshwater environment also, there are groups of aquatic angiosperms that grow in polluted waters and show a wide range of tolerance. Their capacity for metal accumulation has been utilised to monitor metal pollution in aquatic environments.

Monitoring

A good number of plants have been identified which can monitor metal pollution in the vicinity of smelters, coal-fired power stations and highways. Analysis of plant tissues such as leaves, twigs, wood and bark demonstrates elevated metal concentrations at polluted sites. It is interesting to note that the degree of accumulation of metal compounds varies with the plant species as well as their different organs. As a result, certain plants only will be suitable for a particular metal contaminant and specific organs only will be more relevant for sampling and analysis. In practice, therefore, a variety of plant specimens and parts thereof are monitored for various metal contaminants in different environments.

Lead and other metal pollutants

Plants growing near highways are usually exposed to lead. The source of this lead is primarily automobile exhaust particulates such as lead halogens which are not water soluble. Lead incorporated into soil remains tightly bound to organic or colloidal materials or may remain in a precipitated form, all of which serve to reduce the uptake of lead into plant roots. Most likely, lead remains in particulate form associated with the surface of leaves and stems. This lead is not absorbed into plant cells but remains as a coating.

These deposits seem to have little effect on stomatal aperture and gas exchange, but are of considerable importance as potential toxins to the microflora associated with leaf surface and to grazing herbivores ranging from insects to mammals. Quite possibly, the most important effect of lead associated with plant foliage is in food chains where plants in essence act as passive lead carrier.

Atmospheric deposition of lead is strongly affected by nature of the leaf surface. Deposition in the smooth surfaced leaves are generally found to be lower than in pubescent leaves at the same site. Seven times more lead deposit was reported on pubescent sunflower leaves than on glabrous tulip and poplar leaves. Concentration of lead in the dead leaves was found to be much higher than in the living leaves of some grasses. The greater capacity of lead accumulation in the dead leaves was attributed to the breakdown of cuticle and epidermis which gives greater access to metal binding sites.

Soils in the vicinity of metal (zinc, lead and copper) smelting and finishing operations show high metal pollution. In many countries these areas are routinely surveyed mostly through foliar analysis. Foliar analysis of beech and spruce trees is mostly employed where ferrous metal industries are located in Czechoslovakia. In the vicinity of silver mine and processing works in New Zealand and also chlor-alkali works in Finland, analysis of pine needles reveal the extent of contamination in relation to the distance from the source of emission. Studies made in Egypt revealed high levels of mercury accumulation by lettuce and cabbage leaves grown in an industrial complex which included chlor-alkali works, paper mills and power generating stations. In the U.S.A., some epiphytes, viz., *Tillandsia usnoides* and *T. recurvata* are commonly employed to detect the levels of contamination of cadmium, chromium, copper, nickel, lead and zinc in industrial areas.

Freshwater metal monitoring

Heavy metals (cadmium, mercury, lead) present a serious form of pollution in aquatic systems since they do not degrade as do most organics but accumulate in aquatic micro- and macrophytes and enter food chain. Sources of heavy metals in rivers and lakes are industrial effluents, the runoff from mining areas and smelter emissions. Often, the composition of plant species in unpolluted and polluted reaches of a river are compared for an index of pollution. But such biological monitoring based on community criteria is subject to variations in natural environmental factors such as light and temperature. This is why it is now preferred to screen individual plants that have the capacity to accumulate metals progressively during an exposure period. *Typha latifolia* is one such example which is used to monitor levels of

