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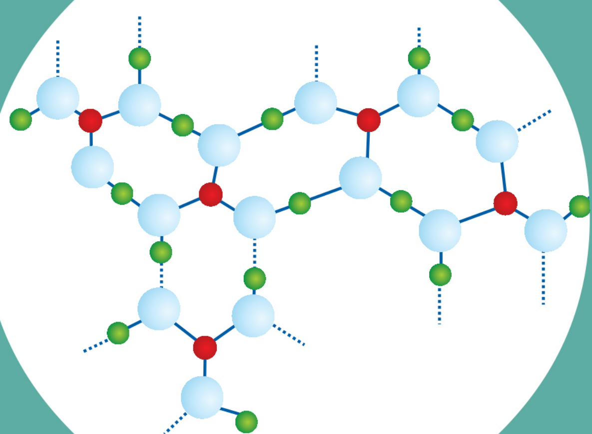

When something goes wrong with our ears, eyes and throat, we use hydrogen peroxide, boric acid and glycerine, respectively, to cure the disease.

This issue is printed in September 2015

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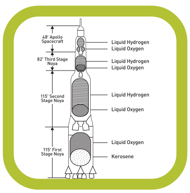
48' Apollo Spacecraft
82' Third Stage Noya
115' Second Stage Noya
115' First Stage Noya
Liquid Hydrogen
Liquid Oxygen
Liquid Hydrogen
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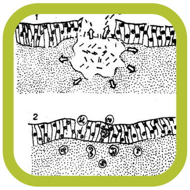
Liquid Oxygen
Liquid Oxygen
Kerosene



EDITORIAL

School Science is a quarterly journal intended to update teachers and students in schools with the most recent developments in science and science methodology. It aims to serve as a forum for exchange of experiences in science education.

The official publication of the *School Science*, a quarterly journal, was started in the year 1961 by the NCERT. In 2011, the journal had the distinction of completing 50 years of publication. During these 50 years the journal has reached to unprecedented height in the area of school education. Also, over the years we can observe the evolution in the type of articles, writing style, etc. Hence, to celebrate the completion of 50 years of the *School Science* journal , the period of publication of School Science from September 2012 to December 2013 is dedicated to commemorate these 50 golden years of the journal by presenting five special issues. This is the first special issue in which we have included best of the articles that were published during these 50 years from various fields like food technology, environmental education, chemistry and conservation of wild life with various social and economical aspects.

In the article entitled 'The Scientific Base of Economic Development' the researcher explains the role of science in the modernisation and talks over the need of direct aid for science.

The article 'Puppets versus Drugs' asserts that for the prevention and treatment of drug dependence; intersectional coordination and community involvement are two essential guiding principles.

In the article related to environmental education 'The Growing Energy Crisis' the author talks about the energy crisis that involves various interrelated political, economic, social and technological problems. The author is of the view that true energy conservation is achieved by recycling of material in industry.

The paper entitled 'Environmental Education – an Urgent Challenge to Mankind', briefly describes the concept, function and system of environmental education at school and university level.

In 'Aerosols and Ozone: How Real is the Threat?' the catastrophic and irreversible damage caused by CFCs to ozone layer is propounded.

In 'The Social Responsibility of the Chemistry Teacher', the researcher discusses the industrial case study and tools for making chemistry more relevant.

'Teaching Hydrogen Bonding: a New Approach', deliberates how hydrogen bond affects the solubility and its role in daily medicinal usage and synthetic fibers.

'Silent Valley – the Need for Wild Life Conservation' is an interesting article which shows the resources, flora and fauna found in this valley describing their need for conservation. The article entitled 'Wetlands and Biodiversity' where the author raises the importance of biodiversity, values of wetland and suggests the action plan for the conservation of wetland.

In 'Bird Migration' the author describes the nature and extent of migration, advantages of migration and migratory routes taken by birds, their orientation and punctuality of migrants.

Three articles — 'Thought for Food: the Social and Cultural Aspects of Malnutrition'; 'Why Nutrition Education?' and 'The Father of White Revolution' focusses on various areas of food technology such as misleading ideas about food, the advantages of breast feeding, the impact of food technology, analysis of food, nutritional problems, improvement of food production and distribution and implementation of nutrition education with operation food programme.

The article, 'Learn More about Bucky-Ball' the author describes allotropic forms of carbon and their structure, bucky-balls, hollow cage shaped huge molecule composed of 60 carbons in a very interesting way. In the paper 'A Game on the Periodic Table' discusses the effectiveness of the game and observes that it is more suitable for learners of Class X and higher classes to understand the properties of elements along the period and down the group.

In 'Faster Fitting for Artificial Limbs' the author describes a new technique for making the sockets for artificial legs by a semi-automatic process. In 'Cryogenics', the author describes the methods of preservation of material at chilling temperature while discussing the properties of cryogenic gases.

We sincerely hope that our readers will find these articles interesting and educative and we welcome comments and suggestions from our readers which will enable us to undertake further improvement of the quality of this journal.

THE SCIENTIFIC BASE OF ECONOMIC DEVELOPMENT

P.C. Mahalanobis

Member, Planning Commission of India (1955-1967)

Phases of Economic Development

The essential characteristic of an underdeveloped country is an extremely low level of living, that is, inadequate supply of food, clothes, housing, drugs and other consumer goods, and also lack of facilities for education, care of health, social security, cultural amenities, etc., for the nation as a whole. It is possible to make available small quantities of consumer goods, by direct imports or by production, on a small domestic scale, with the help of imported machinery. In most of the underdeveloped countries it is, however, not possible for lack of necessary foreign exchange to import or to produce, with imported machinery, enough consumer goods for the people as a whole. In India, the first textile mill was established in 1817; and India gradually became second biggest producer of textiles, next only to America. One hundred and fifty years later, India would still remain underdeveloped. The production of textiles or small quantities of other consumer goods for a small part of the nation cannot, by itself lead to industrialisation and economic development.

Economic development can occur only by increasing the per capita production of the nation as a whole, through an increasing use of machinery driven by steam or electricity as a substitute for human and animal labour. In countries with appreciable natural resources, it is necessary to establish the basic engineering and power industries to enable the manufacture of both consumer and capital goods within the country. Establishing a minimum complex of such basic industries would take at least ten or fifteen years, for which planning must start ten or fifteen years in advance.

To increase modern industrial production would call for an increasing supply of engineers, technologists, and technical personnel. The only way to ensure this would be to establish and increase the number of schools, training colleges and universities, and also to train teachers for such institutions. This would take at least fifteen or twenty years; so that, planning for this purpose must start fifteen or twenty years in advance.

The best way of utilising the raw materials and natural resources available within the country, for both domestic consumption and for exports, can be found out only through applied scientific research.[1] Applied research, in its turn, must be

1. Even the most advanced countries are obliged to devote large resources to research for the improvement of products already being manufactured and also to develop new products in order to hold their position in the world export market. It is not possible for the underdeveloped countries to start or expand the export of fully or partly manufactured products by simply borrowing the current technology from advanced countries; it is essential also to develop applied research for a continuing improvement of technological methods.

based on advances in fundamental research. Also, to establish an adequate base for applied research it is necessary to promote the spirit of pure research and supply the stimulus of scientific criticism. This would be possible only when at least a certain minimum number of scientists are engaged in fundamental research and opportunities for pure research are becoming increasingly available. It is therefore, necessary to promote the advancement of both applied and fundamental research. To establish a minimum base for scientific research would take more than a generation of twenty-five or thirty years; this, being the most slowly maturing sector, must be given the highest priority.

The Scientific Base of the Advanced Countries

The scientific base of the modern age can be appreciated by even a brief review of the recent history of the advanced countries. Four hundred years ago the generally accepted view was that the earth was at the centre of the universe; the position of human beings was unique and supreme; and the highest sanction of truth was either divine revelation or abstract logical reasoning in the mind of man. In the sixteenth and seventeenth centuries, there was a complete revolution in the picture of the physical world; the earth was seen as a small planet moving round the sun; and the method of empirical observation and experimentation was gradually established in both physical and life sciences.

Progress was at first slow in the sixteenth century. A few selected names may be recalled to indicate the gradual transformation of ideas. In astronomy, Nicholas Copernicus (1473-1543) supported the view that the planets including the earth itself were revolving in orbits round the sun; Tycho Brahe (1546-1601) supplied astronomical observations of unprecedented accuracy to make the next steps possible; Johann Kepler (1571-1630) formulated the descriptive laws of planetary motion; and Galileo Galilei (1564-1642) made conscious propaganda in favour of the new philosophy of the universe. In anatomy, Andreas Vesalius (1514-1564) published his observations on the human body in 1543; in physics, William Gilbert (1544-1603) gave an account of magnetism based on trustworthy experiments in 1600; in physiology, William Harvey (1578-1657), described the circulation of the blood in 1628; John Napier (1550-1617) supplied a convenient tool for computation by the use of logarithms; and Rene Descartes (1596-1650), a philosopher, contributed the powerful concepts of coordinates for geometrical representation and of mathematical functions. Francis Bacon (1561-1626), firmly stated that the only true method in science was to proceed from particular sense observations to wider generalisations (*Novum Organum,* Book I, xix), and clearly recognised that 'the true and lawful goal of the sciences is ... that human life be endowed with new discoveries and power.'

The concept of an objective world of physical reality gradually took firm shape in the seventeenth century in the hands of gifted astronomers, mathematicians and scientists. A few names may be mentioned from among those who were born in the first half of the century; Pierre Fermat (1601-1665), Christian Huygens (1629-95), Blaise Pascal (1623-1662), Robert Boyle (1627-1691), John Ray (1627-1705), Robert Hooke (1635-1703), Issac Newton (1642-1727), and Gottfried Wilhelm Leibniz (1646-1716). The rate of advancement of science increased progressively in the eighteenth and the nineteenth centuries, and during the last few decades has opened new frontiers with almost unimaginable possibilities.

The advancement of science prepared the ground for the industrial revolution in Europe in the eighteenth century, first in spinning and weaving, next in the use of iron and steel, and then of electricity in the nineteenth century, which stimulated the growth of the capitalist economies in West Europe and North America. The spread of the scientific outlook also prepared the ground for the Age of Reason and the French Revolution, which occurred at the end of the eighteenth century, and promoted the growth of nationalism in Europe, in its modern sense, in the nineteenth century.

The industrial revolution increasingly replaced human and animal power by steam or electricity to drive machinery for the increasing production of both consumer and capital goods. The development of engineering techniques led to a close linkage between science and technology; and during the last hundred and fifty years, industrial development has been stimulated by scientific discovery and scientific discovery has been stimulated by industrial needs.

For the last five or six thousand years, or more, the average per capita production remained more or less constant or fluctuated within narrow limits. The industrial revolution changed all this, and led to a spectacular increase in the variety and volume of goods produced. As a consequence of such increasing production, the standard of living of the advanced countries of West Europe and North America reached a level far higher than the rest of the world. Also, the advancement of science, technology and industry made it possible for the western countries to become strong military powers; and, because of such military supremacy, the west was able to bring a large part of the world either into direct colonial rule or into conditions of economic-political subjugation.

The first half of the twentieth century saw the rise of the U.S.S.R. as another world power, rapidly growing, through the promotion of science and technology, in economic, industrial and military strength together with a continuing increase in the level of living. The monopoly of scientific and technological knowledge and the unchallengeable military supremacy of the western countries have now gone. The increasing parity between the western and the eastern countries in science, technology, industry, and military power is a most significant fact of the present time. Because of the unprecedented destructive power of atomic and nuclear weapons, it has become absolutely necessary to avoid a nuclear war which would be catastrophic for both sides and the whole world. Co-existence of both the western and the eastern powers has become indispensable.

There is no intention on either side to make a direct attack. The advanced countries pose no special problems because it is not possible to hold such countries indefinitely in subjugation. However, so long as there are underdeveloped areas, both power groups are likely to try to extend their influence over the less advanced countries; and this would remain a continuing source of potential conflicts. The very existence of underdeveloped countries should, therefore, be seen as a threat to peace. Rapid transformation of all the underdeveloped countries into modern viable societies is an essential condition for peaceful coexistence. Such a transformation would promote the enlightened self-interest of both power groups, and would also create conditions favourable for the advancement of human and cultural values on a worldwide basis.

The Role of Science in the Modernisation of the Less Advanced Countries

Modernisation of the less advanced countries through rapid industrialisation is thus an urgent need for the whole world. Is such modernization possible or can a modern society with a viable economy, with expanding social and political freedom, and cultural amenities, be sustained without establishing a sound scientific base? This is a question of crucial importance for the present age.

In order to answer this question, it is necessary to appreciate the deeper changes in human thinking which were brought about by the emergence of science. In every sphere of organised activity in human society, authority has always been associated, and must always be associated with a system of hierarchical levels. This applies to primitive societies, matriarchal, patriarchal or tribal; successive levels of feudal lords; organised churches and religions; military, police and administrative systems; enterprises, business and commerce; and law. A law court of appeal may reverse the decision of a lower court; but the decision of the court of appeal is itself subject to change by a still higher court. The decision of the highest court, to which a case has been actually referred, has to be accepted not because such a decision is necessarily right, but because it is the decision of a superior authority.[2] Society must accept this authority principle for stability and orderly progress, even in organised revolutionary activities.

This very authority principle must, however, be absolutely and completely rejected in the field of science. Modern science is based on a patient accumulation of facts, on the study of processes and their interrelations or interactions and a stability or uniformity of nature[3] which can be discovered by the human mind. The findings of the most eminent scientists are subject to critical check by their professional colleagues and by the youngest scientific workers, and must be rejected if there is no satisfactory corroboration. Science can advance only through free criticism on a completely democratic basis, with every research worker of competence enjoying equal status. The theoretical or conceptual framework of science must be continually revised to find a proper place

2. It is possible indeed, that this decision itself would have been reversed if there had been a still higher court to which the case could be referred. If a decision of a higher court of appeal is considered to be like the turning up of 'heads' (in tossing an unbiased coin) when the decision upholds the verdict of the lower court, and is considered to be like the turning up of 'tails' when the verdict of the lower court is reversed, then the successive decisions of the higher court would look like the results of the tossing of a coin. This would be the real guarantee that the system of law is functioning properly.

3. The phrase 'uniformity of nature' must be, of course, interpreted to include chance events and random processes. Although games of chance were known and were widely prevalent in ancient times in China, India and other countries, it is important to note that the concept of probability did not arise until the sixteenth and the seventeenth centuries, that is, not until the emergence of modern science. This is easy to understand. Before the emergence of the modern scientific view of an objective world of physical reality, all chance events would have to be necessarily ascribed to the whims of gods, demons or supernatural forces. After the emergence of the scientific view of an objective world of physical reality, it became necessary, both logically and psychologically, for the human mind to accommodate the occurrence of chance events as an integral part of the uniformity of nature. This could be accomplished only on the basis of the theory of probability, or rather, as I prefer to put it, only through a statistical view of the world. It seems to me, therefore, that the concept of probability, or the statistical view of the world, did arise at the same time as the emergence of modern science only because it could not possibly have arisen earlier.

for all known facts. A single new observation may call for a more comprehensive theory. The older accumulated knowledge continues to remain valid; later discoveries must, however, be integrated with the earlier knowledge. The accumulation of scientific knowledge is increasing through the efforts of all the scientific workers of the world. A new fact may be observed or a new theory formulated by any worker, however young, and in any country where research has been established. International collaboration is, therefore, an indispensable condition for the progress of science.

Authority derived from status is irrelevant to science. Science has introduced a new concept of 'scientific', or 'objective validity' which has its foundation in nature itself, and which cannot be upset by any authority based on status or by supernatural powers. The transformation of all the advanced or rapidly advancing countries has been based on accepting, in an increasing measure, a scientific or rational view of life. This is the foundation of the modern age.

It is essential in every country to establish and strengthen the outlook of science, a way of thinking which becomes more and more powerful as it is more widely adopted, and which replaces dogma, superstition, and outdated customs. This scientific outlook cannot be established by force. It must depend on acceptance through proper understanding. In practical affairs, the important point is that a wise policy and programme of action should be increasingly adopted on the basis of rational argument, supported by relevant factual evidence, and should not be rejected because of emotional bias or formal dogmas or conventional rules of procedures. It is, therefore necessary, continually, to encourage and promote the advancement of science in every country, large or small. Because science is indivisible, and also because science must be established in every country, it is also necessary, continually, to promote scientific collaboration between all countries of the world, large and small, and advanced or developing.

It is scarcely necessary to point out that there is no conflict between the scientific and rational view of life on one hand and aims and objectives based on moral or cultural values, on the other hand. On the contrary, moral and cultural values which are truly universal, and are narrowly sectarian or nationalistic in a restricted sense, must have an objective and rational basis.

The advancement of science and the growth of the scientific outlook must be recognised as an essential condition for the modernisation of the less advanced countries. It is necessary for each country to have, as quickly as possible, a sufficient number of men with a scientific outlook to influence the thinking of the nation. How to attract and hold a sufficient number of able persons to science is thus the crucial problem of national and world development. This can be achieved only through a proper and adequate social appreciation of science and scientists. The actual transformation must be brought about from within each country. Scientific aid from the advanced countries can, however, be of great help in this process.

Current Programmes of Technical Aid

The need of technical aid has been recognised for some considerable time. Bilateral or multilateral and international technical aid has often taken the form of either offering educational and training facilities to young workers from the less advanced countries or sending technical or scientific experts to such countries. Considerable benefit has no doubt accrued through such aid but it is necessary to recognise that such effort has also been wasted.

Scholars from the less advanced countries are usually selected on the basis of results of examinations; success in examinations not being a necessarily reliable indicator of scientific or technical ability, the very process of selection is inefficient. Some of the young scholars have difficulty in adjusting themselves to the pattern of living in the advanced countries. Some of them do not do well in their studies. Some pass the examinations successfully but have no aptitude for scientific work. Some of the more able scholars prefer to live and settle down in the advanced countries, especially in the U.S.A., because of the higher level of living or greater opportunities for scientific work. Some scholars of ability, when they return to their own countries, are unable to find suitable openings for a scientific career; and some of them go back to the country where they were trained. In applied science and technology, and especially in social sciences, many young scholars, who had often studied problems or learnt methods which are appropriate for advanced countries but totally irrelevant to their own native countries, are unable to adapt or develop methods to suit local conditions. Out of the large number of scholars who go to advanced countries for training, only a very small number of really able scientific workers ultimately become available for fruitful work in their own country. The cost of giving scientific or technological training in an advanced country is also very high. Giving training to individual scholars in advanced countries (whether the expenses are provided in the form of foreign aid or met by the scholars themselves or by the country of origin) have been, therefore, extremely wasteful in terms of both men and money.

There have been continuing difficulties in finding suitable individual experts for the less advanced countries. Competent scientific workers are reluctant to accept such assignments partly because of the lack of facilities for their own work in the less advanced countries and partly because their scientific or academic career is likely to be adversely affected through their absence abroad. In consequence, assignments sometimes have to be given to persons who are not fully qualified for the job, with unsatisfactory results. To create suitable conditions for scientific work in the less advanced countries is an indispensable condition for attracting competent scientists to go out to such countries.

Programmed technical aid on a group basis has been more effective. A team of young engineers from a less advanced country can receive most valuable training in an advanced country when such training is oriented to specific technological projects. Teams of experts from advanced countries have also been of very great help in establishing factories or in starting new projects in the less advanced countries. Such technical aid, especially in engineering, technology and applied sciences, should be continued and expanded. Special projects for establishing technological and research centres in the less advanced countries have also been taken up by some of the international agencies. This type of aid can be of great value provided a sufficient number of scientific workers in the less advanced countries can be trained to work in such centres and also provided necessary conditions are established to enable them to do their work properly.

Science Education and Research

It has been argued in the earlier sections that for modernisation it is necessary to establish a foundation for scientific research and the social appreciation of science in the developing and less advanced countries. Every path-finder in a new field of research must work in the first instance by himself; if he is successful, other persons gradually get interested in the subject. Such path-finders always had, and will always have to overcome much opposition, and even hostility, until the new subject becomes a recognised part of the 'established' field of science. But it is only a few scientists of outstanding ability who can work in isolation. Most research workers require the stimulus of free interchange of views and ideas and of appreciation among professional colleagues.

The community of scientists has a structure of a series of widening circles similar to the structure of scientific subjects or of science as a whole. When a top scientist speaks appreciatively of some work in his special field, other scientists or laymen accept his evaluation and pass on the information to others. The social appreciation of science gradually emerges as a result of the diffusion, in widening circles, of the views of scientists, who are experts in specialised fields of research, to scientists in related and associated fields, then to scientific workers generally, and finally, through persons of position and standing who have contacts with scientists, to the general public. The speed with which such appreciation can spread, increases rapidly with the increase in the number of scientific workers and improvements in the channels of communication. In the advanced countries, the awareness of the importance of science is increasing rapidly which, in its turn, is raising the social status of scientists and is promoting an increasing flow of resources for research.

The whole process is extremely slow in underdeveloped countries. The number of research scientists is very small; and channels of scientific communication are non-existent or meagre. Scientific workers usually receive lower pay and have a lower status than the administrative staff in government or in business concerns; and have to work in a rigid system of hierarchical authorities. Promotion may depend, not so much on the high quality of the scientific work done, but on success in pleasing those who are higher up in the official hierarchy. Even permission to apply for posts elsewhere is subject to the discretion of superior officers. There is a continuing tendency to bring scientists and scientific work under strict control of the administrators, partly, perhaps, from an unconscious fear of rivalry of power. Even if the right of criticism is accepted in principle, it is restricted in practice because scientific workers are often afraid, rightly or wrongly, of giving offence to persons holding higher posts. In consequence, many scientists in underdeveloped countries suffer from a lack of self-confidence, and are afraid to take up original lines of investigation. There is little possibility of a proper evaluation or appreciation of scientific work within the country. This leads to an exaggerated dependence on the opinion of foreign scientists and gives rise to much imitative work. Also, when there is lack of appreciation or criticism from the advanced countries, there is sometimes a tendency to ascribe the unfavourable view to racial or national prejudices, and there is resistance against collaboration with foreign scientists.

In underdeveloped countries there are very few, sometimes only one or two, individuals of outstanding ability in scientific research or in any other scientific field. As leadership can be supplied only by individuals of high ability, and as such persons are few in number, it is much more difficult in underdeveloped countries to utilise the services of individuals of average ability and qualification. The advanced and advancing countries have a double advantage. They have a large number of persons with qualities of leadership and can, therefore, utilise in a fruitful way larger numbers of persons of average ability. This is why many scientific workers from underdeveloped countries, who are unable to do much useful work in their own native country, can often do very good work in the environment of a higher state of organisation of research in an advanced country.