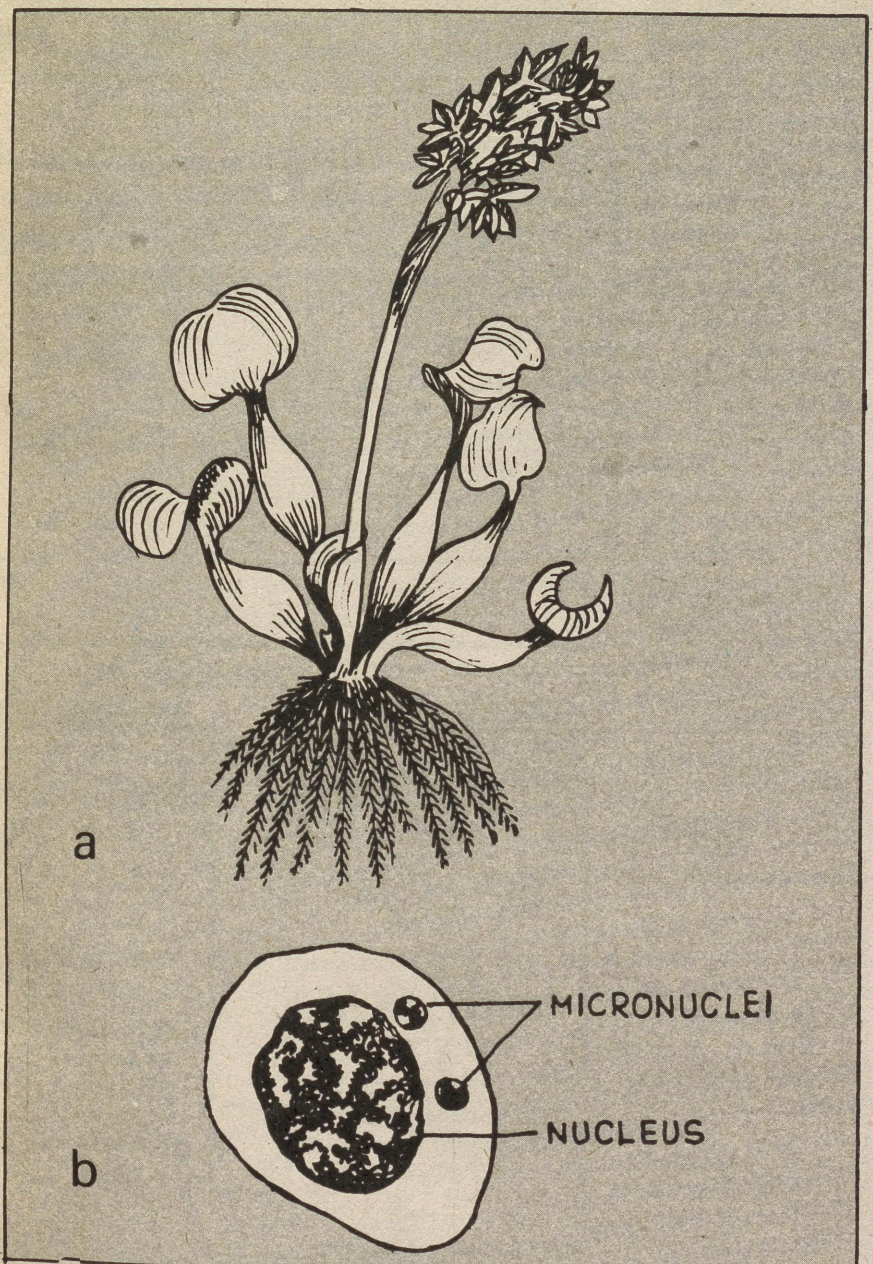


Fig. 2. (a) *Eichhornia crassipes,* **a common waterplant and a weed of considerable notoriety, is a promising biofilter for metal-contaminated surface water; (b) Heavy metals induce formation of micronuclei in their dividing root cells. This biological end-point can be relied upon to monitor level of metal contamination in the surface water**

metal contamination. This plant grows in softwater lakes and accumulates different metals in different parts thereof. The root, shoot, flowers and fruits show accumulation of trace metals differently, each indicating the "luxury level" of certain metals.

In the U.K. and Canada, species of *Potamogeton* that grow wild in lakes and rivers are usefully employed to monitor levels of contamination of copper, lead and zinc. Similarly, in Thailand, a few aquatic weeds, viz., *Ceratophyllum demersum* and *Ipomoea aquatica* are used to measure the level of mercury contamination in the vicinity of a caustic soda factory.

Another water plant that finds frequent sampling in metal monitoring is *Pontedaria cordata.* It is especially ideal for detecting copper and lead at various distances from an effluent source. Water hyacinth, *Eichhornia crassipes* which is a common wetland weed has a high capacity for metal accumulation and with no apparent deleterious effect. There are positive reports from field experiments on the use of this water plant as a biofilter for removal of metal contaminations. Further, its role as efficient absorbers of heavy metals in water bodies makes it an ideal monitoring system.