The aim of scientific aid must be to create in every underdeveloped country, as quickly as possible, a sufficient number of research scientists to form a community of professional workers which would be sufficiently large to facilitate an independent evaluation of scientific work through free criticism and frank exchange of views. It is, therefore, necessary to focus attention on identifying and giving support to persons who have the ability to undertake research work of high quality, and to try to increase their number as quickly as possible, and at the same time to offer opportunities for training to persons of average ability whose services would be equally essential in supplying a wide base for the pyramid of scientific work.

There is urgent need for fostering the spirit of objective scientific criticism through free expression and exchange of views and opinions. One effective way of promoting this would be to make it easy for scientific workers to migrate from one post to another and give an absolute guarantee of such freedom to migrate. Any scientific worker who feels, rightly or wrongly, that he does not have enough opportunities for fruitful work in one institution would be free to migrate to some other institution. Such migrations or the possibility of such migrations would have an indirect but most important selective effect on scientists at all levels.

It is necessary to recognise that the social value of an individual scientist of high ability is far greater in a developing country because of the leadership he may be able to supply. It is only scientists engaged in fundamental research who can function as the eyes and ears of the nation in making the nation appreciate and identify urgent needs of applied research. The emergence of even one or two outstanding research scientists can enhance the prestige of the nation in a most significant way at the international level and promote the growth of self-respect and self-confidence of the nation. This is why it is particularly important in developing countries to identify such individuals, at first very few in number, and give them all possible facilities and encouragement to continue their work in their own country.

In the highly developed countries science advanced both from progress at the highest levels of research, at the top, and from the wide diffusion of education, at the bottom. The same strategy may be adopted with advantage in the less advanced countries. What is urgently needed is to lay the foundations, with as wide a base as possible, for a countrywide system of school education oriented to science and, at the same time, to develop advanced studies of science and technology and research at the highest level. The school system must fit into the economic life of the general mass of the people and have its grassroots in the villages. It must offer facilities for training technicians and technical personnel for science and technology and also supply candidates of outstanding merit for admission to higher scientific and technological institutions.

Need of Direct Aid for Science

I shall offer, briefly, a few suggestions for giving direct aid for the development of science in the less advanced countries. I have stressed the need for building up a system of school education with a definite orientation to science. It would be, however, a fatal mistake to establish an expensive system of education on the model of the advanced countries which would have little relevance to local needs and would be beyond the means of the national economy. It is necessary to evolve a system, through experimentation and trial and success, which would be within the means of the national economy. The approach must be therefore, to use teaching aids which are easily available or can be made available on a large scale and at a low cost. As most of the pupils will be living in villages, it would be of great advantage if agriculture and some of the rural industries can be adopted as a base for the teaching of science. The programme may consist largely of nature studies, observations, and experiments which can be done with the help of simple articles, specimens, etc., likely to be locally available or which can be constructed with local materials.

There would be still some need of supplying teaching aids and materials from outside which would have to be specially designed to reduce costs. It is essential also to prepare books of instructions and textbooks to suit a fairly wide range of needs. These are difficult tasks which would call for extended study and research by scientists of high calibre with a serious interest in problems of science education. As basic conditions in underdeveloped countries are likely to be similar to a large extent, it may be possible to evolve broad general methods for science education which would be capable of being adapted without much difficulty to suit differing local conditions.

A great deal of pioneering research would be necessary for this purpose for which the help of advanced countries is indispensable. A good deal of experimental studies will have to be undertaken under conditions actually prevailing in underdeveloped regions. In the beginning, the studies would have to be organised on a small scale with the help and support of the local authorities and of such teachers and scientists as may be available to cooperate in the venture in the underdeveloped country itself. The project can be gradually extended, in the light of experience, to cover different subject fields at different educational levels, and also from one underdeveloped country to another. Fortunately, even one or two scientists can start the work in one single country. The important point is to make a beginning at the earliest opportunity.

I may now mention a second type of programme. Certain facilities for scientific research are already available in India and other developing countries. In most of these countries, scientific work is being hampered for lack of small replacement parts, additional accessories and instruments, and supply of essential consumable stores which have to be imported from the advanced countries. It is often difficult to secure import licenses on account of shortage of foreign exchange. This difficulty can be overcome through a simple plan of gifts in kind of replacement parts, instruments and equipment, stores, books and journals and reprints or microfilms of scientific papers etc., to be arranged through non-governmental committees of scientists. Such committees, which can be set up in the advanced countries through or in cooperation with appropriate scientific organisations or societies, would try to secure suitable grants from Government and other sources. In developing countries where scientific research has already started, the counterpart committees of scientists would also be set up, preferably, at a non-governmental level and with a majority of members from universities and non-governmental scientific institutions. All arrangements would be made with the concurrence of the government of the less advanced country concerned, but decisions relating to gifts for scientific work must be made by direct consultations between the scientific committees themselves. A scheme of this type can be usefully started, on an experimental basis, for a few selected countries, at a low cost, with gifts of the total value of perhaps one or two hundred thousand dollars per year. The amount can be increased if the experiment proves successful.

Another important form of scientific aid would be to arrange for competent research scientists from the advanced countries to work for a year or two in existing research units in the less advanced countries or to help in establishing high level research units in such countries. The less advanced countries can offer challenging problems and opportunities for research in many fields of science, which cannot be duplicated in the advanced countries, for example, in geology, meteorology; biology, botany, and zoology; agriculture; medical science and public health; economics of development; linguistics, archaeology; and historical and cultural studies of various kinds. In some of the developing countries there would be also increasing opportunities for active participation in research in mathematics and statistics, and physico-chemical and technological sciences. In establishing research units in underdeveloped countries it would be desirable to keep one broad aim in view, namely, to encourage joint studies by active collaboration between different research units. This would help in developing a community of research cells or units which, in its turn, would foster the growth of the spirit of scientific criticism and appraisal among wider circles of scientific workers.

To attract competent visiting scientists it is necessary to offer them facilities to pursue or start fruitful research in the less advanced countries; sometimes special equipment may have to be provided for this purpose. Secondly, the assignment in a less advanced country would have to be treated as deputation in the same way as participation in scientific expeditions, and which would be recognised as a part of normal duties and also as a possible qualification for promotion. The visiting scientist must receive sufficient compensation in his home currency to meet his continuing home commitments during his absence abroad. Living and other local expenses should be normally met by the institution or by the government of the country in which he would work. Such sharing of costs would promote effective cooperation by the less advanced country, and would also reduce the total cost appreciably.

An important part of the responsibilities of a visiting scientist would be to give training to the scientific workers of the underdeveloped countries. When necessary, the visiting scientists would be able to select, for further training in an advanced country, the right type of persons who can be depended upon to go back to their own country after the completion of the training abroad. It would be also possible to give aid in the form of equipment and instruments in an effective way on the basis of objective appraisals of needs and possibilities by the visiting scientists.

A fourth programme could be to send from advanced countries young scholars, who have just finished their education in universities or higher educational institutions or have already done some research, to start or continue suitable lines of research for about two years or so in existing institutions or in research units to be established for this purpose in underdeveloped countries. The common participation in research projects of young scholars from the advanced and the underdeveloped countries would be of great help in establishing scientific traditions and an atmosphere of scientific criticism. It would promote self-confidence among the scientific workers of the underdeveloped country, especially if the visiting scholars from advanced countries earn higher degrees from the less advanced countries.

All the above forms of scientific aid can be started, if desired, on a small scale and at low cost, and, if successful, can be expanded in the light of experience. Also, these forms of scientific aid would not in any way overlap or hamper bigger programmes for gifts of expensive equipment or large projects for the setting up of national or regional centres and institutes for scientific research in the less advanced countries. On the contrary, the modest programme described in this note would prepare the ground for bigger projects.

Conclusion

In conclusion I may refer, very briefly, to some recent developments. After the Second World War the movement for terminating colonial rule gained rapidly in strength; and one country after another in Asia and Africa won political independence. It is being increasingly realised, however, that independence is not enough for economic development. The need for economic and technical aid is also being increasingly appreciated. Both the western and the eastern powers have started helping in the economic development of the less advanced countries in Asia, Africa and Latin America, but still without an adequate impact. The time has come to recognise that economic aid is essential but is also not sufficient.

Revolutions to capture political power have been occurring throughout human history and are even now occurring in many of the politically independent countries in Latin America or in most of the newly independent countries in Asia and Africa. Such revolutions do not automatically promote rapid economic development, because purely political revolutions do not lead to any fundamental transformation of the old society, based on the principle of authority associated with levels of status. It is becoming increasingly clear that rapid economic development cannot be achieved without developing a structure of society in which decisions would tend to be made more and more on grounds of reason, that is, in accordance with the principle of objective validity instead of authority. It is relevant to note that the French Revolution was preceded by the Age of Reason; the American War of Independence had the support of influential leaders inspired by the spirit of science; and the socialist government, which was established after the October Revolution in 1917 in Russia, made great efforts to build up a countrywide system of science-oriented education and to promote scientific research and, in this way, succeeded in modernising the whole society leading to rapid economic development.

One thing is clear. In the absence of rapid economic development, political conditions in the less advanced countries will remain unstable. In many or most countries there would be one revolution after another tending to get the two power groups involved directly or indirectly in the struggle. The world must get out of this vicious circle. There are only two possibilities. One is for a violent type of revolution to occur which would suddenly change the whole structure of society to make it fit for rapid development of science and economic progress. The other alternative is to build up deliberately the foundation of science-oriented education and research to promote the modernisation of society in a peaceful way, and make conditions favourable for economic development.

Aid for scientific and economic development from either the western or the eastern countries, even when given in a spirit of competition, would be cooperative in effect. In any event, competition in constructive tasks of building up scientific foundations in developing countries is less dangerous and is likely to be far more useful than competition in the methodologies of warfare. Also, collaboration in promoting education and research in pure science can be pursued without any threat to national security or national interests, and would be of great help in promoting a rapid advance of the underdeveloped countries and in fostering better understanding among the nations of the world. The advanced countries have a great opportunity for peaceful cooperation in giving aid for science.

This pamphlet was first printed as a pamphlet for private circulation. Certain aspects of these problems were discussed by me in articles and addresses between 1955 and 1959 which were reprinted in *Talks on Planning* (1961), and in other articles such as *A Note on Problems of Scientific Personnel* (1959), *Recent Developments in the Organisation of Science in India* (1959) and a lecture at Sofia University in December 1961. Some of the ideas given in this article were presented by me before a Conference on International Cooperation in Salzburg-Vienna in July 1962.

Professor P. M. S. Blackeet in his presidential address to the British Association for the Advancement of Science in 1957 and in other articles in *Nature* (3 February, 1962; May 1962 etc.) has considered various problems from the point of view of the advanced countries. Professor Stevan Dedijer made a penetrating analysis in an article in *Nature* (6 August 1960) and in another article published recently in Stockholm, TVF, 33, (1962).

PUPPETS VERSUS DRUGS

Edith Massun

Mexico's Youth Integration Centres are tackling drug abuse within the community itself, in the conviction that only if the community is involved can it become responsible for its own health.

Centros de Integración Juvenil (CIJ) is a health-sector institution that was started in Mexico City in 1970 specifically for the prevention of drug abuse and the treatment and rehabilitation of drug-dependent persons. It is one of the largest specialised centres in Latin America, with over 16 years of field experience. There are now 32 local Youth Integration Centres sited at strategic points around the country, generally in the most densely populated towns. They employ a regular staff of some 600 and several hundred volunteers.

The CIJ's somewhat unconventional organisational structure ensures that it is in constant touch with the needs of the community and, at the same time, gives its managerial and professional staff the necessary stability of tenure. Though officially recognised and subsidised from the federal budget, CIJ does not come directly under the government; it is a civil association, directed by a 'National Board of Management' on which sit members of the community. This system also obviates one of the problems that beset many Latin American institutions: the replacement of their managerial staff with every change of government or administrative reshuffle.

The structure of the CIJ reflects its approach to drug abuse. It defines drug abuse as a public health problem symptomatic of individual, familial and social stresses; and to resolve it will call for the active participation of the population. The mere fact of belonging to a social group or milieu in which drug abuse is a problem implies that each of its members shares some responsibility both for the genesis of the problem and for its solution. Only to the extent that society involves itself in tackling the problems that affect it will it be possible to solve them. Inter-sectoral coordination and community involvement are two essential guiding principles in the prevention and treatment of drug dependence, but few institutions manage to put them into practice. I asked the Medical Director of CIJ, psychiatrist Raul Zapata, how he gets the community involved.

He told me: "It is a whole process that begins with informing and alerting opinion, continues with a guidance phase, and culminates at a more complex level of in-depth action which is the training phase. The most complex part of this process is training prevention officers, (who include heads of families) so that they can guide their children, and train health officers who are in touch with the community so that they can identify those at risk and help those who already have a problem."

"The idea is for them to be strategic elements of the community who are progressively sensitised to the drug abuse problem and in turn generate awareness by a 'snowball' effect. Parents who are conscious of the problem will influence not only their own child but others too; a teacher will influence a new group of pupils each year... Our objective is to have people forming completely self-run groups that can design their own preventive programmes within their own communities."

It often happens that certain people use the information they receive to launch out into alarmist or sensationalist anti-drug programmes, which can do more harm than good. Many people in Latin America want to combat 'drug trafficking' without knowing how to distinguish between trafficker and consumer, delinquent and sick person. I asked how such misdirected initiatives and counter-productive activities could be avoided.

Dr. Zapata replied: "It is true that people always prefer to involve themselves in 'blitzkrieg' campaigns (with slogans like 'Let's fight the drug traffickers!') rather than committing themselves to serious, longer-term activities. It is also true that the drug scene fascinates the public. Everyone wants to know about their effects, but very few ask what is the reason for drug abuse and what can be done to prevent it.

"The information meetings or talks we start with serve as an initial 'screening' to show us who it is possible to work with. Mostly they are people already with a high level of awareness, concerned for the welfare of their group: community leaders, social workers and so forth. We know that a group is ripe for us to 'set it loose', and even to support it with our entire infrastructure, when its members really understand that drug abuse cannot be prevented by taking the easy path of 'yellow' journalism or trying to lay the blame upon others.

"In addition to the trained volunteers from the community, we make a point of including young assistant teachers (students of psychology, social sciences or social work) in the preventive activities. This not only saves staff resources but it is also in keeping with the philosophy of our institution."

In a country as large and heterogeneous as Mexico, with 18 million people in the capital alone, how far can the Youth Integration Centres go in this 'social mobilisation' against drug abuse?

"The problem of drug abuse is so complex that no single institution can take on the whole gamut of activities that are needed," said Dr. Zapata. "We must see to it that all the other institutions do something, each in its sphere of competence. We constantly try to involve other agencies in our programmes, particularly the Ministries of Health, Education and Labour, but at the decision-making level so as to have all the necessary support."

A visit to one or two of the 32 local CIJ centres can only give an incomplete impression of a whole gamut of activities that are conducted daily on and off the institution's premises. The CIJ's work ranges from scientific research on drug abuse problems, through preventive programmes, and treatment and rehabilitation of drug dependent persons, to continuous training of volunteers and of its own regular staff. Every local centre carries out all the phases of comprehensive care for those with drug dependence problems, from the patient's admission, diagnosis and treatment by various techniques or therapeutic and rehabilitative approaches, to family guidance. And the staff also go out to meet the community: their regular activities include talks to inform and alert opinion, street theatre and puppet shows given in the schools.

At the Southern Centre in Mexico City, the psychologist S. Cisneros was getting ready for one of the daily guidance sessions for the families of drug dependents. "Here we bring together the closest relatives of patients who are undergoing individual treatment at the centre," explained Mr. Cisneros. "With family members, the primary objective is to lessen their anxiety and then to change their idea of what drug dependence is. Because generally they individualise it: to them the problem is the child who takes drugs. They don't understand that it has to do with the social and above all the family environment. We have to analyse with them their own attitude towards the problem."

The mother of Tonito (aged 14) is a 46-year old peasant woman who has brought up her 11 children alone. Obviously this is the first time in her life that she can talk about her problems and her doubts to someone who really listens. "My husband never had time to help me about the house ... When Tonito had the accident as a little kid..." The psychologist listens and asks questions only to set her thinking: "And how do you feel about it? Is there anything more you can do?"

After an hour and a half, Tonito's mother begins to understand her son's problem better and feels there is something she can do to help him. She agrees to come back next week and report on what she has been able to achieve.

The Netzahualcoyotl Centre is in an outer suburb where two million people live in deprived conditions. There I witnessed one of the most interesting outside activities conducted by a particularly dynamic team. The object of the exercise was to convey a preventive message to children at one of the local primary schools through the medium of puppet theatre. The play titled *The Champions* and written by the Medical Assistant Director of CIJ, is about abuse of pep pills and tranquilisers.

Four children are getting ready for a race. One takes some pills to overcome his fear, another to feel stronger and thus beat the others. The race begins—but one of them falls asleep before even starting to run and another has a terrible headache and has to stop in the middle of the race. The winner is Gustavito, the only one who has taken no pills and is in the habit of eating properly and exercising regularly.

The CIJ team (including several volunteers) arrive at the school in the middle of the break. They start getting the theatre ready and putting on make-up in front of the children so as to attract their attention. The drawing power of the show for the children never fails! In a minute they are all around the team watching the preparations and asking questions. As the event has been publicised in the district through posters, some of the school children's neighbours and parents also arrive, with their smallest children in their arms.

During the performance the children are not just passive spectators; they are constantly invited to participate. The puppets address them, ask what they think about what is happening on the stage and make them take part in the action. Fascinated, the children readily forget that what they are watching is only a play and take it for a real-life happening. When they are asked which of the four main characters they would most like to resemble, they all shout in unison: "I want to be like Gustavito, so as to win!"

Clearly, the preventive message came across and reached those it was intended for much more surely, and probably to more lasting effect—than if they had merely been passive recipients of a lecture on the dangers of pills. When the play is over, another surprise awaits them: the puppeteers suddenly appear before the audience, each holding his or her marionette. They make them move and talk, inviting the children to come and visit them at their district CIJ centre, where they will teach them how to make puppets and act plays with them. This way of publicising the centres never fails, because it appeals to the children through an activity that really pleases and interests them.

The puppeteers are already packing up their gear and removing the white grease-paint from their faces, but the children are still clustered around them, hoping they won't go away just yet. Once their interest is aroused, questions and doubts pop out from their little heads like sparks and demand answers. The first step has been taken towards initiating genuine preventive education with these children.

Courtesy: WHO

Information on Drug Abuse

Access to comprehensive information is a prerequisite for sensible action and policies about drug misuse. It was this basic principle that underlay the founding, in 1968, of the Institute for the Study of Drug Dependence (ISDD) in response to the United Kingdom's first wave of public concern about drug abuse in the 1960s. Over the years the Institute has provided valuable advice to WHO on a variety of technical issues in this field.

Apart from its publications, the resources of ISDD are not generally available outside the British Isles, but the Institute is carrying out a computerisation programme which will make its library accessible on a more international basis.

This library is now one of the largest and most comprehensive collections of scientific, academic and other documents on substance abuse in the world, numbering some 40,000 articles and books. The indexing system is unusually heterogeneous and multi-disciplinary. An end-product of this work is ISDD's *Thesaurus of Indexing Terms,* already available in English and Spanish with a Portuguese version in the pipeline and a prospect of a French version later. This indexing tool enables material to be retrieved from the library on any topic; when eventually the library database is transferred on to computers, it will be accessible to researchers and information seekers outside the UK.

Besides the library's facilities, ISDD has an experienced professional information staff who deal with some 8,000 individual enquiries each year, ranging from school and university students for help with essays and theses to requests from policy-makers and researchers for material relevant to their current interest. The needs of the latter are also catered for by the monthly publication of selected abstracts of the library's latest acquisitions, selections from material published in the UK press, and a listing of all documents and books added to the library each month.

Wider dissemination of information on drug misuse is achieved through a comprehensive range of booklets and brochures aimed at particular audiences, such as social workers, school teachers, parents and family doctors, whose occupations bring them into contact with drug problems. The library ensures that these publications present an up-to-date and balanced account of the facts of drug misuse, while ISDD's journal *Druglink* is available internationally and serves to keep its readers abreast of developments in UK policy and practice on the misuse of drugs.

The ISDD's Research and Development Unit aims to support the growth of knowledge and competence among those who work with drug problems. It concentrates on social research in the areas of prevention, evaluation of education and social work, and development of tested training and teaching methods and materials.

The ISDD seeks to be a credible source of information and support to everyone concerned with drug misuse. It therefore takes great care to remain independent from government (though it does receive some of its finance from the UK government) and from any faction, and generally refrains from expressing opinions on issues of drug policy. The Institute, based at 1-4 Hatton Place, London EC1N 8ND, is of potential interest to other countries as a model institution to support their national response to the misuse of drugs.

Courtesy : WHO

THE GROWING ENERGY CRISIS

Thomas Mathew

Office of Environmental Planning and Coordination
Department of Science and Technology
Technology Bhavan, New Delhi

The inhabitants of Delhi will remember the summer of 1973 for the fickleness of the city's power supply. Yet it served as an uncomfortable reminder to the citizens of the capital, of the acute power famine that is now plaguing the whole of the country. Apart from the inconvenience caused to the public, the industrial and agricultural sectors of our economy are hard hit, since for them power is an essential requirement. Industry as a whole may lose up to ₹ 30 crore a month. Dr K.L. Rao has estimated that the loss to the country from power cuts is of the order of ₹1000 crore. And on and on runs this disheartening story.

There are many valid reasons for this power shortage. The rain gods have been unkind. Maintenance of power plants has been very poor so that even existing facilities have not been fully utilised. Power planning has not been of the highest order. There have been frequent labour troubles. Transmission loses in our power lines have been the highest in the world. There is a shortage of fuel.

All the above reasons, save the last, can, at least in theory, be controlled to some extent. By fuels one is referring to what are known as fossil-fuels like coal, oil and natural gas. These have been formed over millions of years beneath the earth's surface, and provide the energy to run our industries, electricity to light our homes and power our gadgets, and speed many of our locomotives. So far mankind has been freely plundering nature's invaluable gift of energy. These fuels are non-renewable since the time period over which man consumes this resource is an insignificant fraction of the time it takes nature to produce them. It is only in the last decade or so that we have been seeing the limits to this plenteous supply. This, together with the realisation that in the future our energy needs can only keep increasing, is at the heart of what has come to be called "the growing energy crisis".

Energy is vital to our very existence on earth. The ability to master the use of energy for his own needs has been the key to man's survival and development. In modern times it plays a crucial role in providing man food, comfort and raising the quality of his life.

Today, the world demand for energy is growing at an annual rate of six per cent. It doubled in 13 years up to 1971 and is expected to double again by 1982. This gives some idea of how the world energy consumption is growing. The trend for the last third of the twentieth century, and beyond, is striking. It is the fossil fuels that have so far shouldered the brunt of this mammoth demand. And these, we can see, are now running out.