B.B. Panda and co-workers of Berhampur University, Orissa, have devised a novel method of detecting low levels of mercury around a chlor-alkali factory. This method is based on a specific effect induced by mercury in the root cells. Root samples of water hyacinth are collected and cell division in the root tips is studied. The contaminated roots are characterised by the formation of micronuclei in their dividing cells (Fig. 2). The frequency of occurrence of cells with micronuclei reflect in most cases the level of the contamination in the area of collection. This method is sensitive enough for effect-based monitoring in an aquatic ecosystem at distances far away from the source of contamination.

Presently, vigorous research to understand the range of effects of bioaccumulation of trace metals on all stages of growth, differentiation and reproduction at the individual and community level, is in progress. It is likely to strengthen the role of plants in assessing the impact of metals on the quality of our environment.

B.N. Behera
Deptt. of Botany
S.K.C.G. College
Parlakhemundi-761200
Orissa

B.B. Panda
Deptt. of Botany
Berhampur University
Berhampur-760007
Orissa

INTELLECTUAL SUPPRESSION: Australian Case Histories, Analysis and Responses, Edited by Brian Martin, C.M. Ann Baker, Clyde Manwell and Cedric Pugh, *Angus and Robertson Publishers,* North Ryde and London, Pp. 304, Price not stated (ISBN: 0 207 15132 6)

SUPPRESSION of intellectual dissent is not a new phenomenon. The price a Socrates or a Galileo had to pay for free expression is common knowledge. Suppression, however, is characteristic essentially of modern industrial societies with a high degree of literacy. It is more rampant, ironically, in societies in which communications and mass media are well developed and in which the standard organisational form is bureaucracy.

Suppression may take a myriad of forms: blocking of funds, denial of publication or promotion, outright harassment, subtle undermining of reputation, and, in extreme form, dismissal, and several others.

Science and academia are often held out as havens for intellectual and scholarly dissent. Such a view is more of a myth than reality. The case histories documented in this book provide ample evidence to show that it is ultimately the bureaucracy of one kind or the other that rules the roost, be it a totalitarian society or the so-called free world. The contributors, 15 in all, are drawn from a wide perspective of disciplines; they include agricultural scientists, physicists, psychologists, philosophers, economists, historians, social activists, environmental activists, science policy analysts, and journalists. Apart from case histories, the book provides analytical insights into this social malaise as a feature of a wider power structure in society. Also set out are ways and means to oppose suppression and strategies to evaluate teaching and research which could help intellectual dissenters to challenge the official excuses often given for dismissal or blocked promotion.

Suppression of intellectual dissent has far-reaching implications for society than just repression and oppression of the dissenters or tarnishing of their image. Suppression of scientific criticism may lead, for example, to millions of people being exposed to harmful drugs or environmental chemicals.

One of the well-documented cases of suppression highlighted in 'Case Histories' is that of Dr John Coulter, a medical researcher of some standing at the Institute of Medical and Veterinary Science in Adelaide. Because Coulter was outspoken in his views on such issues as uranium mining and the hazards of environmental chemicals, which threatened the vested interests of elites in corporations and the government, he was dismissed from his job. Worse still, the facility for testing environmental mutagens, which he headed, was closed down. The reasons given by the Establishment for his dismissal, to say the least, were insubstantial and inaccurate.

Do brilliance, hard work and scholarly output enable a person to get ahead in academia? Not always. Sometimes just the opposite occurs. Highly talented and highperformance individuals may be resented precisely because they are so good, says Brian Martin, one of the contributors and editors of *Intellectual Suppression.* "If those already in positions of power are mediocre in scholarship, then they may be threatened by a talented person."

Victimisation of intellectual dissenters is not the only weapon in the armoury of corporate and bureaucratic elites, whose prime concerns are profit and bureaucratic expansion respectively. They could scuttle even sound projects if not in their interests. Wind power research in Australia is a case in point. Like other small-scale renewable energy sources, wind power is not especially attractive to large corporations or government bodies concerned with production of electricity and electricity-generating equipment.

Opponents of nuclear power industry, for instance, could be at the receiving end should they voice in public their criticisms of nuclear safety. The powerful nuclear lobby in the UK hounded out Rodney Fordham and co-workers when they made public their dissent of the nuclear power programme.

How free are American scientists to offer professional dissent? Suffice it to quote Howard Bahr, who has made a study of official statistics of the American Association of University Professors: "There are approximately one hundred perceived violations of academic freedom for every officially reported." Individual cases of suppression or repression apart, corporate elites whether in the US, or the UK or Australia have the last word in the funding of projects. The medical establishments, in unholy alliance with the pharmaceutical lobby, would rather fund curative medical research at the expense of preventive medicine. The reason: financial stakes in curative medicine.