It Affects All Mankind

The first point to realise is that this is very much a global problem, since energy is basic to any progress. For developing countries like India, all our huge and ambitious developmental plans hinge around this vital resource. Apart from our industrial build up, we need it to further our Green Revolution and provide food for all our people. We need it for the expansion and modernisation of our armed forces, to protect our borders from restless neighbours. But the energy crisis hits harder at the industrially advanced nations because they consume much more energy. The U.S., for example, uses one-third of the world's energy production though they have but six per cent of the world's population. In fact the developed countries together swallow up 80 per cent of the total energy produced.

To make matters worse, there was a time not very long ago when fuel was available far in excess of the world's requirements. The U.S., the Soviet Union, West Asia and other countries had enough fuel for themselves and more. So that industries geared themselves to be fossil-fuel based. Now with a gradual depletion of fuel resources, they are beginning to feel the pinch.

In order to understand the problem we have to see what the balance sheet looks like. We can calculate pretty accurately how much fuel is used at present for all the world's industry, agriculture, life and leisure. We could also make a projection of our future needs. But there is a controversy which may in the long run turn out to be largely irrelevant, about the fossil-fuel left at the world's disposal. The debate is over the 'proven' and 'unproven' reserves. The figures on proven fossil-fuel reserves represent a basic minimum estimate of potential world resources. This means it only refers to the amount of fuel which on the basis of geological and engineering information is assumed to be recoverable from known reservoirs and under current economic and technological circumstances. On the other hand unproven reserves may take into account probable and possible reserves.

For instance, coal resources determined by mapping and exploration have been estimated at 8,610 billion metric tonnes. In addition, resources in unmapped and unexplored areas are of the order of 6,570 billion metric tonnes. This "guesstimate" will vary with the methods used for such predictions. But for coal one has also to slap on a fraction for recoverability – 50% by present mining experience – which is the quantity judged to be recoverable under given technological conditions. Hence recoverable known reserves would work out to 4,305 billion metric tonnes. Where does this leave us?

If energy use was to grow at the expected annual rate of five to six per cent, then cumulative energy requirements by the end of the century might amount to 400 billion metric tonnes of coal equivalents. Not only could the estimated 4.3 trillion tonnes of recoverable coal resources meet this entire growth of energy demand, but in the year 2000, at then prevailing rates of total energy consumption, enough coal would be left in the ground to meet the entire bill for a century and a half beyond.

But then one must remember that such exercises do not look at the resource pinch that may occur much earlier, in localised regions. Moreover, they ignore the fact that at present coal accounts for well under 40 per cent share of energy use and seems destined to account for progressively lower percentages in the years ahead. But this is typical of the type of hypothetical excursions that the energy planners indulge in these days.

Incidentally, energy forecasting has become a science with its own highly sophisticated techniques. There are a large number of uncertain factors that may swing estimates either way, like unproven assumptions, lack of data, etc., apart from economic, social and political factors. But it is a necessary exercise in order to get some sort of a handle on a complex problem.

There is more controversy over estimates for oil and natural gas reserves. A significant body of opinion flatly states that we are going to run out of oil by that magical year 2000 A.D. There is another vociferous group which states that the above estimate is based on present limited technology and once we, for instance, learn to extract oil from shale, and find more yet undiscovered sources like those beneath the deep blue sea, our oil supply is going to last much longer.

Our Precious Environment

There are other considerations to complicate the energy crisis still further. We are becoming gradually more and more 'environment conscious'. This issue of *School Science* is one manifestation of this concern. It is dawning on us how we have been ravaging our natural environment through the many and diverse activities of modern civilisation. A large portion of this environmental degradation has to do with man's use of energy in some form or the other. Thus the exhaust from our cars, buses, trains, aeroplanes and so on is causing a lot of air pollution. Our industries belch out smoke and other harmful chemicals. The way we tap our energy sources is coming under severe fire. For instance, strip mining of coal which literally gouges the coal out of the ground, is being frowned upon since it leaves large tracts of scarred land that are not only an ugly sight but cause damage to the flora and fauna for miles around. Our thermal power plants throw up into the air fly-ash and other particulate matter. They cause thermal pollution because the large amounts of water required for cooling purposes get heated and are released into the streams and rivers causing harm to fish and other aquatic organisms. The nuclear power plants, apart from causing thermal pollution, have a radioactive waste disposal problem that is going to progressively increase in magnitude. Moreover, people are getting increasingly finicky about the quality of fossil-fuel that we use for energy purposes. High sulphur coal or oil is rejected or subjected to prior treatment so that it does not cause air pollution through excessive sulphur dioxide release.

The exploitation of an energy source involves seven operations, some of which are inter-related. They are: discovery of the resources, harvest, transportation, storage, conversion, use and disposal. What our enhanced concern for the quality of the environment is going to do is to increase the cost of these steps and hence make energy all the more expensive. Ironically enough, society's avowed goal of cleaning up the environment is going to require more inputs of energy. Thus we are going to require power for our sewage treatment plants, our industrial effluent cleaning processes and other pollution abatement facilities and (to complete the vicious circle) for using more efficient and less damaging ways of tapping energy sources. It is not difficult to realise how all this is going to add to the energy crisis.

Political Implications

But lest one should run away with the idea that all this is purely a scientific or technological problem, it is well to remember that the long fingers of international politics and high finance creep into the situation to further mess up an already messy problem. The world's consumption of oil is increasing by eight per cent a year. U.S. consumption is now nearly 40 per cent of the total. On the supply side we see that the Arab countries and Iran together are floating on 70 per cent of the world's oil. This area is now doling out oil to satisfy 60 per cent of Europe's needs, almost the whole of Japan's and about 20 per cent of America's, apart from a large percentage of the needs of developing countries. The combined income of these oil producing countries (excluding Iran) which was $4.4 billion/year five years ago is now $10 billion/year and by 1980 could reach $40 billion/year.

What this means is that within a decade or so, these few countries, some of them politically unstable, will be sitting on a stupendous portion of the world's money, and will be able to threaten the international monetary system. The oil wealth will give the Arabs power undreamed of, that could be used for peaceful development or for political arm-twisting, violence and revenge.

This has given the developed nations an added incentive to go scurrying around looking for alternate energy sources as well as to develop new technologies to try and become self-sufficient in energy. These new technologies are in various stages of readiness and economic feasibility. It would be interesting to review some of them.

Energy of the Future

It is obvious that in the future man will have to turn increasingly to nuclear power. There are quite a few atomic power plants of various sizes working all over the world. Almost all of these are the conventional water cooled reactors, fuelled by U 235, that is becoming increasingly difficult to mine and process economically. One modification of the normal fission technology that appears closest to widespread application is the "breeder reactor".

In simple terms, this is a reactor that would use fissionable fuel to produce power, at the same time creating more nuclear fuel in the ratio of about one and half parts of fuel created for every part burned. During the normal chain reaction, surplus neutrons from the atoms of U 235 in the reactor core, bombard a surrounding blanket of U 238, a much more plentiful though non-fissionable form of uranium and converts it into plutonium. This fissionable by-product can be used as fuel in other breeders. But then there is still the problem of fission wastes being highly radioactive and extremely difficult to store or dispose of.

Probably the most exciting future possibility is harnessing of the energy source of stars—nuclear fusion. The principle behind it is that when light atoms like deuterium are made to collide at very high temperatures, their nuclei combine to form heavier atoms. This process releases tremendous amounts of energy. Thus in a controlled thermonuclear power plant, which is a power plant built around a fusion reactor, the energy released from the fusion reaction would be recovered as heat and converted through steam into electricity. The raw material deuterium is plentifully available in sea-water. But there is still a long way to go before this process becomes feasible. Very optimistic scientists are shooting for the turn of the century.

The magneto-hydrodynamics generator (MHD) is a future power source for which Indian scientists have produced a design based on the one worked out by their Soviet counterparts. MHD promises to produce power from fossil fuels that will be five to 20 per cent cheaper than thermal power and also will be less polluting. It creates an electric current by passing a stream of hot ionised gas at high speed through a powerful magnetic field.

People all over the world are working to make use of solar energy. When one realises that the sun bathes the earth with about 100,000,000 kw of light energy each moment one begins to wonder why we cannot utilise some of this energy. The trouble is that this is a very diffused form of energy and has to be concentrated before it can be put to any practical use. So far solar energy has been used only for heating water and generating electricity for spacecraft—nothing on an industrial scale.

Then there are the eternal energy sources such as the tides and geysers. Geothermal power utilises the underground reservoirs of steam and hot water. For instance, the geysers in California drive turbo-generators that produce roughly 40 per cent of San Francisco's total electricity requirements.

And so on to the wayward wind. Our ancestors used this unseen force to do their work. There are still a number of windmills, standing as forlorn showpieces of a bygone era. But the earth's winds are considered too irregular to serve as a major power source.

An overview

It would be simplistic to think that technology by itself can produce a magical solution to man's problems. The energy crisis involves an unholy maze of inter-related political, economic, social and technological factors. The only thing definite, at least for the foreseeable future, is that we are going to require energy on an unprecedented scale. Those who fondly believe that man can all of a sudden achieve a decrease in total energy demand are being naïve. Even if the world's population control effort is successful we are going to have a significant increase in population over the next few decades. The basic energy demands of these increased numbers will be enormous.

True, energy conservation can go a long way towards relieving shortages. Already, recycling of materials in industry is achieving substantial savings. But, man will have to go further than that. We will have to have changes in our attitudes life styles.

Being a controversial question, the energy crisis invites a wide variety of opinions. There are those who believe that this is not much of a crisis after all. Man will find substitute materials for the diminishing fossil-fuels and that well-tried law of economics will work wherein if a commodity becomes more expensive then it encourages producers to increase supplies at the same time pressuring consumers to cut down their demand for it. Whatever be the truth in this complex situation, a hot debate is on.

There is one unifying thread that runs through this diverse fabric. The energy crisis affects all mankind, so that the 'oneness' that ecologists have been trying to stress, and the concept of all men being co-passengers on Spaceship Earth are not merely philosophical or sentimental ideas. Mrs. Indira Gandhi meant quite the same thing when she said at Stockholm, "Life is one, and the world is one". Being caught up in this "web of life", where what happens in one part of the system affects other parts, we have to seek collective solutions to all our problems, not the least of which is the energy crisis.

But since we are only human, controversy will always rage, with sweeping pronouncements from people of all points of view. The situation is serious, of that there is little doubt. But when one hears profound statements being made beginning with the words: "If present trends continue, we are headed for doom...", then one must take them with large pinches of salt, since one of the chief lessons of history is that present trends are only for the present. Man is an ingenious animal. His ingenuity has carried him through many crises in his evolution. May be just a few decades from now, he will have made energy such a clean, freely available commodity that he will laugh when he thinks of the time people thought there was an impending energy crisis.

Suggestions for Further Reading

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2. Energy and Economy of Nations: W.G. Jensen.
3. New Scientist, 4th Jan. 1973.
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ENVIRONMENTAL EDUCATION – AN URGENT CHALLENGE TO MANKIND

Dr. Jan Cerovsky

Paper presented at the Working Meeting on "Environmental Conservation Education Problems in India", held at Dehra Dun in November, 1969.

In recent years the total deterioration of human environment, in the first place of its natural component, became the most urgent challenge of mankind, being a question not only of its present and future economical, physical, mental and social welfare but also of its survival at all. This problem is clearly one of worldwide importance. The first necessary steps to make human society aware of the totally unpleasant situation and to start immediate improvement has been undertaken by UNESCO (Biosphere Conference, Paris, September 1968 and preparation for MAB international programme 'Man and Biosphere') and further by UN (agreement on UN Conference on Human Environment in 1972). The main reason to hold the UN Conference was expressed briefly but clearly: 'because there is a world environment crisis' (UN General Assembly, 3rd December 1968). A better, wiser use of natural resources, landscape and the environment as a whole, request a basic change of Man's relations with Nature. This is a matter of both practical and ideological approach. The modern 'Man's partnership with Nature' has to be achieved through appropriate education emphasising a real perspective ecological thinking. It has to reach all general public. It's tragic that ecological understanding is not a prerequisite for policy making (Prof. Laumont C. Cole in 'Canadian Audubon', 3015, Dec. 1968, p. 132).
It is necessary to influence the approach to the biological problems that surround us; every community has its difficulties with pollution, sewage disposal, the misuse of pesticides, neglect of parks, unnecessary deforestation and, of course, family planning (Kenneth V. Thimann in Bio-science' 18/12, Dec., 1968, p. 1101). The great challenge to mankind is an appeal for proper education.

In the same way in which the nature conservation movement began to make the public opinion conscious of the modern civilisation's danger for mankind by the impact on its natural environment, conservation education was trying to seek and to outline the principles, methods and forms by which to create an up-to-date 'man's partnership with Nature'. Since 1948 these educational activities are coordinated on a wide international scale by the permanent Commission on Education of the IUCN (International Union for Conservation of Nature and Natural Resources) Therefore because of one year-long experience I would like to explain briefly our main thoughts about environmental education.

What is 'Environmental Education'?

There has been just a lot of research carried out during this century on the problems of change in the human environment and on the techniques for its design and management. So there is the knowledge available, but the application of it is inadequate and slow. There is still insufficient public awareness of the relationship between Man and his environment, arising from inadequacies in our education systems. (Dr T. Pritchard in 'Biological Conservation' 1/1, 1968, p. 27).

By 'Environmental Education' we understand all kinds of education and information which aims at creating the correct approach of Man to his (natural) environment in the sense of conservation, wise use and management.

Although 'ecological thinking' is the basic feature of this correct approach and, consequently, of environmental education, this education by far cannot be only a matter of science and specially, biology teaching. Environmental education focussing on modern conservation of Nature and natural resources and landscape planning and management including not only scientific but also broader cultural, economic, hygienic, aesthetic and ethic aspects is an essential part of general civic, moral and liberal education. By its ideology it has to determine Man's philosophy concerning his relationship to Nature and landscape as well as his role in society, living in this Nature and landscape and using them as the basic component of its whole environment. As practical instruction it has to influence and even to correct Man's behaviour in the wise use of his environment providing him with basic principles and rules of such behaviour and action. Facing the dangers of many-sided environmental pollution and deterioration in our modern world, this philosophy and rules of acting are of equal importance along with mental and physical hygiene, being in fact also a compound of it, because Man himself is the most valuable and at the same time the most powerful resource of the Biosphere.

Concept and Function of Environmental Education

A short concept of environmental education was compiled by the Education Commission of the Unesco Biosphere Conference. It is presented in the following paragraphs:

(i) The critical problems of the biosphere urgently require the development of environmental education to form an attitude of man and his society towards the biosphere in the sense of rational use and conservation of natural resources and the unity of the landscape.

(ii) The basic principles of environmental ducation, interpreted according to possible levels and purposes, should be: to maintain and wherever possible to enhance the economic and social capital of the biosphere; to provide an integrated scientific approach to the planning, management and development of the environment as a unit in space and time; to seek man's personal fulfilment in partnership with Nature through and with natural forces: and to develop a policy of trusteeship for posterity.

(iii) Environmental education is required in different depths, according to the level of education being provided and the objectives being pursued, and should reach: specialists in different occupations dealing with both biosphere management and education in order to fulfil effectively the principles set out above: adults in order to guide children and young people, to develop criteria by which they can judge policies and practices affecting their environment and, generally to enrich their lives; and children and young people, as part of a scientific and liberal education, to enable them to enjoy the environment and use it wisely.

(iv) All available media should be employed in an integrated as well as continuous and sustained programme of education and information about the environment. Each country should have a council, centre or similar institution for environmental education and these activities should be coordinated on an international scale.'

The function of environmental education can be more readily seen and appreciated if the groups of people are considered who will make an impact on the environment and who have to be educated and trained properly in the light of their role in society (quoted from Dr. Pritchard's article on page 2 of this report):

(i) Firstly there are those who will embark on a career in the earth and life sciences, including biologists, geographers, geologists and agricultural and forest scientists, as well as farmers and foresters.

(ii) Secondly, there are those who, as planners, landscape designers, architects, civil engineers and the like, will deal with the design, construction, and control, of projects affecting the environment.

(iii) Thirdly, these are those destined to become physicists, chemists, and technologists, whose research and development work may severely affect the environment.

(iv) Fourthly, there will be the future statesmen, public servants, and other leaders who will locally, nationally, or internationally formulate policies and authorise actions having far-reaching effects on the environment.

(v) The fifth group and probably the most important in the long term, will be those who, as the educationalists of the future will have the task of interpreting knowledge to young people.

(vi) The last group includes those who, without any direct professional involvement should have sufficient interest to form a collective voice which will influence those in the previous categories.

System of Environmental Education

The environmental education, in order to be effective, has to be carried out as a united education system including both children and youth as well as adults, formal education at all levels (pre-school, primary and secondary schools, high schools, colleges and universities, post-graduate studies), out-of-school education and activities and all sort of information, and all this must be well integrated within the general education systems. Environmental education is not to be considered as a specialised matter of science education only as it provides some important general educational benefits which shall be pointed out in the following paragraphs.

Environmental education at its present development stage does not exist as a necessary, integrated, continuous and sustained programme. The elements of it occur in science, especially biology teaching, are developing at some universities (special chairs and institutes), within the activities of some youth and adults voluntary organisations and promoted by some mass-media. In general however, there is a lack of proper integration.

However important it is to have an integrated environmental education system, there exist some items of it which deserve the highest priority. This should be given to teachers' and other educators' training and further (post-graduate) education, to the role of ecology and creative conservation in university training of technologists (engineers), sociologists, economists and politicians and to the out-of-school education and activities of children and youth.

Pre-School Level

From his first day, the formative young child has to make the first acquaintance with his environment, with other living organisms, earth, water, air, weather etc., and to learn how to enjoy and protect it. The education merely through the parents with increasing role of kindergarten has to form a sensitive approach to the environment, its beauties and importance for Man. Also the role of picture-magazines and TV should not be neglected.

More studies on child psychology, mental development and best educational methods are still needed. The effort of education at that age, depend in the first place on the education of parents and on the training of creche and kindergarten staff.

Primary and Secondary School

The main 'environmental subject' at primary and secondary school levels is Nature History and Biology. In many countries environmental and conservation education at that level is being considered as one of the principal educational tasks of science and especially biology teaching. The approach and space given to environmental education in school-curricula and textbooks, however, usually does not correspond with the promoted importance of it and with actual needs. The curricula and textbooks remain overloaded with morphology and description of classes, families genus and species, but try to be up-to-date by emphasising genetics and molecular biology. Generally, they are neglecting ecology which is yet the principal means of environmental education.

There is an urgent need for revising the school curricula and textbooks in science and especially biology teaching. Environmental education should penetrate all this teaching, illustrating by examples the applicability of science to the improvement of Man's life and through this approach at the same time giving a sound appreciation of science and better understanding of its principles.

In view of the broad interdisciplinary character of environmental science also the environmental education can embrace not only simple biology and earth science but also chemistry and physics, mathematics, history, arts and literature into which he has got to infiltrate. In many countries a good unity of approach is imaginatively taught at the primary school level. It appears much more difficult to maintain it at the secondary school level, where even biology frequently becomes separated into more specialised compartments. One of the necessary features of that united approach must be to overcome the existing discrepancy between science and technology, between naturalists and engineers. Not only technology with its modern concerns, but also biology especially from the ecological angle, discovering the life cycles and chain of events and changes within the ecosystems, is a real adventure of discovery. Both of them have today their important role in design and management of the natural environment and the top goal of a harmonic, well-balanced, and wisely used landscape.

Besides new textbooks which fully respect and include principles of environmental education, there is an urgent need for all kinds of other audio-visual teaching aids. Formal teaching in school has to be completed and supported by conducting simple experiments, field excursions and observations and other forms of semi-out-of school and out-of-school educational activities (such as competitions, camps, expeditions etc.).

The key personalities in environmental education at this level are the teachers. Therefore the environmental education with a special view to its methodology has to be included in teacher training programmes as an obligatory course, a general one for primary school teachers and secondary school teachers in non-science subjects and an advanced one for secondary school teachers in biology and earth science. The course should also contain field observations, studies and practical conservation training. Weekend and summer sessions, workshops, special lectures and courses, excursions, field studies etc., in environmental education for teachers should be organised within their post-graduate training.

High School and University Teaching and Training

There are many special technical high schools training engineering specialists of middle-rank qualification, such as agriculturalists, foresters, builders, geologists etc. The training programme is split into specialised subjects (courses) which hardly give them a correct approach to the environment, in order to take environmental problems and interactions into consideration. Therefore, sociology has to be introduced as an obligatory subject in most schools of that type and level or at least given the utmost possible attention and care within other appropriate subjects.

During recent years environmental education has developed in some countries through the introduction of new courses, post-graduate study programmes, diploma and degrees in environmental science, integrating ecological thinking into other courses through lectures, seminars and excursions, establishing special university chairs and institutes. This development should be encouraged while emphasising the inter-disciplinary character of environmental education. There is still a strong need for suitable teaching and training techniques, textbooks and audio-visual aids. Universities dealing with social sciences and publicity relations (adult education, out-of-school education, leisure-time use, journalism etc.) should develop research projects on methodology of environmental education among the general public.

Out-of-School Education of Youth

In the dialogue between youth and adults, there are more and more questions emerging, of bad approach of the past and present generation towards the environment (heavy criticism of pollution and deterioration of all kind, protest-songs concerning this subject etc.). Young people request immediate action, are ready to serve it and in many cases are developing their own initiative. This should be encouraged and interest among broader masses of youngsters stimulated through:

(a) Support to already existing youth clubs and societies specialised in environmental studies and activities (national and local young nature-friends, naturalists, scientists, biologists, farmers, hikers etc., organisations) through funds and advice and establishing new ones of that pattern.

(b) Introducing environmental studies and activities in a proper way into the programmes of other youth organisations, such as boy-scouts, girl-guides, young tourists, hikers, mountain-climbers, students, working youth, countryside inhabitants, Red-Cross, etc.

(c) Giving proper publicity to environmental problems in youth journals, magazines and all other kinds of literature, broadcast and TV programmes, using the suitable mass media as organisers of these activities.

It is not difficult to awaken interest in environmental problems among the young generation. It seems to be much more difficult to keep the interest developing by providing funds and tasks for real activities. Young people ask to be involved in concrete action which while improving their knowledge at the same time makes them useful to society. They themselves wish even at their age to be able to take over their share in the general responsibility for human environment and not to be only instructed in a—what to them it seems to be-rather abstract and theoretical way on the environment. This can be reached through organising studies, excursions, expeditions, camps, workshops and training seminars, work-camps like 'conservation corps', assistance at afforestation, landscape management and use, public-relations campaigns, etc., not only on local and national, but also international levels, because of the attractiveness of international exchange and travelling possibilities for young people. The environmental studies and activities must become a real adventure to young people.

This out-of-school education of youth is of great importance for the future and even present situation of our environment. Its profit can be expressed in three main points:

(a) General education, i.e. erecting of a correct attitude of the future generation towards environment;

(b) Search for and training of future specialists in environmental studies and management of environment;

(c) Immediate efforts in improvement of environment (working camps, conservation corps, youth research projects, information campaigns).

Furthermore, in this component of education we also find some very important general educational features. These will be especially:

(a) interesting and advantageous use of leisure by young people;

(b) education for self-conducted and devoted service of the general public;

(c) education for international mutual understanding and for peace.

(Dr J. Gerovsky: International Youth Cooperation in Field of Nature Conservation. Paper presented at 'Vere in Naturschutzpark European Conservation Conference, Stuttgart, May, 1969).

The out-of-school environmental education of youth deserves a high degree of priority. It enables young people to act, it involves the enthusiastic young generation not infected by older people's scepticism, the generation which will have to use and manage the environment wisely, at the same time enjoying it thoroughly.

Out-of-School Education of Adults

Out-of-school environmental education of adults is being provided by voluntary organisations and foundations which in some countries seem to play quite an important role. They are organisations—

(a) dealing with environmental studies and management as a whole;

(b) concerned with some special component of environmental studies and management (fishery, forestry, game, management, nature study, protection and conservation, gathering, planting trees and shrubs etc.);

(c) paying attention to environment within broader activities (tourists, hikers, technologists, writers, journalists etc., this group including also some general bodies, such as trade-unions, youth associations and even political parties). All these educational activities and efforts are to be encouraged and developed.

A very broad and important field for environmental education has been opened by growing potential of working man's leisure time which quite a lot of people try to spend in Nature. The many sided problems of recreation are becoming very urgent and topical ones at the present time. It may be said that the modern member of the human society bored and tired both mentally and physically because of the negative influence of urban and industrial explosion is seeking through recreation his new partnership with Nature. This is quite a valuable coin, but as usually a two-sided one, one side being the newly awakened man's interest in and understanding for the natural environment, the other one however a negative impact of man through recreational activities in his natural environment, especially vast and even small protected territories, beautiful natural areas, mountains and sea-shores. Therefore, the environmental education has two main tasks and at the same time stages in this context:

(a) to prevent the damage caused to environment by people through their unconscious bad behaviour in Nature during their recreation.

(b) to strengthen their knowledge and understanding of the environment and its needs.

All this education must be carried out in attractive and interesting ways, presenting to, general public the adventure of discovering knowledge, not annoying it by forbidding and boring instructions.

Information

An accessible mass-media, cultural and lecturing centres and clubs of adults' out-of-school education have to be used in the continuous and sustained programme of dissemination of information, knowledge and understanding concerning environment. These efforts should be aimed at creating powerful public opinion on environmental problems which should be one of the most important means to influence all those who actually decide and act in the management of our environment.

The Need for International Cooperation

It has become quite clear that the problems of environment have to be solved not only on national but also on worldwide level, because the environment is a matter of the whole mankind and it does not know any frontiers. The environmental education is an international matter too, for this reason it must be coordinated internationally with much more intensive care than usually given to international cooperation in other fields of education and sciences.

AEROSOLS AND OZONE : HOW REAL IS THE THREAT?

Roy Herbert

There are fears that the ozone layer, high in the stratosphere, is under threat from man-made chemicals and will no longer shield us against harmful radiation as efficiently as in the past. But there is a lot yet to be learned about the atmosphere, for it is a bewilderingly complex reaction vessel. One thing is clear, that any pronouncements about stratospheric ozone should include plenty of provisos.

The Victorians thought highly of Ozone. They went down to the seaside and inhaled deeply, expanding their lungs as far as they would go. Ozone, according to popular belief at the time, could be smelt in the sea air (it was probably the difference between the clean air of the seaside and the polluted air of the towns) and it was supposed to do you good in some indeterminate fashion. The Victorians were right, but not in the way they thought. Ozone was certainly doing them good and every one else, too. It is doing us good now. It has always done so. So fundamental is ozone to us that life could not have developed on earth without it. But it does not do its job at the seaside or in the air we breathe. Ozone is working for us high above the earth's surface, in the stratosphere.

One of the many characteristics that distinguish man from the rest of creation in his ability to change his environment, for good or ill. In recent years there has been a theory that he was, almost inadvertently, changing it for the worse and moreover, at the level of the stratosphere, where damage would be irreversible. That meant that the ozone on which we depend would be affected, with consequences that would be bad and could be catastrophic. For, to come to the point of all this, ozone forms a layer at high altitude that protects us from harmful radiation from the Sun. It was in danger because we had begun to use certain chemicals in such quantity that they were getting up into the stratosphere and starting a process there that threatened to destroy the ozone shield.

Most of us have used the chemicals concerned. Squirting our shaving cream or hairspray, aiming insecticide sprays at flies, painting with a can instead of a brush, we were all, according to some authorities, taking part in destroying our own protection. We were doing the same thing in using refrigerators. We were helping the destruction by sitting on foam cushions and using foamed plastics in the other hundred ways that we do. All these products use chemicals called chlorofluorocarbons.

Villains in Disguise

CFCs, as they are called for short, were discovered in the USA. There is a range of them, but they all have fluorine, chlorine, hydrogen and carbon atoms in their molecules. First of all they were used as refrigerants because they are neither poisonous nor flammable, as their predecessors were. During the Second World War they proved their efficiency as propellants in aerosols and more recently, as agents for foam-blowing to make the familiar light, resilient plastics. Two of them, known as F11 and F12, are ideal materials. They are chemically stable and fairly cheap to make. F12 has a low boiling point of -30^0 C and F11 has a higher one of 24^0 C. By juggling the proportions of the two it is possible to produce propellants specially fitted to practically any requirement. These two CFCs are by far the most important of the range and industry the world over had made them in quantity for years. In 1974, annual production had reached about 475,000 tonnes for F12 and nearly 400,000 tonnes for F11. After that there was a sudden drop. It was the year of the dawning suspicion that CFCs might be villains in disguise.

The stratosphere is the layer of the atmosphere above the troposphere, which can loosely be termed the air we breathe. In the stratosphere, the atmosphere is tenuous. It contains nitrogen and oxygen, as does our breathing air, but some of the oxygen instead of being in the usual two-atom form, has molecules of three atoms; that is ozone. The amounts of it are small, around five or ten parts per million of the already thin air. Moreover, the stratosphere is not a definite section, like the layer of a cake. It extends from about 15 to 50 kilometers above the earth's surface and its height varies from the Poles to the Equator. Nevertheless, there is enough ozone in this fluctuating region to protect us from the Sun. In addition to the energy we know as heat and sunshine, the sun pours out radiation at other frequencies, including ultra-violet. Ultra-violet is harmful to life; there is, for instance, a well-recognised connection between it and cancer. The ozonosphere, as some like to call it, absorbs the ultra-violet, so it is essential to us and clearly should be inviolate from man himself.

It appeared some years ago, though, that man was about to damage it. The concentration of ozone in the stratosphere depends on the amounts of other trace gases there, including oxides of nitrogen. Exhaust gases from supersonic aircraft contains quantities of them and if fleets of these machines were going to fly in the lower atmosphere, as once predicted, then ozone would be destroyed and far more ultra-violet would get through to the ground. The fleets of supersonic aircraft did not materialise and the threat vanished, but it has alerted everyone to the subtlety and sensitivity of the stratosphere.

Long Life

Early on, manufacturers of CFCs had realised that the fate of their products in the atmosphere was important. Their very stability made them obvious subjects for investigation. In 1972 an international panel was set up and work carried out by it suggested that the concentration of the two CFCs in the atmosphere had risen at a rate that could be linked to their manufacture and release. That could mean that they had a long life in the atmosphere.

The stage was set for the revelations of two US researchers, Professor F.S. Rowland and Dr. M.J. Molina of the University of California. They published their theory (which was based partly on information that the manufacturers had provided) that CFCs were not broken down at all in the atmosphere. Neither was their 'sink' for them there. What happened they said, was that the CFCs rose higher and into the stratosphere. There they were decomposed by radiation from the Sun. Chlorine atoms were liberated by this and started chemical processes that destroyed ozone. There was very little chance of the stratosphere being able to cleanse itself of the chlorine. The only process that would do this was one in which chlorine combined with hydrogen from naturally occurring methane, to form hydrogen chloride that fell lower and was eventually rained out. But it could not remove much.

To reach their conclusions, the two scientists had to simulate the stratosphere and the troposphere and the way they interacted. They did this in the normal way, by using a mathematical 'model'. They said, forecasting from results they got with the model, that if CFCs were made and used on the scale they had been, the ozone in the stratosphere would have fallen by about one-sixth in twenty or thirty years. That would mean an increase in ultra-violet and an increase in skin cancers at the least. They said also that no important stratospheric process had been left out of their calculations. The right thing to do was to ban all use of F11 and F12 at once unless it was absolutely essential. It had to be done at once because the stratosphere reacted so slowly that any action taken to correct the situation, if delayed, would make no difference.

There was uproar, the US government started to form regulations on the use of CFCs in aerosols. Lobbies sprang up for and against the theory. It was, obviously, not one that could be dismissed out of hand by responsible authorities, but many people in industry and research organisations thought that a harder look at the complicated region of the stratosphere and what went on there was justified and that there was some weighty criticism that could be made of the hypothesis.

Programmes of Research

In general, the critics said that there were not enough facts to go on. What we did know about the subject was inconclusive. It was impossible, they said, to be so firm when the mathematical model was too simple to reflect the real conditions, and it was equally impossible when only CFCs had been considered. Naturally, this did not prove that Rowland and Molina were necessarily wrong. The only answer was to find out more. So programmes of research in many countries began, under various bodies, for instance through the European Community and the UN Environment Programme, and in national and industrial laboratories. Still continuing, they involve measurement in the stratosphere by rocket, aircraft and balloon, ground measurements, and laboratory experiments in which the chemistry of the stratosphere is reproduced.

All this work has gone to show that the critics were right in being cautious. A scientific meeting on the subject held at Brighton, in the South of England, in October 1978, was in no doubt that the danger to the ozone layer had been much exaggerated. Before that meeting, which reported research results in many areas and highlighted, too, the risks in relying on instrumental performance to reach conclusions, it had become plain that the stratosphere is a bewilderingly complex reaction vessel.

There is certainly a chlorine cycle there which can destroy ozone, but it has been the chlorine coming from methyl chloride, entirely natural in origin. Though CFCs are reaching the stratosphere, it is far from clear that they have any effect on it. There seems to be fairly strong evidence that, despite Rowland and Molina, there is a sink in the troposphere for CFCs, for they are absorbed on dust particles and broken down by the action of light. That there are knotty problems to unravel is shown by the fact that measurements have revealed the presence of some chemicals, produced in the chlorine breakdown of ozone, in eight times the predicted amount. Yet there is no reduction in the amount of ozone in the stratosphere to correspond. One of the outstanding points discovered is that far from there being a reduction in the amount of stratospheric ozone in the twenty years up to 1977, there has been an increase. It is evident from all this that mathematical models of the churning, reacting stratosphere are a long way from identity with it. They cannot now reflect an accurate picture of what is going on and it follows that they are even less valuable as a basis for predicting what conditions will be like at the end of this century and beyond.

The Brighton meeting emphasised this. One British scientist, Professor Jim Lovelock, called analysis into question, remarking that there were serious difficulties in calibrating the gas chromatographs used. He quoted as evidence the enormously different results obtained when identical samples of air containing F11 and F12 in concentrations found in the atmosphere now were sent to different laboratories. Professor Lovelock, who is concerned with the lower levels of the atmosphere, also drew attention to the fact that huge amounts of methyl chloride are produced naturally; forest fires, for example, produce as much as ten times the amounts attributed to CFCs.

Provisos

There may very well be a process by which the stratosphere renews its own ozone. If it loses ozone in the higher levels, then it may be replaced in the lower, because the very action of ultra-violet reaching there would encourage photochemical reactions that could produce ozone. Whatever else it may have shown; the Brighton meeting made it clear that any pronouncements about ozone in the stratosphere should be made with plenty of provisos and precautions.

That, however, does not absolve manufacturers and users from the duty to see that if it is finally thought desirable, there are alternatives to CFCs and that is a hard goal to aim at. ICI, the largest manufacturer of CFCs in Europe, says that it is rather like being asked to invent another wheel. The properties of CFCs are little short of ideal and to find substitutes that will do the same job, be just as harmless and be proved to have no effect on ozone and be cheap to make is a daunting job for chemists and chemical engineers. But the firm has a large-scale screening programme under way, much of its effort being spent, necessarily, on checking toxicity. It takes years to sort this out, and, though only really promising materials would go through the whole gamut of tests, it is expensive, too, costing more than £ 250,000 sterling for a single compound. Substitutes have been found, about six of them after sixty possibilities were narrowed down. It is unlikely just the same that any will be found that will take the place of F11 and F12 directly; only one thing is sure —they will be more expensive to produce and to use. They may not, of course, ever be needed, for the present evidence and opinion supports the view that it would be wrong to ban CFCs. And, fortunately for our peace of mind, that there has been no frightening damage to the ozonosphere and there is not likely to be.

Courtesy: Spectrum

THE SOCIAL RESPONSIBILITY OF THE CHEMISTRY TEACHER

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The last two decades have seen the development worldwide of many new chemistry curricula for the secondary level, nearly all of which have been characterised by an increased academic—and even esoteric—content. The same period has witnessed a relative decrease in students, especially the more able ones, taking chemistry degrees in many countries. It is my contention that this is an example of cause and effect and that to motivate more able students to consider courses and careers in chemistry, it is necessary at the secondary level that chemistry should be seen to have relevance to the students.

What then does the modern student see as relevant? The burning issues seem to be pollution, environmental conservation and social awareness, and successful chemistry teaching must therefore enable students to see connections between the subject-matter and social concerns. In addition to what students see as relevant it is in any case an important part of our task to develop a sense of social responsibility in our pupils and to produce citizens and consumers who are aware of the pros and the cons relating to scientific developments so that they can make rational decisions in the face of the conflicting barrage of opinions presented by the media. Several attempts have now been made in various countries to take examples of the significance of chemistry and to show how by a consideration of health, well-being, sociological, economic, geographic and related factors chemistry itself takes on more meaning to the able and concerned pupil.

Overall Acceptability

In the June 1979 issue of *School Science Review,* there is a very relevant article by W.G. Burtons[1] in which he suggests that pupils should be asked to identify all factors relevant to a particular case study and to categorise them into social and political, industrial and economic, environmental and personal. Each factor is then evaluated on a scale as shown:

10	factor highly acceptable
8	region of intermediate acceptability
6	
4	
2	factor does not contribute to situation or contribution is balanced between acceptable and unacceptable
0	
–2	
–4	
–6	region of intermediate unacceptability
–8	factor highly unacceptable
–10	

After the evaluation, a summation is made. A positive result suggests overall acceptability whilst a negative one indicates an unacceptable situation.

Case Studies

He then outlines three useful case studies: the "poisoning of Michigan" in which 1000 Kg of polybrominated biphenyls accidentally got into animal feed; "Minamata 'Disease'" as a result of mercury poisoning and "The Seveso story" in which 1500 Kg of tricholorophenol and 2.5 kg of 2, 3, 7, 8 - tetrachlorodibenzo-p-dioxin (TCDD) were accidentally discharged to the atmosphere. For each case study some of the relevant factors are listed; for example, some factors relevant to the Seveso incident are:

Social and political

Seveso has become an undesirable place to live.

Community life has been disrupted by evacuation of residents and the presence of guards.

The incident may have affected the passage of a sensitive abortion bill through the Italian Parliament.

The incident may have affected the balance of power in local government.

The herbicide has found a use in warfare.

Industrial and economic

The factory provided employment.

2, 4, 5-T has helped farmers combat weeds.

Medical treatment for the victims has been expensive.

Compensation to victims will be expensive.

The cost of decontamination will be high.

Environmental and personal

A large area of land has been destroyed.

Local people have lost pets and livestock.

People may go through life feeling less well than they should because of TCDD.

What is it like to grow up with a face disfigured by chloracne? A family may produce and have to bring up a deformed child. A woman may have to face the prospect of having an abortion or producing a deformed baby.

The major failing of these examples seems to be that, even if pupils evaluate the factors and give a final positive rating, the negative aspects of chemical industry are given undue prominence by selecting accidents for detailed study. After all, accidents are the exceptions rather than the rule and we should perhaps concentrate more on the norms of industry, although affording due mention of problems encountered.

Coincidentally the same issue of the *School Science Review* give an account more on these lines in an article by S.D. Rust[2] entitled "Soaps and Detergents—a 'social' treatment". In this he outlines how one could tackle this theme historically and in terms of scientific developments and associated improvements in pollution control; pupil experiments are included in his approach, which concluded with a discussion of concerned for the environment caused by the inclusion of phosphorus and boron compounds in modern detergent formulations—a good example of where social responsibility and an ability to evaluate the advantages versus the disadvantages is important.

Industrial Case Study

An interesting industrial case study is provided by the production of ethanol by fermentation of molasses. The latter contains about 50 per cent sugar and can be fermented in the well-known way using the yeast *Sacharomyces cerevisiae* to yield a solution containing 11 per cent ethanol at a conversion efficiency of about 80 per cent. This solution if subsequently concentrated by distillation a 'slop' containing 13 per cent solids by mass is left behind. One can build a discussion around this process in which the economic value to the sugar industry is highlighted, together with the socio-economic implications of transporting the molasses and other raw materials to the site of the factory and the industrial uses and social problems associated with the end-product. An obviously important by-product is the carbon dioxide produced in large quantities and used *inter alia* in the soft drink industry and as a refrigerant: in this latter context it is used for keeping miners cool whilst working underground. In South Africa, for example, this provides a link with a very important economic base of the country.

Ecological Effects

However, what is perhaps more interesting is what happens to the 'slop'. In South Africa, disposal as liquid effluent into a local river was entirely ruled out by local regulation—and rightly so as the biological oxygen demand of such material is naturally extremely high. Attempts were made to burn the material but the resultant smoke and smell were unacceptable and the company was thus compelled to find a use for it. The solution was found in spray drying the material and later adding to the product maize meal gluten, wheat bran, mono-calcium phosphate urea and salt. Under the trade name of 'Rumevite' this material has shown promise of revolutionising the beef industry by preventing the loss in mass and condition of animals during winter feeding and formulation plants are now also operating in the UK, Australia, Venezuela and Zimbabwe. In contrast the Brazilians have recently begun to operate a similar plant and are disposing off their 'slop' direct into the local river with catastrophic ecological effects.

There are some more interesting case histories in 'Chemical Industry: Social and Economic Aspects' by F.R. Bradbury and B.G. Dutton[3] including one of topical interest namely the development of tetraethyl lead as an 'anti-knock' reagent. Curiously this is also taken up by C.B. Hunt[4] in the June 1979 issue of *School Science Review* in an article entitled 'Chemistry and the Internal Combustion Engine'. Here the author sets out ultimately to describe some chemical aspects of the internal combustion engine, to view some developments in their historical and social contexts and to illustrate the compromises resulting from the interplay of technological and socio-economic factors.

Food Availability: a problem

An aspect of chemistry which could well be given more attention in schools is the potential for good which it holds; many pupils might be awakened to the fascination of the subject if they could see more clearly the fields in which they might be able to make socially significant discoveries: currently, world population is doubling every thirty years, thus producing a problem of food availability—a problem not unknown in India. Chemistry might contribute to the solution of this problem by improving birth control methods, by supplementing food resources either by producing new feeds, or by developing new fertilisers and by finding chemical ways of slowing down or stopping bio-deterioration. According to Bradbury and Dutton, annual losses due to fungi equal to two per cent of the whole industrial output of North America and Western Europe, whilst the rodent population of the USA consumes or damages food equivalent to $9 per worker (1972 prices); a second field pregnant with potential is that of biologically acceptable methods of disposal of cartons of various types but especially those made of plastics, whilst environmental control by techniques such as chemical seeding of clouds still needs much development work.

Perhaps the principles incorporated into high school syllabi could be illustrated with examples from the field of pharmaceuticals and issues such as drug use and abuse could be stressed. Overriding all other areas of concern must surely be that of energy and it must be part of the chemistry teacher's job to make pupils aware both of the magnitude of the problem and of the social consequences of not solving it. An awareness of the importance of petroleum as a chemical feedstock compared with the extravagance of using much of it purely for travel needs is to be emphasised—especially in the USA judging from published information—whilst the public should be made more aware of alternatives such as the Lurgi process for producing oil from coal as performed so well in South Africa, and the potential of solar, tidal and wind energy. This must be as important a part of a scientific education for the average citizen as, say, a knowledge of atomic orbital shapes as required by so many syllabi in various countries!

Removing Pollutants

Basic chemical ideas and techniques can be linked well with social concern in a consideration of water resources. The shortage of fresh water is acute in many areas of the world and desalination by such methods as electro-dialysis, reverse osmosis and flash distillation is likely to become much more significant in the next decade or two. The chemist is also called on to devise ways of removing pollutants from effluent water such that it will have no significant detrimental effect on plant and animal life and to ensure the satisfactory condition of recycled water. Typical consent conditions for discharge into streams are:

Constituent	Maximum allowed (mg 1-1)
Biological oxygen demand	20
Suspended solids	30
Sulphide (as S)	1
Cyanide (as CN)	0.1
As, Cd, Cr, Cu, Pb, Ni, Zn, individually or in total	1
Free chlorine	0.5
Oils and greases	10
pH	5-7
Temperature	30^0C

These provide a challenge both to the chemist controlling discharge and to the analyst monitoring such discharges.

More Awareness

In essence therefore, my message is simple; the chemistry teacher must himself or herself be aware of areas in which colleagues have to make decisions with social consequences and must instill in pupils the need for thoughtful appraisal of the soil effects—both positive and negative—of chemical advances. Pupils who can accept this more challenging approach to chemistry will, in my view, ultimately get more satisfaction from their studies and wish to take up the practice of chemistry as a career.

We also need to think again whether it is ultimately in our pupils' best interests to study the various sciences, and indeed other related subjects, in isolation from each other. The examples I have given only make sense when discussed in a broad interdisciplinary context and perhaps we should really be covering many traditional disciplines under the one subject of environmental science.

Making Chemistry more Relevant

There are now many materials available to help teachers make their chemistry more relevant. These sometimes take the form of practical projects as described by Daniels and Tomlinson[5] or as simulations and case studies of which several now exist, or as games which combine chemistry and industrial issues. Surely suitable subjects for such material would be both Sindri and Tata, although before materials of this type will be freely used in school, teachers will need an assurance that examination questions will reflect the philosophy outlined above. This has now happened in the UK and I conclude this article by quoting a question posed by an English examining Board.

The following map is of a fictitious island, Jumb, which lies some 350 km south-east of a friendly industrial state, Terania.