Among the many allotropes of suppression is the suppression of feminist critiques, surfacing since 1960s as a global phenomenon. In a provokingly titled chapter 'Who Listens When Women Speak?', Chery Hannah deals with the structural nature of feminist thought in Australian universities and gives examples of strategies used to overcome it.

Given the fact that Australian defamation laws are among the most severe in the world, the reader could guess that the extent and viciousness of suppression is certainly greater than spelled out in the book.

The 'Case Histories' has important lessons for the intellectual community in general and scientific workers in particular. The fact that the average scientist is indifferent to human problems seems to be the root cause of suppression of intellectual dissent. As the eminent physicist and historian of science Gerald Holton

observes, the pursuit of science as currently fostered and understood and social concerns are possibly even antithetical. Hence the compelling need, as Holton also emphasises, to encourage and protect the tiny minority of scientists who are willing to speak out.

P.S. Shankar

THE HUMAN BRAIN *by* M.R. Raghvendra Rao and Yamuna Bai R. Rao, *IBH Prakashana,* Fifth Main, Gandhinagar, Bangalore-560009, Pp. 227, Rs. 30.00

THE book on the human brain by Isaac Asimov starts with the strange but true story of a Scottish sailor Alexander Selkirk who was left to rot all alone on an island for four and a half years. But the survived and returned. The English author Daniel Defoe even based his famous *Robinson Crusoe* on his adventures. One wonders what Selkirk is doing on the pages of a book on human brain. Very soon Asimov draws in biological analogies. A single man against the Universe represents a horrific situation. Similarly, a single cell asked to carry out all the functions would be a horrific proposition indeed. That's why as organisms evolved, cells began specializing but to ensure that there were no "disputes in this multicellular society"; there had to be a chieftain and that's the reason for the existence of the brain.

"The most complex clump of matter in the Universe", that's how the authors describe the human brain in their preface. This is indeed very true. In his famous serial *Cosmos* Carl Sagan exclaims, "Human brain is in fact a liberation. We are no longer trapped in reflexive behaviour!" Almost all geniuses have wondered about this 'three-pound mass of intricate convolutions'. William Boyd in his textbook on pathology writes, "The structures of all other organs seem childishly simple, when compared with that of the brain."

There has been an almost irresistible urge in all curious individuals to know more about this 'black box'. One of the earliest and clearest accounts on this subject written for the layman is the book by Isaac Asimov having the same title. However, the book is now 25 years old, is not easily available, and a few things have definitely gone out of date.

The book under review comes as a succour for lay people wanting the latest information on the human brain in an easily understandable language. The material has been gleaned from several sources and has been presented in a well knit coherent style. There is an account of the cells of nervous system first and then the authors go on to describe the growth of human brain and its structure and function. There are chapters on senses, reflexes, states of consciousness, and the like, and the information is authentic. The book has some useful and interesting tables. The tables on brain: body ratios (the encephalization quotient) and on brain weights of some famous individuals are particularly interesting. However, the authors have borrowed the diagrams freely from other books. There are a couple of them taken from Asimov's book—only somewhat poorly reproduced.

All in all, the book is not a bad buy for Rs. 30.00, and can be heartily recommended to youngsters wanting to know something about this 'little master'.

Anil Aggrawal

A 2-HOUR GUIDE TO PC'S *by* Subroto Bagchi, *Pustak Mahal,* Khari Baoli, Delhi-110006, Pp. 112, Rs. 20.00

IF you are already a computer user, you can make it in two hours plus minus the individual deviations. If you are a novice, well it may take you from two days to two months to go through the book, then you have to augment your reading of this book from other sources before you decide upon having your own PC.

PC as is now very well known stands for Personal Computer first marketed by IBM. It is also called home computer. A PC is a very compact machine and is a micro computer based on microprocessors. Nowadays there are several versions of PC's available.

The first plus point of the book is that it is compact and has a holistic approach. The book is a good introduction to anyone who wants to know about PC—the current hot cake in the industrial, technical and intellectual fashion market. After reading this book anyone can go on for further serious study on the subject or at least can interact intelligently in any circle.