Jumb is scenically attractive with a craggy coast indented by many small bays with sandy beaches. The area of limestone hills has a small region of spectacular caverns. In the north, the swamp region harbours several species of plants which grow nowhere else in the world together with a population of small reptiles which are uniquely adapted to the specific environment. During July and August many Teranians visit Jumb for their holidays and visitors are beginning to come from other parts of the world. The eastern coast and the adjacent hills are becoming particularly popular with tourists.

The population of Jumb is 140,000, with the towns marked on the map housing almost all the people. Coastal fishing was a major industry but in recent years the catches have decreased to a point at which only a small amount of subsistence fishing is carried out. There are small manufacturing industries in each of the towns providing for the consumer needs of the population, but, apart from coal-mining, main employment is seasonal agriculture and tourism. The deposit of sulphur-containing iron ore in the south-east of the island has only recently been discovered and the government of Jumb is anxious to develop a steel industry because

Scale 1 : 500 000

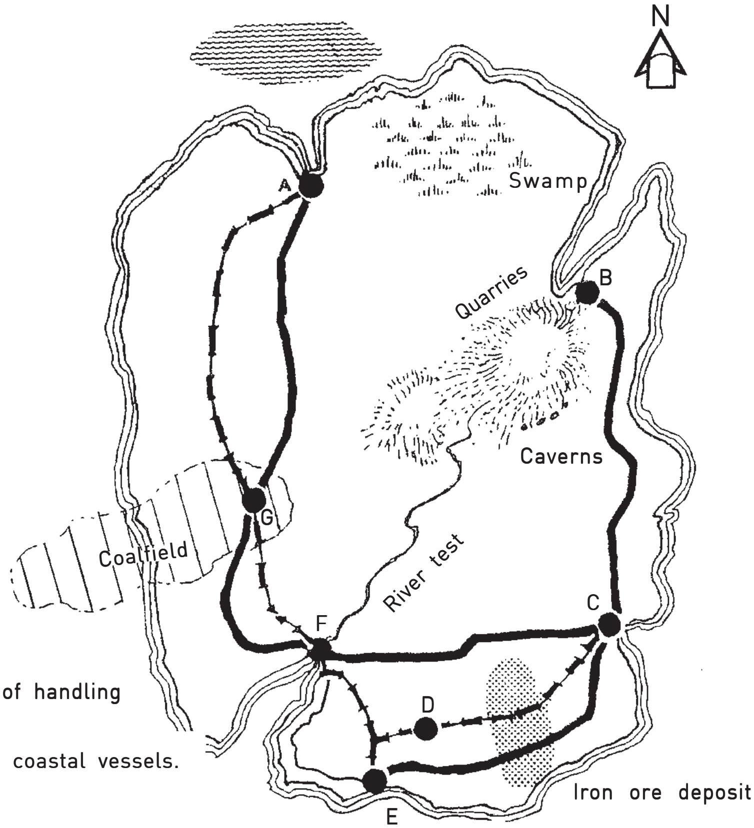
Key

Existing main roads

Existing railways

• Towns

A	15 000 population
B	22 000 population
C	15 000 population
D	10 000 population
E	10 000 population
F	10 000 population
G	22 000 population



Town A is the only port capable of handling large ocean-going ships.
Towns B and F can handle small coastal vessels.

Terania is willing to buy all the steel which Jumb can export. Such a development could provide additional employment in steel production and result in the development of light industries.

(a) Explain where you would recommend the construction of a steel works employing 4,000 men. Give reasons for your recommendation and state why you would prefer your site to others which might be alternatives.

(b) Suggest what pollution problems might arise from the development of a steel industry and discuss ways in which the dangers could be reduced. (1) Give special attention to measures which could be taken to preserve the island's amenities for the development of tourism.

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TEACHING HYDROGEN BONDING : A NEW APPROACH

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While dealing with school science teaching, sometimes we are placed in a very embarrassing position because we do not have any model or demonstration to make the lesson interesting. Under these circumstances we should try to correlate teaching with environment. In this article an attempt has been made to motivate teachers of chemistry to teach hydrogen bonding at the +2 level through environment.

Hydrogen Bonding – How Much it Concerns us

Man, the elemental component of society, is a product of environment and heredity. Environment means our surroundings, the climate, the kind of house we live in, the type of food we eat, the type of clothes we wear, and other articles of daily use which concern us. Heredity decides the kind of person we are likely to become, but the combined influence of heredity and environment acting together decides what we actually do become. The everlasting aspect of both these factors from the chemist's point of view is that these make use of hydrogen bonding.

What is an Hydrogen Bond?

When a hydrogen atom is attached to a highly electronegative atom, A, the electrons A-H bond are found more towards the electronegative atom. The strong positive charge of the hydrogen nucleus is then attracted by the lone pair of electrons of the electronegative atom of the same or a different molecule, resulting in the formation of a hydrogen bond:

A — — H — — — B

A and B may be same or different electronegative atoms. The broken line indicates the hydrogen bond.

O — — — H — — — O. Example of the same electronegative atoms.

N — — — H — — — O. Example of different electronegative atoms.

Hydrogen Bonding in Ice

The commonest thing in our environment is water, and both the liquid and solid forms of water possess hydrogen bonding. The crystal structure of ice contains an oxygen atom surrounded by four other oxygen atoms through hydrogen atoms in a tetrahedral arrangement as shown in Figure 1.

Water in the liquid form (Fig.1) contains hydrogen bonding with a similar arrangement. This evidently means that only a fraction of the total hydrogen bonding breaks when ice melts and is converted into the liquid form.

How much Hydrogen Bonding is Broken when Ice Melts

We have already discussed that in ice each molecule has a complete set of hydrogen bonds which bind it to four other molecules. Water vapour, on the other hand, behaves as if the molecular units are separated water molecules of 18 amu. This obviously shows that the process of conversion of ice into vapours is a process in which all the hydrogen bonds are broken.

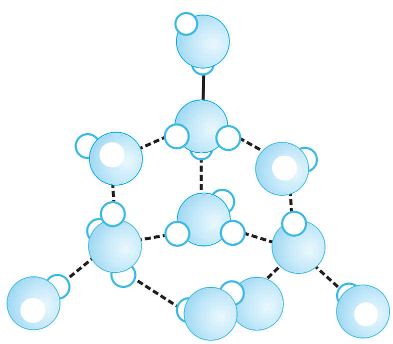

Fig.1: Hydrogen bonding in Water–Shaded sphere: Oxygen atom; Hollow sphere: Hydrogen atom

$CH_{4(s)} \quad CH_{4(g)} \quad \square\ {}_{S}H = 2$kcal/mole

The enthalpy of sublimation is 12 Kcal/mole.

$H_2O_{(s)} \quad H_2O \quad \square\ {}_{S}H = 12$kcal/mole

Methane in contrast to water can form no hydrogen bonds in the solid phase. For solid methane, the sublimation process requires 2 Kcal/mole of methane.

The enthalpy of sublimation for methane denotes an energy quantum to separate molecules against Vander Waal's attraction, and this is a requirement for any system, including water. As Vander Waal's forces depend upon the size and shape of the molecules, and water and methane both being tetrahedral species have the same molecular size . It, therefore, seems plausible to expect that the extent of Vander Waal's attraction in both cases is the same. On this basis the breaking of the hydrogen bonds in ice requires 12–2= 10 Kcal/mole of energy. When ice melts, about 1.4 Kcal of thermal energy is absorbed per mole of water (remembering that a mole of ice contains 18 g ice and phase change of 1 g ice requires 80 calorie of thermal energy). This is 14 per cent of the total energy required for the breaking of all the hydrogen bonds. We therefore conclude that the melting of ice breaks about 14 per cent of the hydrogen bonds and leaves the remaining bonds intact.

Hydrogen Bonding Affects Solubility

When an uncharged organic compound dissolves to any appreciable extent in water, the solubility may be attributed to hydrogen bonding. Thus, dimethyl ether is completely miscible with water, whereas dimethyl sulphide is only slightly soluble in water. Oxygen as compared to sulphur has a far greater tendency to form hydrogen bonds.

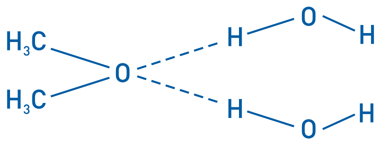

Fig.2: Hydrogen bonding between ether and water

Carbohydrates such as glucose and sugar which are important articles of our daily use dissolve in water due to the formation of hydrogen bonding. Urea, another organic compound and an important fertiliser, is soluble in water due to hydrogen bonding. Each urea molecule provides seven sites for the formation of hydrogen bonds with water molecules.

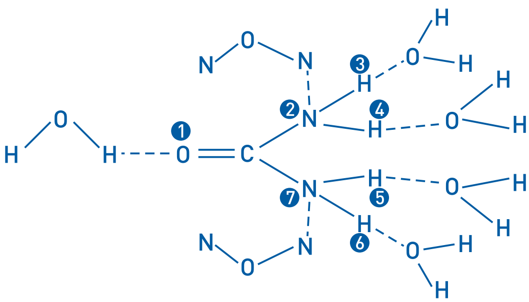

Fig. 3: Hydrogen bonding in urea and water

Hydrogen Bonding in some Compounds of Daily Medicinal Usage

When something goes wrong with our ears, eyes and throat, we use hydrogen peroxide, boric acid and glycerine, respectively, to cure the disease. All these medicinal compounds contain hydrogen bonding. Whether the hydrogen bonding plays any part or not in curing these diseases we do not know definitely but hydrogen bonding helps in aggregation of these compounds. The aggregation of boric acid molecule to give solid is shown in Figure 4.

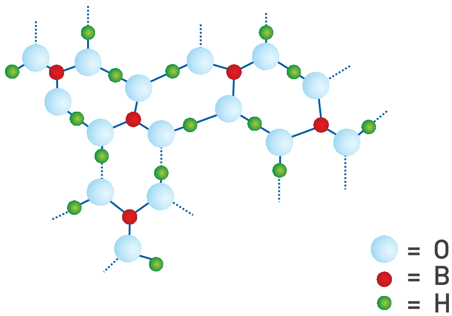

Fig.4. Hydrogen bonding in boric acid — broken lines indicate hydrogen bonding

Synthetic Fibres and Hydrogen Bonding

Synthetic fibres surround us. They are made by man. Synthetic fibres are polymers and result from a repeating arrangement of small molecules. Some of the synthetic fibres also contain hydrogen bonding. The commonest example is that of nylon which is a polyamide. The long polyamide chains are held together by the formation of hydrogen bond between the CO and —NH groups as shown in Figure 5.

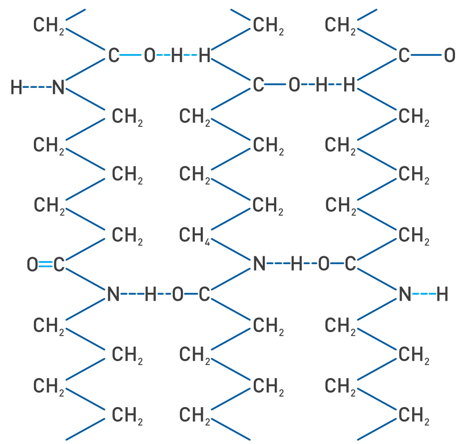

Fig. 5: Hydrogen bonding in polyamide—broken lines indicate hydrogen bonding.

Cleansing Action of Soap and Hydrogen Bonding

Everyone knows that water makes things wet. But do you know that it is possible to make water 'wetter'.? By that we mean that substances may be added to water which enable water to soak into materials better. To understand this, we must realise that the surface of water acts like an elastic film due to hydrogen bonding. To some extent the film tries to keep water away from the things it touches, that is, water soaks into many materials only to a very small extent. If the surface film of water is broken or weakened, the water is better able to soak into the things it touches. In other words, water is wetter. When soap is added to water, the anion of the fatty acid of soap breaks the hydrogen bonding of water molecules in its immediate vicinity, and makes the surface film of water weak. This enables water to soak into fabrics faster and farther than it could otherwise do. The dirt particles attached to the fabric in turn are surrounded by water which rinses them away. This accounts for the effectiveness of soap as a cleansing agent.

Hydrogen Bonding and Humanity

Man himself is fabricated of H-bonded materials. Nucleic acids are of great interest because they are the units of heredity, the genes, and because they contain hydrogen bond of the type N — — — H — — — O.

Water, which itself contains hydrogen bonding, influences the chemical behaviour of metabolism through fresh hydrogen bonds. Water molecules can attach themselves to other molecules in the system by forming hydrogen bonds in either of two ways. Firstly the water molecule may supply the positive centre hydrogen atom as in the case of the negative centre supplied by fats in the body.

Alternatively, the water molecule may supply the negative centre of oxygen atom to interact with the positively charged hydrogen atoms, as in the case of the positive centre supplied by proteins in the body.

In the end it may be emphasised that these are only a few examples of the things that directly concern us. The teacher can make use of several other examples to arouse the interest of the child in the learning of this topic which is of immense use to him.

SILENT VALLEY – THE NEED FOR WILDLIFE CONSERVATION

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For an average human being wildlife conservation means setting up some national parks to protect areas of natural beauty; to establish sanctuaries for the preservation of one or more endangered species of animals, to create botanical gardens for maintaining a vast collection of plants for research and educational purposes etc. But there is a good number of intelligent and well-informed persons, who know that every living organism on this earth is a mini chemical factory of its own kind with tremendous potential and also each species in the wild is a rich living genetic resource which provides a vital component for the whole life support system of the universe. This resource is a must for the well-being of not only the present generation but also the many more to come in the future. Further, it is now amply understood by everyone that man depends for his food largely on the produce of foodgrain crops like cereals and pulses, potatoes and tuber crops, fruits and vegetables and certain oil yielding species. In addition, from the plant world we obtain wood, many kinds of fibres, essential oils, drugs, stimulants and many other natural products which enable us to live a civilised life and to support a very large number of industries of various kinds. It is a remarkable fact that such high-yielding food plants like wheat, rice, maize, sorghum, millets, pulses, tapioca, oilseeds and a wide variety of fruits and vegetables have been developed by man during a period of less than ten thousand years, from their wild and weedy relatives which hardly gave any yields, but the progenitors of our widely cultivated and high-yielding varieties are indeed the wild varieties. This fact demonstrates the vital importance of wild species of plants as basic resources for future requirements.

Plant breeders, by applying the advances made in a number of disciplines of science, like genetics, cytology, physiology, etc., have been able to breed high-yield varieties which form the backbone of modern agriculture. It is well known that no amount of fertiliser, irrigation water, and pesticide application will result in greater production unless the variety itself possesses the genetic constitution which can respond to improved agriculture technology. As the saying goes, 'good crops must start from good seeds' and good seeds mean not only pure, disease-free seeds, but also seeds of genetically superior varieties. While as a result of modern advances in agricultural science and technology a high level of production has been achieved in certain areas, there are many regions where, because of varying soil and climatic conditions, this has not yet been possible. Special varieties will need to be evolved to suit, for instance, very arid regions. Even in areas where high production has been achieved, there is need not only to stabilise the present productivity but also to increase it further to support rapidly increasing human population. For such purposes, we need a very wide range of plant genetic material to build upon; and from time to time, scientists find it necessary to go and search for some attributes which are required, from among the species and varieties growing in the wild.

Every now and then a new pest or a new disease arises, causing great havoc to, and a substantial lowering of, the food reserves of mankind. Only a few years ago, in the United States, the hybrid corn indicated a very high level of productivity of maize. Suddenly fungal disease assumed epidemic proportions and caused a tremendous drop in production, because virtually none of the hybrids on large scale commercial use was resistant to the disease. Maize breeders frantically searched for resources of resistance in the wild varieties to combat the new enemy of the maize crop. Another example is of a new rice pest, in the form of the brown plant hopper, which assumed menacing proportions; and all the high-yielding dwarf varieties under cultivation were found to be susceptible to it. In fact the rice crops suffered severe losses in countries like Indonesia; and it was feared that there might be a major build-up of the pest in the rest of the rice-growing regions. A world-wild search for sources of resistance against the brown plant hopper indicated that a few old rice varieties from the State of Kerala were the only ones possessing resistance. These Pattambi rice varieties have now been widely used during the recent five year period in hybridisation programmes for further improvement of the rice crop, both at the International Rice Research Institute in the Philippines and in our own country. These varieties of Kerala may have done more for the continued productivity of the rice crop than any other variety in the crop improvement history during the last decade.

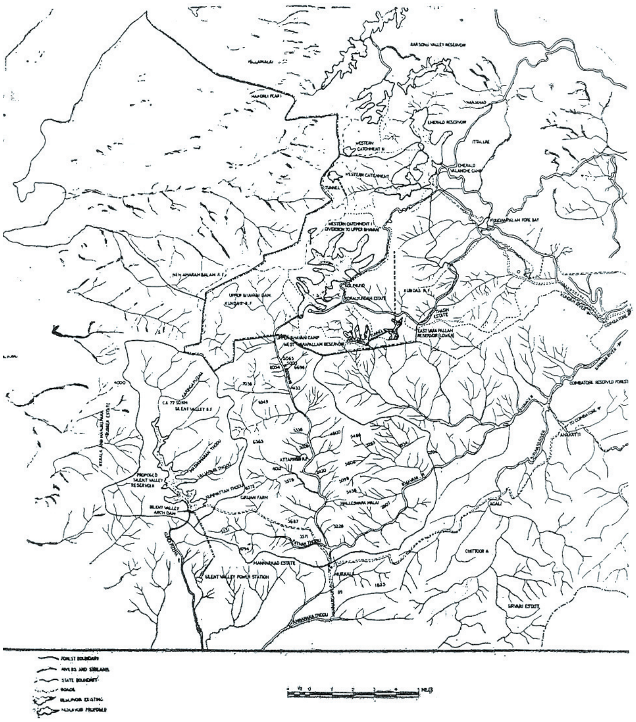
It has become clear that as more and more high-yielding varieties of crop and other economic plants are released for general cultivation, the problem of heavy losses through diseases and pests which thrive under conditions of intensive agriculture will become increasingly important. Thus, the plant breeders will have to turn, in such situations, to the genetic resources found in the primitive type varieties and their wild relatives. And, thus, it is important to preserve those areas of the world, which are rich in plant genetic resources, as biosphere reserves. The importance and sanctity of wildlife conservation for posterity may be illustrated through a well-documented example of the much talked-of 'silent valley.'

Silent Valley

The Silent Valley forests, also know as Syrendhrivanam, are on a plateau perched at the south-western corner (Latitude 11°5' N and Longitude 76°26' E) of the Nilgiris in the Western Ghats region of Peninsular India. While the local name relates to the era of the Mahabharata, it is believed that the name 'Silent Valley' owed its origin to the relative absence of the *Cicada* insects which cause a distinctive sound in a forest environment.

Lying at an elevation of about 1,100 metres, the Silent Valley plateau is flanked, to the south and the west, by steep escarpments, descending a thousand metres to the plains of Kerala and, to the north and the east, by sheer walls rising another thousand metres to the upper plateau of the Nilgiris. It falls within the revenue district of Palghat, Kerala, about 45 kilometres north of Mannarghat, the nearest township. On the north, part of the boundary is formed by the vested forests of Nilambur Division and part by the Nilgiris. On the south is the vested forest of the Palghat Division. On the east, the Attapadi reserve forests are continuous with the Silent Valley reserve. On the west, the boundary is shared by the forests of the Nilambur Division. The total extent of the Silent Valley reserve is 8,952 hectares.

The river Kunthipuzha runs all along the centre of the Silent Valley in a north-south direction. Originating at an elevation of almost 2,400 metres on the outer run of the Nilgiris, the river descends rapidly to 1,150 metres on the northern edge of the plateau and then pursues a gentle southwardly course for about 15 kilometres before cascading down to the Mannarghat plains through a gorge at an elevation of 1,000 metres of the southern edge of the plateau. Having an average annual rainfall of 4,600mm over a catchment of 77 km^2, the river Kunthipuzha is expected to yield an annual run-off of 293 mcm, with the steep escarpment of the southern edge of the Silent Valley descending to the Mannarghat Plains at the elevation of about 100 metres. This river offers a straight head of 857 metres, the highest in the Kerala State, for generation of hydro-electric power. The Silent Valley, therefore, offers an attractive site for location of a Hydro-electric Power Project (see Map).



The site (lat. 11°5'33"N and long. 76°27'15" E) selected for the construction of a dam to impound the water as required for hydel power generation is on the southern edge of the Silent Valley plateau where the river transverses through a very narrow gorge. The project, in its first stage, will involve:

(a) Construction of a RCC arch dam (131 metres high and 430 metres long) across the river Kunthipuzha.

(b) Formation of a reservoir submerging an area of 830 hectares and impounding 317 million cubic metres of water.

(c) A water conductor system comprising 4267.2-metre long power tunnel, 259.08-metre long pressure pipeline and 2355-metre long penstock branching into two near the power house end.

(d) A power station on the bank of Kallan Patti, a small stream joining Kunthipuzha at the toe of the hills about eight kilometres from Mannarghat.

The first stage of the project envisages the construction of two power units of 60 MW each, the water conductor system and the power house structure having been designed for the ultimate stage to accommodate all four units. Stated to be completed within six years, the Silent Valley hydro-electric scheme is expected to contribute 522 Mu of electrical energy per annum. Furthermore, the water released from the power house is expected to irrigate about 10,000 hectares of land lower down in Palghat and Malappuram districts.

Case for Conserving the Silent Valley

The concern which has been voiced in India and abroad regarding the consequences that are likely to befall the Silent Valley if the Kerala Government's Hydel Project is pushed through, rests on the following three main foundations:

1. The Valley occupies an area of about 77.5 sq km and its vegetation is typical of the southern tropical wet evergreen forests characterised by high plant species density, rich biomass production, a wide range of biological niches and pathway of energy circulation and adaptability. The former Director-General of the International Union for the Conservation of Nature and Natural Resources describes it as a unique sample of ancient tropical flora and an essential key to understanding the origin and evolution of Indian-Malaysian-Australian Floras. Shri S.K. Seth, former Inspector General of Forests and one of the foremost authorities on forests in India has stated: "It is the finest intact evergreen forest area for scientific research and training purposes. We have enough knowledge of it to recommend, with all the emphasis possible, that this entire valley should be declared a Biosphere Reserve as early as possible".

The Silent Valley with the adjoining forests represents the largest presently available area of this type of forest and the one which has been least disturbed by human interference: and therefore of priceless value for training of botanists; foresters and others for basic studies on the evolutionary processes.

2. The Silent Valley sustains a remarkably rich wildlife (fauna and flora). Its fauna includes four endangered species of mammals, viz., Lion-tailed Macaque, Tiger, Nilgiri Thar and Bonnet Monkey. The absence of human population and easy access has helped in protection and isolation of these animals as well as other biotypes. Recent surveys carried out through various expenditions from Zoological Survey as well as by some other national organisations and zoologists from other countries have revealed the existence of several, up till now unknown, wild varieties such as a curious hill stream fish, large eels, lizards, a flying snake and a number of limbless amphibians. The Archaeological Department survey on human settlements has come out with a statement that the Valley has never been inhabited even by tribals. Incidentally, it may be pointed out that the Lion-tailed Macaque is one of the only two black monkeys existing in our country. The Silent Valley is the abode for one of the two viable populations of these monkeys existing in the world.

3. The Silent Valley constitutes a remarkably rich pool of genetic resources. A majority of the modern crop varieties and other economic plants have been developed from their wild and weedy progenitors during the past 10,000 years. Crop evolution is a continuous process. High-yielding, disease-free, and nutritionally superior varieties have to be constantly produced to suit a wide range of agro-climatic conditions. Heavy losses through diseases and pests are becoming increasingly important under intensive agricultural practices for evolving high-yielding varieties. Although the present-day varieties are vigorously screened for resistance before their release for cultivation, from time to time a new pest or a virulent disease suddenly develops, causing extensive devastation leading to shortages in food and other materials. Severe losses in rice in Indonesia, as a result of brown plant hopper, has already been mentioned. A frantic search was made and providentially the old *pattambi* rice varieties growing in Kerala were found to be the only ones possessing genes resistant to this pest. These genes have been incorporated in the present day improvement programmes and this operation has been started to alleviate the fears and gain the confidence of the farmers. Many other such examples can be cited.

It has become clear that, as more and more high-yielding varieties of crops and other economic plants are released for general cultivation, the problem of heavy losses through diseases and pests which thrive on the conditions of intensive agricultural practice will become increasingly important. Thus, the plant breeders will have to turn in such situation to the genetic resources found in the primitive types of varieties and their wild relatives. Studies in this direction have shown that certain regions of the world are more richly endowed with plant species than others. The Silent Valley is one of such very rich areas. It would be tragic if the plant genetic resources which have been created through centuries of evolution are allowed to be destroyed.

It is for these reasons the nature reserve and all those who aspire for healthy living strongly recommend that the proposed hydro-electric project in the Silent Valley should not be proceeded with and the Valley along with the adjoining areas be immediately declared as a national park and consequently a biosphere reserve. With more information now at hand, the author is convinced that the 'safeguard' suggested by the Western Task Force of which he himself happened to be a Member-Secretary, would not be able to save the precious ecosystem if the project is implemented.

The Other Viewpoint

However, there has been strong pressure within Kerala for going ahead with the project. An attempt has been made by some persons to denigrate the importance and value of the Silent Valley ecosystem by making statements such as, the Silent Valley is no longer a virgin forest, the species found in the Valley may be found elsewhere, and that the area which will be submerged if the Dam is built comprises only a small part of the total area in terms of percentage, and therefore, would not really damage the Silent Valley ecosystem as a whole. It is obvious that such questions, particularly those relating to the plant and animal wealth actually existing in the Valley, cannot be satisfactorily answered on the basis of individual opinions or casual visits to the Silent Valley but on the basis of factual data collected from the area by plant and animal specialists. Some of the findings of these surveys are briefly recorded here to counter the casual observations.

Plant Life (Flora)

Although only the periphery of the impenetrable forests and the shore vegetation has been botanised, scientists of the Botanical Survey of India have collected over 1,200 species of vascular plants. Amongst the species obtained from the submergible area and considered new to science are a few orchids *(Enlophla propax):* some ferns, *(Tectoria* sp. and a member of the Thalpteridacese), an extremely specialised and endangered aquatic flowering plant, and a climbing bamboo *(Ochlandra).* Many other plants have been noted for the first time in South India and have not been listed by Gamble in his authoritative *Flora of Madras Presidency* or preserved in the Madras Herbarium.

Plants abundant in the Silent Valley which have either disappeared or are scarcely represented outside have been catalogued. The Silent Valley also abounds in plants considered rare, endangered or threatened elsewhere (species of ferns, three ferns—Cycads, Gnatum, Sarchandra).

Mosses are better represented here than in the Nilgiris or the Western Himalayas on account of high humidity, low light intensity, and ideal elevation from the sea level. Over 50 genera and 100 species of mosses and over 25 genera and 100 species of lichens have been gathered and are being identified. Over 41 species of Hyphomycetes— a group of interesting fungi-comprising 36 genera have been isolated from the submergible area. Several of these were unknown to science. The role of micro-organisms in the cycling of biological elements in the biosphere and biological nitrogen fixation is well known.

Some of the world's most spectacular life saving drugs have come from soil micro-organisms. The floor of a tropical rain forest is one of the richest areas for micro-organisms and it would be a pity if this is allowed to be destroyed even before scientific studies have been undertaken which could yield results of outstanding value for agriculture and medicine.

The National Bureau of Plant Genetic Resources has recorded that the submergible area of the Silent Valley possesses a remarkably rich diversity of genetic wealth of several economic plants and their closely related wild species. These include turmeric, ginger, cardamom, cinnamon, nutmeg, black pepper, jackfruit, okra, *Dioscorea, Cestus, Bryanopias* and many important aromatic and dye-yielding plants. Natural populations in spices like cardamom and pepper showed a great diversity and the plants were free from attacks of diseases and pests, indicating that these gene types could be used for developing resistant cultivated varieties. The six species of wild black pepper exhibit enormous variation in their vegetative and fruit characters and appear to be free from cardamom disease such as cellar rot and quick built. They are, therefore, significant for future improvement of this very important species. Similarly wild relatives of *Arhar, Moong* and Urad showing resistance to several diseases and pests are distributed in the submergible area. These need preservation and could be utilised in developing special varieties of pulss.

Animal Life (Fauna)

The records show 23 mammalian species including the three endangered ones, i.e., the tiger, the lion-tailed macaque and the Nilgiri *langur*. The Zoological Survey of India has recently collected more than 8,000 specimens which have established the existence of many rare and even new species in groups, such as fishes, the amphibia and the reptiles. Even a few new genera have been found to illustrate it further, three species of hill stream fish and a new subgenus of scorpion have been discovered.

The richness of the amphibian fauna from the area exceeded all expectation of the survey teams. As many as 17 different species belonging to newer genera were reported during these explorations. An interesting discovery was the limbless amphibian (or Colecilian) collected in good numbers. Among 2,500 examples of insect collection, more than 250 species are recognised so far. The collection is under further scrutiny.

Among snakes, species like brown whip snake, cat snake and flying snakes, which, so far, were known to Assam and Sri Lanka were recorded. The Pit Viper was found both in the Valley and the New Amarampalam forests. Several other species of insects found more abundantly in the submergible area than elsewhere are also reported.

The zoological explorations mentioned above have given an excellent opportunity to assess the faunal variations and the disappearance or depletion likely to set in as a result of major disturbances by human agencies, in this hitherto undisturbed ecosystem.

Conclusion

In the light of the richness of flora and fauna in the area, one of the points raised by some persons and referred to earlier, that the Silent Valley is not a virgin forest, does not really need even cursory discussion. In the strict sense there are no virgin forests left in India and hardly any in the world because of the increased mobility and increased human requirements and consequent human disturbance. However, the Silent Valley remains the only major forest area of its type in the country largely because of its relative inaccessibility. The studies carried out in the area indicate that though there was an attempt made for coffee plantation in an outer area of the Valley and also some selected felling of trees, especially for providing railway sleepers, yet the Valley with its genetic treasures is still intact.

Recently there has been some damage by the operations of the Kerala State Electricity Board in preparation for the starting of the Hydel Project, which is still confined to a limited area at one end. As a matter of fact, from his association with the Silent Valley project since 1976 as Member-Secretary of the Western Ghat Task Force and then Co-ordinatior with the expert survey team of April/May 1980, the author emphasises once again that the Silent Valley is the only rain forest available with us, which for all practical purposes is a virgin forest, that is to say, is relatively an undisturbed one.

The argument that there are similar forests of comparable size and richness in other parts of the Western Ghats is not correct. Although at one time there were undoubtedly such forests, they have been reduced to relatively smaller pockets. The Silent Valley is particularly important because, apart from its amazing richness of wildlife, it constitutes, together with the adjoining forests, the largest contiguous belt of relatively undisturbed West-Coast tropical evergreen forest left in the country. It is floristically and faunistically different from similar forests found in some parts of our north-eastern states.

A great deal has been sought to be made of the fact that in terms of percentage only a small portion of the Valley would be involved, overlooking the fact that the heartland of the Silent Valley ecosystems would be submerged. A noted forest expert has stated that "the entire Valley at all levels from its floor to its highest point is an invaluable whole as the floral composition varies at every level in a continual series (ecotones), no part of which can we afford to sacrifise."

The submergence of the ecologically most crucial area of the Silent Valley together with the activities of a large number of workers on the project with their families for several years would no doubt give a shattering blow to the delicately balanced ecosystem from which it cannot be expected to recover and it would be lost forever.

The assertion by some individuals that the Silent Valley does not contain any plant or animals of special importance or which cannot be found elsewhere has been shown to be not determined by factual data. Even the preliminary work done by the BSI, ZSI, and the National Bureau of Plant Genetic Resources has demonstrated the existence of a variable treasure house of plants, animals and micro-organisms including many new forms not only of great interest to science but also vital for future needs of agriculture and other fields.

To sum up, the Silent Valley represents the only remaining undisturbed tropical rainforest of its type in India, built up over thousands of years. It affords the finest intact evergreen forest area for scientific research and training. Its richness and living resources show that it is one of the genetically rich areas with great significance for the future generations in dealing with problems of agriculture, medicine, etc. It belongs to the category which a former Director-General of FAO described as "an invaluable and irreplaceable world heritage."

The climatological repercussions of disturbing the rainforests are also well known. The effectiveness of forests in modulating localised weather patterns is clear and there is no dispute about it. Localised effects of forests on precipitation are documented by Puri (1960, Chapter 21). Lagris and Blasco (1969, pp. 57-59) present evidence that reduction in rainfall in the

Palni hills in the Western Ghats has accompanied the destruction of the wet evergreen forests. It is to everybody's knowledge that large parts of Kerala and Karnataka are dependent for their irrigation water supplies mainly on the monsoon precipitation falling in the Western Ghats. Destruction of the Ghat Shollas or the alterations in their character inevitably endangers water supplies to the region for which these forests serve as catchment areas. Krishnamoorthy (1960) predicted for example, that hydro-electric projects folding many forested valleys in Kerala would threaten rainfall. Fourteen years later Balram (1974) noted that the dam, regulated irrigation projects, based on pre-deforestation rainfall and the predictions are now feltering due to reduction of precipitation in the Ghat areas. Meteorological data from Andaman and Nicobar Islands (the islands are colonised by wet evergreen rainforests) reveal that in the seventees, that is, after the de-forestation programme for rehabilitation, etc., undertaken on the island the rainfall amount is receding gradually, e.g. in 1974 the maximum rainfall was 121.80'' in 1977 the maximum recorded was 91.80'' whereas in 1978 it was only 6.18''up to March.

Further, destruction of even the vegetation cover of the submergible area along with disturbances created by human activities is bound to affect the ecological cycle of precipitation — percolation — transpiration — evaporation. The total surface area of transpiration provided by the total leaf surface of all the plants of the forests which are to be destroyed would be several thousands sq km as against the total water surface area of the full reservoir level, i.e., 8.30 sq km. Thus, the input of water vapour into the atmosphere will be drastically diminished. This is bound to affect the precipitation not only locally but also in the adjoining regions. Deforestation has also been reported to bring about disasters like landslides and cloudbursts, resulting in extensive damage and loss of life.

WETLANDS AND THE BIODIVERSITY ISSUE

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A workshop on the Conservation and Sustainable Use of Floodplain Wetlands was organised by the British Deputy High Commission, British Council Division, Calcutta and the Asian Wetland Bureau, Kuala Lumpur in Calcutta in December 1993. Through discussions and interaction and presentation of case studies and papers, environmentalists from Britain, India, Bangladesh, Nepal and southeast Asia produced a statement of the problems affecting Indian floodplain wetlands and drew up action plans for their conservation and management in the states of West Bengal, Bihar and Assam. A paper presented by the British expert, Professor Patrick Denny, currently working in the Netherlands, is reproduced here.

An understanding of the meaning of biodiversity in the context of the Convention on Biodiversity, held at the United Nations Conference on Environment and Development (UNCED), is given in this paper. The values of biodiversity as a natural resource are also considered. Examples of the different types of values are given using wetland ecosystems wherever possible. An outline strategy for the conservation and wise use of wetlands is suggested here.

Since the UNCED Conference in Rio de Janeiro in June 1992 much has been written and said about biodiversity. Care must be taken that the euphoria born at the Rio conference is not allowed to degenerate into a series of platitudes in which words like 'biodiversity' become political words of convenience rather than words of true meaning.

It is helpful to have a clear idea of the meaning of biodiversity, its attributes and values. At the convention, it was defined thus:

Biological diversity means the variability among living organisms from all sources including, interalia, terrestrial, marine and other aquatic ecosystems and the ecological complexes of which they are part; this includes diversity within species, between species and of ecosystems.

Note that biodiversity does not just refer to the biological diversity of species and the protection of threatened species but covers the whole spectrum of the natural environment. The definition brings out the significance of scale, from strains of microbes to entire ecosystems and landscapes.

Importance of Biodiversity

There is no doubt that the actions of mankind have degraded the natural environment and diminished biological diversity. Statistics suggest that half of all extant species may become extinct within the next 100 to 300 years (Wright *et. al.*, 1993). The rate of habitat loss is even greater. In the Philippines, for example, around 67 per cent of the mangrove forests have been lost over the last 60 years (Dugan, 1990). Likewise, Scott and Poole (1989) found that of the 734 wetland sites studied in Asia only 107 are not under threat. At the other end of the scale, at the molecular dimension, there is the reduction of the total genetic resource due to animal and plant extinctions. If the total genetic resource declines, then the ability of taxa to adapt to changing conditions through genetic diversity declines accordingly, and populations may not survive. Why is biodiversity so important? There is a range of reasons, including precautionary, moral, indicative, aesthetic and economic arguments. The precautionary argument accepts that our knowledge is insufficient to make definitive judgement on how much loss of biological diversity can be sustained without irretrievable damage to the balance of Nature. Until our knowledge is sufficient, it is wisest to conserve biodiversity and use natural resources on a sustainable basis. A more utilitarian argument 'is the commercial value of plants and animals. Breeders draw upon gene and gene combinations from the wild-type genetic pool for a particular quality of individual, be it disease resistance in rice or flavour of fish.

Whilst, probably, only a relatively small number of genetic resources will be of direct commercial benefit to mankind, the precautionary approach argues that the risk of losing valuable genes from the pool cannot be taken.

The moral argument supports the view that mankind is a steward of the natural environment, who should look after and improve it; and hand it on to the next generation with pride. The indicative argument places a value on the ability of biodiversity to provide an indicator or barometer of the 'healthiness' of an environment. A change in biodiversity is often the first indicator that the environment is changing. Eutrophication of rivers and lakes, for example, is often identified by changes in plankton and invertebrate community composition. Aesthetic and cultural arguments are largely emotional, that is, the biodiversity of landscapes and natural ecosystems, and the species they support, can provide solace as well as a feeling of 'homeliness'.

Moral, aesthetic and cultural arguments have other dimensions which have to be taken into consideration; that is, the priority placed on these values compared with the immediate and real needs of the land for other purposes. This is particularly pertinent, but not confined, to the developing world, where national debts, poverty and population growth place enormous pressure on the natural environment. Agenda 21's philosophy of global partnership through the redistribution of technologies and wealth to areas of need should be able to help achieve a balance between the short-term need for non-sustainable utilisation and the long-term desire for conservation.

Economic arguments have been alluded to already. Biological diversity constitutes a capital asset with enormous potential for yielding sustainable benefits, but it is proving very difficult to quantify its value and give it a realistic price. Certain attributes can be allocated prices which reflect their commercial value, such as the value of a habitat as a tourist attraction. The functional values of an ecosystem are much more difficult to price. Often the true and full functional value of an ecosystem, such as a wetland, is chronically underpriced as only a small proportion of all its functions is considered 'commercial'.

There is a plethora of values for biodiversity which defy any sensible pricing scheme. It is a sad reflection of our times that values have to be reduced to monetary terms. However, the monetary approach is likely to prevail and it is prudent for wetland socio-economists to attempt to devise a working model. For the model, it is essential to have a clear understanding of the values of wetlands.

Our knowledge of biodiversity, functioning and uses of wetlands is very elementary, and values attributed to wetlands can only be rough and ready approximations. However, the rates of loss of wetlands are so .acute that one cannot await full, scientifically more accurate, evaluations.

Values of Wetlands

Values of wetlands have been outlined in a number of publications (Denny, 1985; Dugan, 1990; Claridge, 1991; Finlayson and Moser, 1991; Davies and Claridge, 1993; Aksomkoae, 1993). The value for each wetland is intimately tied up with the culture and needs of the people who exploit it, and its location. Some excellent local evaluations for the wetlands of south-east Asia have been undertaken by the Asian Wetland Bureau (Othman, 1990; Yahya, 1990; Said, 1990; Khan, 1990).

It may be helpful to consider values briefly in four categories, namely: global; functional; habitat and anthropogenic values (Denny, 1991).

Global values include those of widespread significance such as the contribution of wetlands to the mosaic of ecosystems which maintain global diversity and their special value as an ecotone between dry land and the open water. There is a long list of functional values of wetlands. The more obvious ones include: the ability of wetlands to ameliorate the forces of floodwaters and their use in flood control management; wetlands for water supply and groundwater replenishment; the effects of wetlands on microclimates etc.

Habitat values are more conspicuous than most. Wetlands not only provide habitats for some of the rarest animals and plants but they provide a precise environment for a wide variety of other organisms. But the association between the habitat characteristics and the flora and fauna therein is often fragile.

Anthoropogenic values specifically refer to the values of wetlands to mankind. They can be separated into extrinsic and intrinsic values. Extrinsic values are those mainly for governments and private organisations who exploit the wetlands for major commercial purposes. This may include rice schemes, tourism, water supply and fisheries. Intrinsic values are of direct value to the people who live around and in the wetlands, especially those whose whole lives and customs are intimately linked with the wetland functions. They rely upon the wetland for their everyday needs for food, water, building material and trade. To these people, the wetland is a priceless commodity.

The Way Forward

Wetlands are under particular threat through the destruction of ecosystems and loss of species. Indeed, the extinction of species in wetlands is higher than for any other ecosystem due, probably, to their bio-geographical isolation in the larger continents and also their tendency to behave as biological islands. In order to conserve wetlands and their biodiversity, it is important for a nation to define its 'critical environmental capital' *(English Nature,* 1992). That is, those elements of the environment, for which loss would be critical on a global, national or local level. This is the 'Natural Capital Stock' of a national heritage which just cannot be traded.

A key element in conservation is the accurate determination of the carrying capacity of the habitat. As mankind is the main moderator of the natural resources, either directly or indirectly through his activities, then the size of the human population and the pressures its activities impose on each ecosystem must be assessed. In this way, an optimal population size for balance with its natural resources can be projected. If the carrying capacity is exceeded, then the environment suffers accordingly, and discussions on moral, aesthetic and cultural values become largely academic.

The first step in an action plan for the conservation of wetlands and wetland biodiversity is to evaluate the total wetland resource of a nation. Then, it is important to develop management plans appropriate to the needs of each wetland. The carrying capacity of all compartments of the wetland, including fisheries, grazing, cropping, seasonal agriculture, tourism, wildlife etc., must be assessed for its sustainable use. Objectives and targets should be set to optimise the uses of the wetland for particular functions and a programme of survey and monitoring needs to be established to audit its management. If this procedure is followed, then wetland biodiversity can be conserved and a strategy for the wise use of wetlands can be formed.

BIRD MIGRATION

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After more than 2,000 years of observations climaxed by a century of experimental studies, we are still not certain regarding many facets of migration. We have authentic data on breeding range, wintering quarters and many migratory routes of a large number of birds but we still are not in a definite stage to explain why birds go where they do at the time they do, and their manner of navigation is only partially understood.

Introduction

One of the most spectacular events in the animal world is the migration of birds – the feathered bipeds. It has intrigued mankind for many centuries. It led to such wild speculations that the swallows hibernated in the mud and that some birds flew to the moon for winters. Continuous observations and experiments have dispelled some of these fanciful notions about the life cycle of birds but the many more years will be required to ascertain the how and why of migration. Most of us in India have also noticed the great influx of birds during September to November. The trigger-happy hunters shoot the snipe, geese, teals, ducks, etc., during winter for their table. During the annual royal shoots, thousands of such migratory birds were hunted by the rulers and their guests. In Bharatpur, 4,273 ducks were shot on 12th November, 1938 by Lord Linlithgow, Viceroy of India, along with his 38 gunmen in a single day while 10,437 Imperial sandgrouses (migratory birds) were massacred by King Sardulsinghji of Bikaner, on two days in February 1929 at Gajner.

Larks, leaf-warblers, wagtails, pipits, etc., all seem to pop up suddenly in winter from nowhere. Only a few of us have ever bothered to know as to why this event takes place year after year. Many only think that the birds move because it is in their nature to do so; from where they come, does not concern them and why and how they do it, is clearly the birds' own affair. The migration of birds has been so regular and definite that the Red Indians of Fur countries named their calender months after the arrival of the migratory birds.

Migratory Movements in Other Animals

Apart from aves (birds), many other animals also show migratory movements. Certain insects, particularly butterflies, undertake regular migration, some going south for winters. Sharp periodicities in the breeding cycles of most amphibians involve short journeys to and from a water source. Many reptiles travel for suitable winter quarters. Among the fishes, the amazing migrations of the eels and salmon are well known. Among mammals, the cyclic outbreaks of lemmings (a small arctic rodent like rat) are classic; the lemmings, at an interval of three to five years, reach population peaks, apparently compelling them to practice death migrations, sometimes drowning in the sea.

Basis of Bird Migration Knowledge

Modern knowledge of bird migration, although still far from perfect and complete, is based on the following six sources:

(i) Extensive data available on the distribution of many species in many countries.

(ii) Direct observations of visible migration by day or of resting birds, at favourable localities.

(iii) Nocturnal observation of birds attracted to lighthouses and lightships; attraction to light in a particular period (Jatinga in North-East India), or heard (calling over of geese overhead in autumn and spring) or seen through telescope while crossing the face of the moon (moon watching in America).

(iv) Observation of migrants (day or night) on radars.

(v) Ringing of individual birds by bands of metal or plastic.

(vi) Experiments on birds especially on pre-migratory restlessness (development of a particular metabolic or physiological condition called 'Zugdisposition' by Europeans.)