The author of the book is known to interested readers as a writer on the subjects of information technology and management. Obviously he has done his job neatly. The book is well produced.

Subir K. Sen

RHYMES ON SCIENCE (separately in English and Bengali) *by* Kamal Chakraborti, *Hiralal Printing Works Pvt. Ltd.,* Apt. 5, 3rd Floor, Readymoney Terrace, 167 Dr. Annie Besant Road, Bombay-400018, Pp. 28, Rs. 10.00 (illustrations by Tapan Chattopadhyay, artwork by Shib Sankar Bose).

THE book is intended for children in the age group of 9-12 years. Even older students may refresh their memories by reading the rhymes in the book. Some of the rhymes, especially the Bengali versions, are very well written, some however are less rhyming and more prosaic. A few, as for example the very first piece,

should have been altogether dropped. Of twentysix, about seventeen fall in the domain of chemistry, three deal with the laws of motion, others are Boyle's law, Charles' law, reflection, rectilinear propagation, and Ohm's law. The rhyme on Boyle's law is "The temperature being constant,/If the mass of gas is fixed,/The volume of the gas diminishes/When the pressure is increased."

The illustrations, artwork, the printing and overall production are superb. The book can be recommended to school children safely, if not because of its literary quality, for the sincere attempt on the part of the author and publisher to keep statements as faithful as possible to 'science' and to produce a book for children which is both cheap and attractive.

Subir K. Sen

PHYSICS AND GEOMETRY OF PERCOLATION THEORY *by* A.L. Efros, Translated from the Russian by V.I. Kisin, *Mir Publishers,* Moscow (Available from: *USSR Book Center,* Connaught Place, New Delhi 110001) Pp. 259, Rs. 10.50

THE present book, one under the series "Science for Everyone", serves to explain in a popular style the random phenomenon called 'Percolation Theory', an offshoot of mathematical probability theory. Percolation theory has wide applications mostly in physics and chemistry; in particular, a few like impure (p & n type) semiconductors and doped ferromagnets are explained in the book in greater details. Mathematicians have called this theory the "Geometry of Disorder", as it originated from the behaviour of random networks and critical paths. In the early sixties, it was realized that percolation theory is indeed universal in having diverse applications in fields such as deforestation patterns, spreading of forest fires, flash-floods, river flows and estuaries, conductance of randomized electrical networks, clustering in doped ferromagnets, mobility of charged carriers in impurity-doped semiconductors, and even propagation of rumours! Percolation ought not to be confused with diffusion which is somewhat deterministic. The phenomenon described by the former is indeed critical, that is, at some particular state of the system, there is sudden phase transition of some parameters of the system.

The book is broadly divided into three parts and has 14 chapters in all. Part I introduces the basic concept of site percolation and outlines the rules for calculating the probabilities of random events, definition of continuous random variables, and generation of random numbers. The origin of percolation threshold first in a simple 2×2 network and later extended to a bigger matrix of 137 × 137 sites formed by electric circuits is pointed out. The author has referred to an illustrious example of percolation, i.e., flow of gas through carbon granules in gas masks studied by S.R. Broadbent and J.M. Hammersley in British Coal mines. They coined the term "percolation" and published their work in 1957. However, the author of the book has chosen the classic paper of W. Watson and A. Leath published in the 1974 issue of the *Physical Review* as the base for discussing percolation theory.

In chapter 3 of the book, a generalization of this site percolation procedure termed 'clustering' has been discussed in detail taking the specific example of the magnetic moment of 'doped ferromagnet'.

In Part II of the book dealing with applications, mention must be made of the problem of planting saplings in such a way as to avoid the propagation of infection. Another problem discussed in the book is the electronic conduction in doped semiconductors. In Part III of the book on the critical phenomena of percolation thresholds, the emphasis is on the well-known 'Bethe Lattice'.

This reviewer would have liked the inclusion of a brief discussion of current developments in the field in the book, namely, Wilson-Kadanoff renormalization group and block-spin techniques—a powerful tool in high-energy physics and condensed matter physics. Another important area might have been covered is the virus growth and control in a diseased organ.

For the benefit of students, a large number of exercises are included which often supplement the text material. The book concludes with answers and solutions to most of these exercises. In the final analysis, the book is well-written and satisfies the curiosity of a physicist for whom this might be a first encounter with percolation theory.