Definition

Migration in a broad sense as defined by Cahn (1925) is "a periodic passing from one place to another". The most commonly accepted definition now is. "Regular movement of birds between *alternate* areas inhabited by them in different times of the year, one area being that in which the birds breed and the other being an area better suited to support them in the opposite season. A. Landsborough Thomson, an eminent ornithologist, describes Bird Migration as "Change of habitat periodically recurring and alternating in direction which tends to secure optimum environmental conditions at all times." It is the back and forth movement that is the crucial feature of bird migration. The periodic invasion of locust swarms *(tiddi-dal)* is not migration for they do not entail a return to the starting point; it is just an overflow movement. Thus march of locust army differs markedly from the seasonal return traffic taking place among birds. According to celebrated ornithologist Padma Vibhushan late Dr. Salim Ali - Father of Indian Ornithology — the 'Pendulum-swing' movement is noticeable in some other groups of animals as well, but it has reached its rhythmical climax in birds.

Nature and Extent

Most birds migrate; some may go only a few thousand metres while others may travel thousands of kilometres. The longest migratory journey is performed twice in a year by the Arctic Tern, *sterna macrura;* it migrates in winter from the Arctic and goes south right across the world to Antarctica and back again in summer, the distance being 17,600 kms one way. It breeds up to 82°N latitude and reaches 75°N latitude in its off season. Some birds in the high altitudes are sedentary, i.e., they do not migrate. The birds that stay during their migratory journeys at a definite place are known as true migrants while those passing at a place in autumn or spring are termed as autumn or spring passage migrants respectively. Some birds breeding in high Himalayas in summer have to come down to valleys or foothills to escape severe winters and the descending snow line. There is an exception to it. In Dead Sea area, some birds breed in the warm valley about 300 m below sea-level and come to the adjacent hill country during winter. It is also another exception to the axiom of Nature that the birds always nest and breed in the colder portion of their migratory range.

Advantages of Migration

As seen above, migration involves occupation of two different areas by the bird, at the respective season, favourable in each. It implies a swing from a breeding or nesting niche in the bird's home to a feeding or resting place in its winter quarters. The absence from high altitudes during the cold winter weather enables the bird—

1. To escape cold and stormy weather.
2. To tide over conditions reducing availability of food (due to freezing of water and covering of feeding grounds by snow).
3. To avoid short daylight hours for searching food.

Similarly, return to high altitudes in the summer hot weather provides the distinct advantage of—

1. Making available large uncongested expanse of land for nesting.
2. Abundant food supply due to luxuriant growth of spring plants.
3. Longer hours of daylight for searching food much needed for the young ones.

Migratory Routes

Migration, in its more extensive form, essentially means a change in altitude; the general trend, therefore, is north to south. It is often considered that the birds take straight and definite routes.

Maps suggesting migration routes based on the recoveries of ringed birds could also be misleading, particularly when they are banded and captured only at their breeding and wintering centres or vice-versa. Birds ringed in Bharatpur have been recovered in (earstwhile) U.S.S.R. in their breeding zone and if this is joined by a straight line or linking line, it gives, what is known as, 'Primary Direction'. The actual migratory route is, however, far from straight and is often modified according to feeding ground, weather conditions and topographical features. Occasionally, the birds follow a curve and at times they even take a totally opposite direction for a while. Migratory routes can be differentiated in narrow or multiple flyways. Narrow route is rather uncommon and only a few birds adopt it. Some storks use a long and narrow flyway through Eastern Europe and near east due to their aversion to crossing wide seas.

Most birds prefer to take multiple flyways spreading over a wide area; the width varying with the species of bird and the local conditions. At certain places, these multiple airways may converge due to narrow territory where migrants get funnelled down in dense concentrations. As the passage broadens, the migrants spread once again. Many migrants like to follow low contour routes, rivers, valleys to enjoy flying conditions. Certain tracts strongly repel some birds. Land birds especially passerines (sparrows etc.) hesitate to cross wide waterways. In certain cases, on reaching shore, they are reluctant to proceed further and change the course, temporarily, to fly along the shore (land) just to delay the inevitable. Sometimes islands lure the birds. Terrestrial birds, after crossing the sea, between the Netherlands and Frision Island fly east west but change the direction to fly along the entire length of these islands. This phenomenon is seen with many birds of Andaman and Nicobar island groups. Land repels sea birds and many sea birds like gulls change their route to avoid land although they could save time and energy. Many birds, however, do not get deterred by the territory over which they fly. Lesser Black-headed Gull from Baltic, crosses entire Europe to reach the Mediterranean Sea and some even proceed to East Africa, crossing the desert. Many ducks and geese such as Mallard cross over the Himalayas from Central India to winter in various parts of north India. The major migration from and to the northern lands (Central Asia, Siberia, Mongolia, etc.) in autumn and spring each year takes place at both ends of the Himalayas, mainly through Indus and Brahmaputra valleys. The migrational stream of land birds such as redstart, buntings etc. converges down the two sides of the Penninsula to Ceylon forming the terminal.

Flight

Birds exhibit astonishing feats during the migrational sojourns.

Speed: Migratory flights are, of necessity, faster than the normal flight speed. Although it is difficult to measure the speed due to wind, etc., some speeds have been worked out as below: Hawks (like Sparrow, Besra) fly at 50 to 65 kms/ hour while waders (ruff and reeve, lapwings, curlew, etc.) cruise at 65 to 80 kms/hour; the ducks (pintails, shovellor, pochards, etc.) and geese (gray lag, bar-headed, etc.) fly at 80 to 100 kms/hour.

Duration: A bird's flying day or night stretches over 6-11 hours, and migrants cover long distances in this manner and then they come down to rest and feed. Some interesting features of a single hop of birds are 1. Coot – 250 kms; 2. Stork – 240 kms; 3.Woodcock – 450 to 480 kms; 4. Plover (Golden plover) – 880 kms (with the flying period of 11 hours).

Birds migrate by day or night and are termed as diurnal or nocturnal respectively. Most of the smaller birds, essentially insectivorous like bee-eaters, fly-catchers migrate at night so that, in day, they may catch insects as well as take rest. Small song birds as thrushes, larks, etc., are also nocturnal. Swallows and swifts, which feed on wing, migrate by day. Hawks, rollers and most birds of prey (falcon, harriers, eagles, etc.) also are diurnal. French ornithologist Jean Dorst (1962) says "in some instances, migrants must cover long distances without a break. Land birds flying from Scandinavia to Great Britain fly 220 to 400 miles non-stop. The Eastern Golden Plover *(Pluvialis dominica fulva)* makes its 2,400-mile trip non-stop from Nova Scotia to South America in about 48 hours. This bird lives in West Alaska and North East Siberia arid is a regular visitor to the Hawaian Islands." This plover is also a winter visitor to India. The snipe *Capella hardwickii* — which breeds only in Japan and spends winter in

Eastern Australia and Tasmania must habitually fly 4,800 kms non-stop over the sea because it has never been seen in between.

Distances: Long distance flier in India is the wood-cock *(Scolopax rusticola)*. It breeds in the Himalayas and winters in the Nilgiris and other hills of South India and since this has not been recovered or seen anywhere, it must travel at least 2,400 kms non-stop. A knot, *Calidris canutus,* ringed in England was recovered seven days later in Liberia at a distance of 5,600 kms. Similarly a Ruff and Reeve with the ring number B 4223 of Bombay Natural History Society, ringed in Bharatpur on 9 October 1967 was recovered in May '68 in Yakutian (USSR) at a distance of 5,850 kms.

Height: It was thought that the birds in their migratory flight always flew at high altitudes but recent studies show that night flights are made at low elevations; generally at 1000 m above mean sea level and on cloudy nights, the birds fly at very low heights. Birds flying along sea habitually remain low because the obstacles are rather non-existent. There are many birds which fly very high. A Mallard (Nilsir - *Anas platyrhynchos)* got killed by an aircraft at an altitude of 6,437 m. Lapwings are known to cross mountains at 2,590 m, cranes at 4,572 m. The highest recorded altitude at which the birds migrate is probably of geese *(Anser* spp.) crossing the Himalayas at 8,839 m; almost equal to the Mount Everest height. Crow like bird, chough, followed Sir Edmund Hillary up to 7,772 m to 8,200 m during his ascent to Mount Everest in May 1953. The Everest expedition also met birds like crows, griffon vulture and mountain finches at 6,400 m to 7,000 m. Observations with the help of radars have shown that birds migrate at 7,500 m in large flocks, without there being any apparent physical compulsion for them to take such heights. In spite of the numerous observations, studies, etc., we are still conjecturing on the migration aspects of the birds.

Orientation

We are still probing in the dark as to how the birds orient themselves during migration. It is, however, now agreed that the birds can orient themselves by sun in the day and by stars and moon in the night. Cloudy day or night often mislead the migrants. Generally the migratory flights commence before nightfall or in the early morning supporting the theory of sun orientation. In Bharatpur, it has been regularly noticed that the migratory geese and ducks come in long V-shaped fashion and even the cormorants on their daily feeding flights outside the Keola Deo National Park in Bharatpur move in a V-formation. Pelicans and Siberian cranes fly spirally over this park, giving loud calls to collect their group members before migrating away.

Number in Migration

Some birds may migrate individually like birds of prey or in a scattered association but they continue their touch with each group by yelling frequent calls. Other birds like ducks, geese, passerines, shore birds move in close formations. It was noted that all the Greater Snow Geese, 70,000 in number, stopped in a strip of marsh along St. Lawrence in 1957 on their journey to the Atlantic coast.

Punctuality of Migrants

A few birds are very specific in selecting their breeding site year after year. There is the classic example of swallows in Europe, where they return to the same locality but even to same nesting site in the same building every year after covering over 9,500 kms each way. In our country, a ringed Wagtail *(Motacilla caspica)* was found to occupy the particular lawn (not bigger than a badminton court) in Greater Bombay on almost the exact date in September for five years continuously. An Orphean Warbler *(Sylvia hortensis)* which was ringed in Saurashtra (Kathiawar) in September one year, was recaptured in the nets on the self-same acre or two in the same month, almost to the date, in the next year and in one case, even in each of the three successive years. It must not however, be lost sight of that the regularity and accuracy of return of the migrants is largely dependent upon the availability of food and shelter in that particular locality in that particular year besides the climatic conditions obtaining in the breeding and wintering zones.

Many birds, it seems, are very instinctive as well for they will come to the same place inspite of the impending dangers to their survival, confirming that in crisis, intelligence admits defeat but instinct knows only death. Some chicks which were separated from their parents and did not accompany them to the wintering quarters, also exhibited the instinctive restlessness during the migratory season and some of them did reach the breeding zone and joined their parents.

Conclusion

After more than 2,000 years of observations, climaxed by a century of experimental studies, we are still not certain regarding many facets of migration. We have authentic data on breeding range, wintering quarters and many migratory routes of a large number of birds but we still are not in a definite stage to explain why birds go where they do at the time they do, and their manner of navigation is only partially understood.

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THOUGHT FOR FOOD : THE SOCIAL AND CULTURAL ASPECTS OF MALNUTRITION

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Derrick B. Jelliffe, a silm Englishman in his fifties, has probably done as much as any person now living to focus attention on practical solutions to the problem of malnutrition among young children in the developing countries.

Jelliffe, formerly UNICEF Professor of Paediatrics at Makerere University in Kampala, Uganda, and presently Director of the Caribbean Food and Nutrition Institute in Kingston, Jamaica, is not a science celebrity. He has never won a Nobel Prize and has no outstanding biochemical research to his credit. He is basically a field worker, a teacher, and an indefatigable polemicist, addressing himself ceaselessly to the medical and nutritional fraternity in language it understands and through its chosen organs of communications.

Where he finds time for all the writing involved in the last of these tasks amazes his colleagues. Since 1955 he has written five books, including the WHO monograph *Infant and Child Nutrition in the Tropics and Sub-tropics,* which is the standard broad spectrum work on the subject, and has co-authored or edited three more. He has published more than 250 articles in scientific and medical journals and is a tireless participant in the nutritional community's ceaseless round of seminars, symposia and conferences.

Jelliffe's range is enormous—he seems to have read and assimilated everything remotely connected with community nutrition, and the subjects covered in his publications range from 'Ecologic Malnutrition in the New Guinea Highlands' to 'The Urban Avalanche and Child Nutrition'. Central to his thought is the concept that in practical terms and as it affects hundreds of millions of children and persons of other vulnerable groups today, malnutrition is primarily a cultural, social and economic problem—in fact.

At a distinguished "interdisciplinary symposium" on malnutrition and food habits in Cuernavaca in 1960, Jelliffe referred modestly to the "amateur efforts" of medical men like himself who had adopted an anthropological approach to the study of malnutrition. Margaret Mead, who had listened for several days to Jelliffe's lively interventions and comments, replied that his approach was scarcely an amateur one and that the application of established anthropological principles to other disciplines was to be welcomed. Jelliffe has the true amateur's contagious enthusiasm, however, which is one of the reasons he is so effective in communicating his ideas.

I first met Jelliffe at the UNICEF offices at United Nations Headquarters, twelve years ago, when he dropped in to call on Maurice Pate, then UNICEF's Executive Director. He was one of the few nutritionists I had then met who seemed honestly to realise he was dealing with people (most nutritionists I had met by that time were far more at home with rats). Last autumn I took advantage of a visit to Jamaica to interview him again.

I began by asking him just how he had happened to get so involved in nutrition, particularly child nutrition—and in its social and cultural aspects.

The Beginning

"I didn't start out as a nutritionist at all," he recalled. "At the University of London, where I took my M.D. and did most of my initial training, I specialised in internal medicine and paediatrics. Following World War II, I worked for four years in the Sudan Medical Service, then for three or four years at Ibadan University in Nigeria. After an interlude at Tulane University in New Orleans, I spent two years at the All India Institute of Hygiene and Public Health in Calcutta as WHO visiting professor. Then came my assignment in Kampala and finally my assignment here.

"During this whole period of time I found myself working increasingly with children. Now in the so-called 'less-developed' or poor countries, one finds oneself faced with such huge problems of ill health among children that soon it becomes evident that there is no possible way to deal with these problems in the usual clinical way. You see children discharged from the hospital partly cured, because the hospital is too crowded to keep them there till they're completely cured. You see them going back to the same conditions that led to their illnesses. You see the brothers and sisters of these children developing similar illnesses.

"So, logically, one can assume one of two postures. One can retreat to an ivory-tower: 'I am concerned only with my clinical work; what happens outside the hospital has nothing to do with me'. Or, alternatively, one becomes increasingly concerned with the preventive side of the picture in the environment these children live in.

"Once you begin to look into the environmental factors, you realise that the pattern of child disease in less developed countries is not really related to the climate. In fact, the commonly-used term 'tropical pediatrics' is a misnomer. What it is related to are such factors as social patterns, cultural attitudes and economics. After a while, one also comes to realise that the major child health problem in all less-developed areas is, in fact, malnutrition —either malnutrition as such or as a background to the infections which make up the other major component of mass illness among children".

I pointed out that the less-developed areas in which Jelliffe had worked differ considerably. West Bengal, for example, is densely populated, extremely poor in terms of per capita income, but fairly industrialised. Uganda is a low-income, pastoral country, sparsely populated. Jamaica is a small country with great contrasts between rich and poor but with a relatively high per capita income better than US $600 per year. How could one generalise?

While the problem of these different areas vary in order of magnitude, he said, they show more similarities than might at first be apparent. "This is particularly the case with regard to malnutrition. In the Caribbean, with the possible exception of Haiti, the extent and severity of malnutrition is by no means comparable to what one encounters in some parts of Africa and Asia. Nevertheless, in all these areas, the main type of malnutrition you encounter is the same: protein-calorie malnutrition of early childhood, as we call it—ranging from 'kwashiorkor' when the main deficiency is protein to 'marasmus' when the main deficiency is calories.

"More significant than this, though, is the fact that one can analyse the causes of child malnutrition anywhere in the world—including North America and Europe, I might add—by applying the same principles. We have a useful shorthand method we call the community nutrition-level equation. The community nutrition-level takes into account a number of factors—economic level, educational level, certain health factors, food availability—all divided by the universal denominator of population and its rate of increase. This is a non-mathematical formula—a guide to analysis and all its elements have to be seen in relation to the cultural pattern of the community concerned. The cultural pattern affects every bit of the equation, whether we're talking about Africa, India or America.

Cultural Attitudes Towards Food

"Man does not eat the full range of nutritious foods available to him anywhere in the world. A classic example is the Hadza hunters of northern Tanzania who lived entirely by hunting and food gathering with no agriculture and with no domestic animals. These people who lead as rigorous an existence as any in the world, did not eat everything available to them. They did not eat certain species of fish, for example. They did not eat flying ants, which are eaten by people in outstanding communities. I am sure ants do not sound very appealing to you, but they are really a quite nutritious addition to the diet.

"All of us have our food taboos. Let me give you an example. A friend of mine from Buganda, a part of Uganda, went to the United States to do his training and was disgusted by the objectionable food he had to swallow out of courtesy to his hosts: shrimp. But an American visitor to Uganda would run into a similar problem, for in Uganda green grasshoppers are a prized delicacy. The parallelism is rather striking. One man's food is not necessarily acceptable to people in another community—definitely not.

"So, to begin with, cultural attitudes determine what we regard as food. But it goes farther than that. Cultural attitudes determine who gets what. Something the Women's Lib Movement might like to look into is the fact that food habits almost always seem designed to favour adult males. The more appealing, the more expensive, the tastier items of food—like eggs and chicken in East Africa—which are usually high protein foods, are the very foods that people believe are 'not good' for young children and women, especially when pregnant and lactating. The men get them.

"In most cultures the diet of young children and of pregnant and nursing women—the most vulnerable groups from a nutritional point of view—is largely based on one or two staples. These are often what I call cultural super foods. A cultural super-food is a food that is not only the community's main source of calories but one that has a tremendous emotional, historical, mystical and religious hold on a community. It is usually a food that is bound up with all sorts of rites and is used in a variety of ceremonies. Different parts of the same plant may be used in other aspects of the community's life. In Central America the cultural superfood is corn, or maize, as it is called in most countries. There are corn dances, there are corn gods. In the mountainous parts of the former Inca Empire, the potato is the cultural superfood. In Europe until quite recently, it was wheat. This is reflected in the Lord's Prayer: 'Give us this day our daily bread. Bread is the 'staff of life'.

"Now the importance of this is that when people think of food as something that is essential to life, rather than a snack or what the French call an *amusegueule—a* palateteaser—they think in terms of their particular super-food. In many languages, as a matter of fact, the word for 'food' is identical with the word for the cultural super-food. In Malaysian, I believe, there is 'rice' and the rest is called 'with rice'. Other foods are just sauces or snacks to eat with rice.

"Now when it comes to feeding young children, people often feel that if the child is receiving this cultural super-food, little else is required. If the cultural super-food happens to be rice, wheat or any other good cereal crop, this may not be so bad. These are not complete foods, but they provide calories in a compact form and they have reasonable protein content. But if the cultural super-food belongs to what we call the TPB group—the tuber, plantain, breadfruit group of staples which are bulky and contain very low percentages of protein—then you are in real trouble.

"Let me give you an example. In Northern Uganda, amongst the Acholi people, millet is staple and the cultural super-food. Millet is a relatively good source of protein—its protein content is seven per cent. It provides calories in a compact form and contains little water or cellulose. Despite the fact that the Acholi are poor, 'kwashiorkor' is uncommon amongst their young children.

"The Baganda people in the south of Uganda are considerably more prosperous than the Acholi. But you find a much higher incidence of protein-calorie malnutrition among their children. This is because their cultural super-food is steamed plantain-matoke. Plantain is the cooking banana. It is low in protein—about one per cent—and it is practically impossible to get sufficient protein and calories into young children by feeding them matoke. Yet, because the plantain is so central to life, religion and everything else among the Baganda, the mothers imagine that nothing could be better for their children."

Misleading Ideas about Food

I asked Jelliffe what his own cultural super-food was.

He laughed. "The potato," he said without hesitation. "I'm definitely hooked on potatoes. If I have a hard day at work and I go home tired, the first thing I want are some potatoes to eat—potatoes symbolise security and peace, and especially if mashed, act as a sort of poultice to the bruised psyche. It goes back to my childhood, I suppose. A meal without potatoes just wasn't a meal in my family.

"Now there's a moral to this. All of us base our food preferences on certain irrational factors—people in economically developed countries as well as people in underdeveloped countries. The advertisers are well aware of this. Foods are never advertised exclusively as foods. They are advertised as giving status, sex, upward social mobility. People eat not for food values but for symbolic values."

I agreed that there was a large irrational element in Western food habits, but since people in the affluent countries were so well fed to begin with, did this really matter very much?

"It certainly does, in some cases. I think a new form of neo-cultural food confusion is emerging in the United States and in other countries through food fads. People are frightened of foods that are unnecessarily contaminated with insecticides and want to eat foods that are more 'natural'. This is understandable, but many natural-food enthusiasts go to ludicrous extremes. They come up with non-scientific food classifications as absurd as those that can be food amongst the pygmies of the Ituri forest—and they try to convert other people to their way of thinking. This could destroy much of the popular education that nutritionists have been trying to promote for forty years. It's very dangerous.

"Something else that's dangerous—and is not confined to faddists either—is the idea so common in the Western world that a fat baby is a healthy baby. This is an extremely harmful cultural concept. Many baby shows turn out to be a mere judging of fat stock. The notion of 'growth surveillance' of babies is valuable—height and weight curves are useful guides, especially in countries where mothers pay insufficient attention to their children's growth during the early months and years. But obesity in infants is not a sign of health. It has been shown that if a baby puts on too much fat in the early months of life, this may increase the actual number of fat cells he has to carry around with him for the rest of his life. As an adult, he'll be literally saddled with a blanket of unnecessary fat calls which will be his Pilgrim's Progress burden for the rest of his life."

Another cultural problem Jelliffe is much concerned about is the decline in breast feeding in many parts of the world under the impact of modern civilisation, the drift of rural populations to the cities, and the extensive sales promotion campaigns which manufacturers of "bottle formulas" have launched in many countries. (In one of his papers, he speaks of "commerciogenic malnutrition" — meaning malnutrition resulting from too great a reliance on heavily-advertised products).

Breast Feeding: the Best Thing Anywhere

Breast feeding is the best thing anywhere. There is overwhelming evidence of the tremendous advantages of human milk from recent work in biochemistry, immunology and psychology. It's cheap too—it's definitely the cheapest way of feeding babies anywhere in the world—and safe: you don't have to worry about sterilisation. Until recently, there was a steady decline in breast feeding in Europe and North America. In the past decade, there has been a reversal of this trend in certain places, particularly amongst college-educated women. But, of course, it's feasible to rear children on a whole variety of cow's milk formulas, so even if many mothers in the affluent countries don't want to breast feed, there is no critical problem. The advantages alleged by one manufacturer or another of infant formulas are entirely hypothetical, by the way: one can rear children just as well on simple home-made formulas, though there's a convenience factor involved in some of the proprietary products.