R. Sambasivan

1000 ANIMAL QUIZ by Maneka Gandhi, *Rupa & Co.,* 3831 Pataudi House Road, Daryaganj, New Delhi 110002, Pp. 201, Rs.20.00

IT is quiz time! Sports quiz, science quiz, SAARC quiz— and now comes animal quiz. With the increasing awareness of environmental issues, considerable interest in wild plants and animals has been generated. We are familiar with domestic animals and a few wild animals. Apart from textbooks and other specialized books on animals, there is a paucity of popular books on animals giving specific information in a question-answer form. The book under review fills this gap. For example, do you know which is the fastest running bird? Or which is the largest reptile in the world? How many eyes does a cockroach have? What is an anadromous fish? What is

an Ocelot? Answers to all these and several other questions related to different aspects of animal life are given in the book. Questions on amphibians, fish, reptiles, birds, mammals, creatures of the sea, facts and fantasy, scientific terms, etc., are also given. Many aspects of anatomy, physiology, morphology, evolution, conservation and even mythology are covered. Answers to the multiple choice questions are given at the end of each chapter. Illustrations should be included in the next edition. This moderately priced book by a well-known animal rights activist will be useful to all animal lovers and quizzers.

N.R Mankad

BEYOND THE WOODFUEL CRISIS—People, Land & Trees in Africa *by* Gerald Leach and Robin Mearns, *Earthscan Publications Limited,* 3 Endsleigh Street, London WC 1H ODD, Pp. 309, £8.95

OF the innumerable issues that confront the world community today, the problem of fuelwood shortage affects millions of people. Much of the Third World remains tightly wedded to wood as a primary energy source, either in its raw form or after conversion to charcoal. As wood supplies dwindle, growing number of people would not have enough wood to cook their meals and heat their homes. Even after the recognition of the problem more than a decade back, little progress has been made towards satisfying future fuelwood demands.

This is so because of false diagnosis of the problem and the consequent "top-down" attitudes, bureaucratic hurdles and the failure to involve the local populace. In certain quarters the misleading assumption has cropped up that the use of woodfuels is the principal cause of deforestation. Or, that the expanding circles of deforestation around the cities will shoot up woodfuel prices and provide a powerful economic rationale for all afforestation and conservation measures.

Consequently, remedies are primarily energy focused, for instance, grow more forests and trees, disseminate efficient charcoal kilns, promote the use of oil and electricity, prevent encroachments, and so on. Little do the planners realize that by focusing so closely on woodfuels and the symptoms of their scarcity they are ignoring the much broader and deeper strains in the environmental, social, economic and political fabric of which woodfuel scarcity is only one manifestation.

And so, the book under review addresses the woodfuel problem in its much broader setting of sustainable land use and natural resource management. The book is a "literature of hope" rather than of despair, as the authors would like to describe their work. It throws light on the hard and creative innovations by people, the remarkable work being done by governments and aid agencies to put the land into good shape, increase food production, restore soils and a healthy cover of vegetation, and enhance the livelihood on a sustainable basis.

While most development theories in vogue today work on the lines of 'energy for development', this book focuses on woodfuels as basic needs—'energy for survival'. The authors feel that dealing with this must take a higher priority than looking beyond survival needs to conventional energy developments or the plethora of renewable energy devices such as biogas plants and windmills.

The woodfuel crisis of the developing countries was discovered in the mid 70s when much of the world was gripped by the energy crisis of modern fuels which followed the first oil-price shocks of 1973-74. Tree stocks declined as the trees were cut down faster than they could regrow. It was at this time that the woodfuel gap theory was put forward to measure the scale of woodfuel crisis and suggest remedies.

To measure the scale of woodfuel scarcity in gap theory, one estimates consumption of woodfuels in a given region and compares it with the standing stocks and annual growth of tree resources. According to this calculation, in Sudan forest stocks will fall to zero by 2005. In Tanzania the last trees would disappear under the cooking pot by 1990. There are, however, still many trees there.

The gap theory thus has several flaws. For instance, estimates of woodfuel consumption and of tree resources are rough. Large-scale aggregate perspectives of gap theory obscure the fact that woodfuel problems are location-specific. Also, most gap predictions assume that once a forest has been cut it would not show any natural regeneration. The book seeks to correct such mistaken notions on the basis of which policies are laid down.

Although the book centres around the woodfuel crisis of Africa, the conclusions are as relevant to other parts of the Third World. The most important step, which the authors feel could arrest deforestation is by intensifying cropping and grazing systems. Today, the pressures to clear land of trees, sell the wood to the city and then farm it, are almost irresistible. Farmers are increasing production by acquiring more land and not by intensifying their production methods. Yet another activity that could be taken up is agroforestry-growing trees along with crops. This improves the soil and water resources while at the same time supplying fodder, construction materials, food, medicines and fuel. It benefits the local people in the short term while stabilizing the resource base for the long term.

The book underlines the need for a participatory approach with greater participation by local people at every stage to help them prioritize and solve their own problems. It focuses on the need for local assessments and actions and the unhelpful nature of

large-scale averages. Much could also be gained by reinforcing the efforts of small, local groups and funneling more aid through grassroots organizations.

The book attempts to review as objectively as possible the main issues, positive options and constraints, and successful achievements concerned with the woodfuel problem in its broader setting of sustainable land use and natural resource management. It uses actual case studies wherever practicable to back general discussions with 'on the ground' realities.

A book worth reading for environmentalists, policy makers and the environmentally conscious.

Hasan Jawaid Khan

PRELUDE TO FOUNDATION *by* Isaac Asimov, *Grafton Books* (Available from, *Rupa and Co.,* 3831, Pataudi House Road, Daryaganj, New Delhi-110002), Pp. 461, £ 1.95

THE immensely successful *Foundation Trilogy* was published in a novel form between 1951 and 1953. The three novels comprising the trilogy were basically collections of stories and novels which Asimov had been writing in the SF magazine *Astounding* since 1941. The trilogy has an implicit parallel with Edward Gibbon's *Decline and Fall of the Roman Empire* which had greatly influenced him when he had read it in his teens. In his trilogy a mathematician Hari Seldon has formulated the new science of psychohistory, which is nothing but a set of statistical formulas for predicting the future. He sets up two foundations in the galaxy, which are ultimately destroyed by a genetic mutant, the Mule. At the 24th World Science Fiction Convention held in Cleveland in 1966, the Foundation Series was awarded a Hugo as the All-Time Best Series. And yet Asimov never wrote a ninth story in the series (*Foundation Trilogy* consists of eight stories), mainly because he became tired of explaining in each new story what happened in all the previous ones. This he had to do as each story had to be independent of other stories. Furthermore, he found himself working in more and more cramped position because of the assumptions made in earlier stories.

In the early eighties, however, Asimov decided to write a sequel to his *Foundation trilogy*. The fourth and fifth novels in the series were *Foundations Edge,* (1982) and *Foundation and Earth* (1983). The novel under review is the sixth in the series but Asimov has gone back in time and described events which occurred even before the formation of the first Foundation. Asimov aptly describes this novel as the first in his Foundation series and advances the serial number of all other novels by one.

Prelude to Foundation is a hard-core science fiction novel with a heavy sprinkling of mystery, adventure and intrigue and a light seasoning of romance. Hari Seldon, an Assistant Professor of mathematics at the University of Helicon has delivered a paper on psychohistory on the planet Trantor, the capital of the Galactic Empire. The Empire is ruled by megalomanic Cleon I (Asimov has clearly drawn inspiration from Tiberius and Caligula) along with his evil chief of staff, Eto Demerzel. They come to know of his paper and force him to make predictions about their own future. Seldon's science is not yet fully developed and he expresses his inability to do so. He is released but soon Demerzel realizes the potential dangers of having released him. With his mathematical formulas he could predict that the Empire was dying, (a fact which both Cleon and Eto want to hide) which could bring disaster. They send two hoodlums after him but he is able to put them off his track with the help of a journalist Cheeter Hummin. He is taken to a safe place, the Streeling University, where he meets a beautiful historian Dors Venabili. A kind of subtle romance starts between the two. The meteorologist Jenarr Leggen, who is also teaching in the same University, Conspires with the authorities and takes him to the outer surface of the glass dome covering the whole planet Trantor. Here he is treacherously left alone. Soon he locates a jet-ship looking for him and runs to hide. From here onwards the pace of the novel increases and leads the reader nexorably to the last page. In between there are descriptions of such devices as antigravity cable lifts, neuronic whips, artificial environments, micro-foods, etc. Undoubtedly, another tour-de-force by Asimov. A strong shot in the arm for all SF addicts.

Anil Aggrawal

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