"But the question of breast feeding is quite critical in most of the world. If a mother in a poorer urban area in India or in rural Africa cannot breast-feed her child and tries to feed it artificially, the child will die. It will die partly because it will be starved, since the mother will be unable to afford sufficient quantities of milk for adequate bottle feeding. It will die partly on account of associated diarrhoea because the mother won't have any facilities for keeping the formula sterile—a pure water supply, extra bottles, storage (let alone a refrigerator)—and the chances are one will have instructed her on how to prepare bottle feeds properly."

"Could he be exaggerating this danger a bit," I queried? "From what I knew of village India, for example, breast-feeding was taken as a matter of course."

"You are right as far as village India goes. The problem there is to see that this continues in the future. The great present danger is in poorer urban and peri-urban areas which are growing so rapidly in all the developing countries. Some mothers have to work away from their homes for most of the day. They hear about these 'miracle' infant formulas and leave their babies at home in the slums and shanty towns with their grandmother or big sister to bottle feed. And as I just pointed out, this is frequently lethal. Studies from Kampala, Uganda and Singapore show that the pattern of malnutrition is changing—in towns, anyway. The problem period used to be the second year of life. Now malnutrition is striking during the first year of life, which suggests a disastrous decline in breast-feeding in these cities."

I asked Jelliffe about a photograph on his wall showing a woman suckling a child at one breast and a baby pig at the other. Was this a recommended practice?

"No, it certainly isn't—breast milk is for babies—but it's not harmful in itself. The photograph comes from New Guinea. I have another one here that shows an American Indian woman in the hinterland of Guyana nursing a pet fawn. These are just curios I have to remind myself and my co-workers that breast-feeding in traditional circumstances is no more difficult than swallowing a glass of water. Lactation is basically a confidence trick. If you have confidence, it works. If you're anxious, if you have doubts, if problems are put in your way—as in many Western maternity units, where breast-feeding violates the whole hospital routine—then you have problems. In bringing better maternity services to the cities of the developing countries, this is a very important thing to keep in mind. Otherwise we might do more harm than good."

And what of the older children, from six months of age on, who need supplementary foods? If for infants, the prime consideration was to retain the traditional practice of breast-feeding, how could one go about improving traditional feeding practices for the older children?

"Here again I think it important not to try to alter traditional practices too sharply. Remember what I just said about cultural super-foods. Well, you shouldn't disparage these to the people who believe in them. In southern Uganda, for example, one would never tell mothers that matoke-steamed plantain is not a good food. The message should be that their children need matoke plus skim-milk powder, groundnut or whatever other high-protein food was available. When children begin to put on weight and regain their health, this point is demonstrated by the best possible visual aid—the mother's own child."

The Impact of Food Technology

I asked Jelliffe in this connection if he shared my feeling that all the highly publicised work of the past ten or fifteen years in new high-protein food development seemed to have had fairly little impact on nutritional conditions in the developing countries, at least so far as the rural masses were concerned.

"I think the advances in food technology have been quite extraordinary and almost incredible and have influenced food patterns all over the world. But their impact is going to be largely on the new city dwellers and others who live in a money economy and have no chance of growing their own food. They are not going to affect people living in a subsistence economy very much.

"The backyard approach to nutrition has not received much publicity because it doesn't have anything to do with space-age technology. It's not 'with it'—it doesn't say 'twenty-first century'. But we're realising now that sophisticated processed foods are expensive and that they're hard to distribute in rural areas and that it's just as scientific to think in terms of nutritious mixtures based on foods available in villages themselves—we call these 'indigenous multimixes'. There are few if any perfect foods. Most cultures meet their protein and other requirements through certain types of multimixes. Cereal-legume mixtures are the most common, and the cheapest of these multimixes that supply the full range of amino-acids needed for human protein nutrition. In Jamaica the mixture is rice and peas; in Mexico it's jrijoles and tortillas; in Indonesia rice and various soyabean preparations. In Britain, by the way, baked-beans on toast is a popular snack.

"Now, if as scientists, we study the natural foods already available in a community, we usually find that we can work out a formula for a weaning food that is just as complete as anything the most sophisticated food technologists could work out in a laboratory. We can start with the staple—the 'super-food'—preferably a cereal, but not necessarily. Then we add a legume plus if possible, small quantities of foods of animal origin—milk, meat, eggs, etc. We add a dark green leafy vegetable in small quantities as a vitamin and mineral supplement and lastly, and very importantly, compact calories, preferably in the form of fat. You can do this in almost any culture, and there as many possible multimixes as there are cultures and ecological areas."

And what of the problem of persuading mothers to accept these?

"It's not easy—just as it's not easy to get the press to pay attention to this type of backyard science. It seems so trite and fanal to suggest to a mother that her child's poor weight gain can be remedied and other symptoms of malnutrition prevented by such simple means. There's a disappointing lack of glamour to the whole thing. And people expect doctors to provide a good deal of glamour. When they bring their children to a hospital they regard the taking of X-rays and temperatures as part of the cure. The only solution is to involve the mothers—not just treat the malnourished children and send them home again.

"Dr J. M. Bengoa, now chief of the nutrition division of WHO, worked out a model ten years ago for a nutritional rehabilitation unit that functioned in precisely this way. Different variations have now been developed in different parts of the world and they function quite effectively. Basically, they all embody the same idea. These nutritional rehabilitation units are set up near the villages, away from the central or district hospitals. The mothers are involved from the beginning of treatment. Sometimes they grow the necessary foods, sometimes they purchase them. They always have the job of helping prepare the children's special meals and feeding them to the children. These meals are all based on locally available foodstuffs, and the mothers can see the effect they have on these sick children, so they realise it is good food that makes the difference, and not hospital apparatus or any thing like that. These women tell the new women coming to the clinic with sick children what has happened, and when they return home they communicate their new ideas to other women.

Emphasis on Local Foods

"Dr C. Gopalan, Director of the National Institute of Nutrition in Hyderabad, India has shown that children's nutrition in India could be improved very considerably if mothers were persuaded to feed their young children larger quantities of even the limited range of village foods available to them—especially rice-legume mixtures. Gopalan and his colleagues have developed an uncomplicated 'Hyderabad Mixturei' of wheat, groundnut and other ingredients, all quite cheap, which is used to help children recover from malnutrition. This is given to the mothers of sick children by the health centres. Then, when the child recovers, the nutrition-education people explain to the mother what the ingredients are, how she can prepare similar nutritious multimixes herself. This is a slightly different approach from Bengoa's, but it works, too.

"I want to stress that this work on local multimixes is quite as scientific as any of the more glamorous work in space-age food technology that is going on. Scientifically guided research into various recipes, formulas and mixes is being conducted in many parts of the world. We are trying to determine things like precisely how much rice and how much legume have to be cooked together to get an optimal amino-acid balance for young children. A committee of the FAO / WHO / UNICEF Protein Advisory Group, under the Chairmanship of Professor B. Vahlquist, of the University of Uppsala, Sweden, has developed a manual for village-level multimix weaning foods. I can't think of anything of greater practical import now going on in the whole field of nutrition."

Jelliffe is fond of pointing out that nutrition education based on Western models is not always very effective in developing countries. One of the shibboleths he would like to see nutrition educators get away from is the motion of basic food groups, as presented in those familiar charts which display cereals in one compartment, dairy products in a second, fish and meat in a third, green vegetables in a fourth, and so on, with the injuction "Eat something from each group every day"—advice which is wildly visionary so far as three-quarters of the human race is concerned.

"The idea of the basic food groups—the precise number varies from ministry of agriculture to ministry of agriculture—dates back to the early 1920s, when it was devised in the United States as a means of getting farm families to vary their diet. It was probably a useful innovation at that time. To divide foods into these special groups like this isn't very scientific, however, and it can cause confusion. For example, you can't distinguish as sharply as most food-group charts do between protein foods and carbohydrate-calorie foods. Because of the wide impact of these food-group classifications, educated laymen often don't appreciate the fact that most of the protein eaten by man comes from vegetable sources, and largely from cereals, at that. If you have a properly balanced consumption of vegetable protein, based on several different sources, you can dispense with meat and dairy products altogether."

"A more rational approach to nutrition education, I feel, and one that does less violence to people's cultural concepts, is to start with their staple food and move outwards and upwards from that food in teaching them about good nutrition. If there are two staple foods in a culture, then start with the more nutritious of the two—a good cereal, if possible and show them in very practical terms how they can supplement it. I think this is a more rational procedure and one less likely to confuse mothers. Sometimes the categorisation of products into basic food groups is more appealing from an aesthetic point of view to the nutritionist and the artist than it is useful or understandable to village mothers."

Famines and Families

Lying across the desk from me I saw a reprint of an article on "The Effects of Starvation on the Function of the Family and Society", by Jelliffe and his wife, Patrice. The reprint was illustrated with horrifying photographs of recent famines and equally horrifying line-and-wash drawings of older ones.

"How did you get into this?" I asked. I could not avoid it. You know with the end of the post World-War II emergency period, we hoped we were done with actual famines. FAO, WHO, UNICEF—the UN agencies concerned turned their attention to long-term, chronic food and nutrition problems. They were right to do so. Every day malnutrition in the world's poorer countries kills and damages more children than all the man-made and natural catastrophes combined. But we were wrong in thinking there would be no more famines. There was the Bihar famine of 1967 in India. Then came the Nigerian civil war, when one of the most severe famines in history occurred in the would-be breakaway eastern region. We still aren't out of the woods in Bangladesh though major starvation seems to have been averted so far.

In 1970 the Swedish Nutrition Foundation convened an international symposium on starvation to draw up guidelines for a kind of international fire-brigade to deal with future famines. Famines are certainly going to arise in the future, but with the extensive food surpluses on hand in certain parts of the world and with the space-age communications and transport systems we now possess, there is no reason why they have to be as murderous as in the past. I'm glad to see the UN is already taking up some of the suggestions made at the symposium.

"I was asked to present a paper on the effect of starvation on family and community ties. My wife and I did quite a bit of research into the matter. There's a good deal of information on record about famines going back thousands of years. Many accounts of famines were written under very terrible conditions: often they contain little in the way of precise figures. But the general pattern is clear. "

"The first affected, when famine strikes, are children in their second year—the ones who have been recently weaned or are being weaned, in other words—pregnant and lactating women, and the sick and aged. At first, the infant at the breast is spared. Lactation seems to persist quite well in early starvation, though of course to the great detriment of the mother. As starvation persists, the mother's milk dries up, however, and the infant of nursing age then becomes the most vulnerable member of the community. So basically, the greatest casualties of famine—short of everyone's starving to death—are young children and pregnant and nursing women. Late in the Nigerian war, one observer in the eastern zone noted laconically, 'One hardly sees children aged between six months and five years.'"

"The psycho-social effects of famine are just as clear from the record. At the beginning, the family, the clan, the community draws closer together. But as the experience continues, normal social ties break down. The sole focus of people's thoughts and activities is food. Ultimately it is every individual for himself. This leads to the wholesale abandonment of children. People leave their homes to search for food and simply leave their children behind."

"So far as international relief efforts go, I think it's clear that there should be the greatest attention given to selective distribution of appropriate food to young children and to pregnant and lactating mothers. Lactating mothers are a priority group not only on their own account but because of the need to enable them to continue the production of the most vital of all emergency foods for young babies—breast milk."

The Future

As a wrap-up question I asked Jelliffe what he thought all the international work in the field of food and nutrition over the past 25 years added up to and what he thought the future prospects were.

He told me it was an impossible question to answer briefly. "We've learned a good deal from the things we've done over the past 25 years. One thing we've learned is that some of the orthodox approaches don't work very well. I'm thinking of conventional hospital treatment, large scale and relatively unsupervised supplementary feeding programmes, stereotyped village applied nutritional programmes. The International Union of Nutrition Sciences had a meeting in Zagreb, Yugoslavia, in August, 1971. The subject was 'young child nutrition' and the meeting was attended by fifty persons of considerable experience from all over the world. We looked over all these world-wide programmes, some of which represent investments of tens and hundreds of millions of dollars, and we concluded that the future of applied nutrition work lay in greater adaptation of programmes to local circumstances, community involvement in fact and not just on paper, the use of greater numbers of auxiliaries and volunteers. In a sense, we've got to get nutrition away from the experts. We need to induce auxiliaries and volunteers to go out into the villages and carry messages of a very simple-seeming nature to the people.

"I suppose this is what I've been talking about to you for the past hour or so: that it's the human element that counts. I think the prospects of combating malnutrition among the children of the world's poorer lands are good if we can get through to the people. Which means we have to understand them and that we have to understand just what food means to them."

WHY NUTRITION EDUCATION?

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Hunger is the most important driving force ... It demands food ... Food is fuel of body machine ... Search of ancient men – Hippocrates ...17th century—Helmont, Sanctorius ... Beginning of experimentation 18th Century—avoisier ... 19th Century—period of exploration — Magendie, Liebig, Boussingult, Bidder, Schmidt, Voit, Rubner, Atwater, Lusk ... Beginning of 20th century-Generalisation begins-Langworths law ... Search for food dependent diseases ... Discovery of Vitamins in 1912 ... Advancement of food technology upto 1940 ... Period of war and famine upto 1960 ... Balance sheet of progress re-examined – result showed that a Frankenstein has been created so far as food is concerned ... Human proclamation in 1963 from Rome – Hunger is still our enemy but malnutrition is worse ... Strategy of this fight for nutrition at three areas – Analysis of food and nutritional problems, improvement of food production and distribution, and implementation of Nutrition Education.

Introduction

Hunger is the most important driving force in all animals. The same is true about man. It is in the search of food that primitive man roamed from place to place, crossed deserts, rivers and mountains, visited new places and explored new horizons. With the invention of agriculture the quest for food was minimised and the idea of living together was strengthened. This led to the establishment of villages, towns and cities. To be precise, civilisation started to grow around the spots where it was possible to satisfy hunger. Throughout the history of mankind the major task before all civilisations was to feed its people. In spite of all our progress, hunger is still the worst enemy of mankind. It has remained a Herculean task for most of the Governments of the world today. Some countries are successful, others are fighting hard. All feel unanimously that it is due to hunger that "our civilisation is mutilating in human resources and reducing its chances of progress" (Manifesto issued in World Convention at FAO, Rome).

The history of mankind has repeatedly shown that an empty stomach has often triggered brilliant ideas. But it is also true that millions of potent Van Gogues and Knut Humsuns remained incapacitated and never flourished. More creative minds perished due to hunger than those who were able to express. That is why it has been emphasised that freedom from hunger is man's first fundamental right. Today all human endeavour – arts, science, technology and industry are directed to fight this menace. The war is not against hunger alone. Mere filling up of one's belly is not enough. The worst enemy is malnutrition and our fight is against it. It is a sacred duty of all individuals to join in this crusade. To effectively participate in the venture one must know what has already happened in this fight for nutrition.

Historical Records upto 18th Century

All ancient philosophers have stressed the need for a healthy body, and in some form or other have emphasised the relationship of food with the health. Hippocrates, one of the leading ancient Greek philosophers, said – "Growing bodies have the most innate heat; they therefore require the most food, for otherwise their bodies are wasted. In old persons, the heat is feeble and therefore they require little fuel." Those were the days when experimentation was absent. The relationship of food with the working of human body was first reflected in the works of Von Helmont and Sanctorius. But what is understood today as nutrition, came up only in the late 18th century when Lavoisier performed his classical experiments to demonstrate the processes of respiration and external combustion. Lavoisier's experiments opened up the similarity in the possibilities of future understanding on nutrition. For this reason, Lavoisier is regarded both as the father of nutrition and that of modern chemistry.

19th Century Achievements

Up to this period all foods were considered to be of equal nature and importance. It was Magendie in the early 19th century who for the first time classified food on the basis of its composition into carbohydrates, proteins and fats. This was followed by the works of scientists like Boussingult (France), Bidder (Germany), Schmidtt (Germany), and Liebig (Germany). Liebig's contribution in nutritional studies was followed by his student, Voit. Several biochemists who later worked in the different parts of the world came from Voit's laboratory in the University of Munich. The 19th century ended with the gain of human knowledge on the composition of a large number of foods and their specific functions.

20th Century Progress

Twentieth century dawned with the coming of a book on Nutrition by Lusk in the year 1906. On the basis of knowledge already obtained in this period Langworthy forwarded his famous laws of nutrition, according to which:

1. Nitrogen is supplied to the body only through food and not directly from atmosphere.
2. Nitrogen is never released from the animal body in gaseous state but always excreted through urine and faeces.
3. All animals can adjust themselves to their Nitrogen intake thus maintaining a state of Nitrogen balance, where input is equal to output.
4. Certain amount of food groups – protein, fat and carbohydrate—is necessary for maintenance. Minerals of unknown quantity are essential for the proper functioning of the body.
5. Muscular work, fattening and lactation demands more food.
6. Excess foods are stored at least partly as reserve material mainly as fat and glycogen.

7. The body attains the nitrogen equilibrium at various levels of the intake of protein.
8. Body fats are formed from fatty food, carbohydrates and also proteins.
9. As suppliers of energy the different compositions may replace each other in approximately the following ratios – Protein: Fat: Carbohydrate: : 1 : 2.5 : 1.
10. Nutrients obtained from the food combine inside the body with oxygen of the air and undergo combustion, thus liberating energy for the use of the body.

Enunciation of Langworth's law led to a clear understanding of the relationship between food and working of the body. But no sound explanation was forthcoming to the causes of diseases like Beri Beri and Scurvy, The cure of which was somehow related to the intake of fresh food. Thanks to the works of Hopkins and Funk, we learnt that these diseases were caused by the lack of vitamins. This discovery was followed by tremendous explosion of knowledge about vitamins. By 1940, not only the sources of various vitamins were known, but also their functions and chemical nature were understood and a large number of them were synthesised. Next twenty years saw rapid growth in the field of food production. Millions of dollars were invested in food technology. Numerous methods of food processing were developed. This resulted in a general conviction that a "full belly meal" is enough for good health. There is nothing to worry about one's nutrition, if one gets sufficient food to eat.

In spite of such rapid growth in food production, it was felt that food eaten to meet hunger is not enough for nutrition. Moreover, in spite of prosperity in one half of the population, the other half is facing mutilation due to hunger. To satisfy hunger is the immediate problem of most developing countries but malnutrition still remains a serious threat to all. Literature which has been accumulated in the last 15 years, speaks about the seriousness of the problem and an intensity of human efforts to fight for better nutrition. All of these efforts may be classified into three groups:

(a) Food and nutritional problems: Dealing with the existing food position and survey of nutritional problems both in developed and underdeveloped countries.

(b) Improved food production and distribution: Surveying the human endeavour to produce better food both qualitatively and quantitatively.

(c) Nutrition education: Communicating the truth about nutrition to help in combating half-truth, ignorance and quackery.

The problem of food and malnutrition is a global problem. All our enterprise is based on this assumption that problem of nutrition is more due to the lack of knowledge about food than to the scarcity of food. This information belonging to each group, therefore, deserves a detailed discussion.

(a) Food and Nutritional Problems

Food and Agricultural Organisation (FAO) of the United Nations sponsored a convention in Rome in 1963 to discuss the problem. It proclaimed that "freedom from hunger is man's first fundamental right". Almost all the nations of the world are working together under the banner of world organisations like FAO, WHO and UNICEF to fight for this cause. Latham (1965) has discussed the nutritional problems of tropical Africa and also the steps to combat these problems. This pioneering work with local variation may serve as an excellent guideline for all developing nations. The working model as proposed by Berg and Levinson (1969) to combat malnutrition also deserves mention. The demand of food is growing and more efficient input is needed, especially to supply more calories (Brown, 1961; Oshima, 1969; FAO, 1969). The question of malnutrition which includes both undernutrition and overnutrition, has been critically reviewed in recent years (Davis, 1969). Its ecology, etiology and impact on national development has been thoroughly outlined (Berg, 1969; Robson, 1972). Scrimshaw (1969) has discussed the impact of malnutrition on the learning ability of the child. Recent findings about the relationship of malnutrition with the development of brain and learning behaviour has strengthened the need for proper nutrition. This finding has strengthened the claims of Williams (1971) that malnutrition is the root cause of all kinds of diseases including heart disease and cancer. Recent evaluation of technological involvement in food processing has revealed many interesting findings and the entire food technology is passing through a phase of reappraisal (Lund, 1973; Labuza, 1973; Livingston, 1973; Carpenter and Booth, 1973).

(b) Improved Food Production and Distribution

To fight malnutrition, it is essential to improve food production. Fischnich (1967) has discussed the possibilities of increased food production to feed the hungry millions of the world. The green revolution is the most encouraging step forward in this direction. But considering the rate at which the population is increasing, it will not be possible to cope up with it through the quantitative increase alone. It has been estimated that food already available on this earth, if uniformly distributed, will be of much help to ease the problem. The different alternate means which are available today to safeguard the interest of nutrition have been elaborately discussed by Latham (1965) and Robson (1972). These efforts include production of food materials with enriched nutrient, fortification of foods with amino-acids which are growth promoting and health conserving (Rosenfield, 1969) and development of new kinds of food mixes, specially new protein foods (Altsclaul, 1969). It is now well known that though malnutrition is a global problem, yet it will have to be tackled by taking into consideration each local condition. This has demanded careful survey of local food habits and attempt is in progress to improve the staple food of a particular locality. Together with efforts in food production it is also felt that proper knowledge about nutrition is essential. This makes urgent the demand for nutrition education.

Nutrition Education

The most important cause of malnutrition is ignorance (Fig. 1). This is applicable equally to developed and developing countries. The ignorance prevails among both educated and uneducated people. In a community, physicians, nurses and social workers are responsible for tackling health problems. As nutritional consciousness involves formation of habits and change in attitudes, teachers in schools have a significant role to play. The role of law-makers is equally important. Unfortunately, all the above mentioned functionaries lack proper knowledge about nutrition. The success in the fight for nutrition depends upon the collective works of all these functionaries. Such group work is effective only when all the components of the group have right kind of nutrition education.

Before envisaging the nutrition education for the functionaries as well as the target groups it is necessary to consider the following points:

(i) Our knowledge about nutrition has come from different disciplines – medicine, biology, chemistry, physiology, agriculture, economics, politics and social sciences. It is imperative, especially for functionaries, to have a thorough grip on the contribution of these different areas to the field of nutrition.

(ii) Malnutrition is a global problem and the fight against it is operating at different levels – World, Country, Community and Individual. The victory depends upon the success at the last two levels – community and individual— and the success will depend on the coordinated activities of the different functionaries. Local problems will have to be sorted out and it should be solved as far as possible with local means.

(iii) It is to be remembered that opposite forces are also operating which include quacks and other unscientific elements. They spread their half-truths more speedily. Stare (1973) has rightly pointed out that nutrition education is urgently eeded to meet the challenge…"in communicating the truth more effectively than quacks spread their half-truths and misfortune".

Next comes the most important question of planning nutrition education for the target group, i.e., general masses. With our limited resources it is not possible to affect all. Thus target group has been pinpointed to the most vulnerable section of the society—children, pregnant and lactating mothers belonging to low income groups. And for effective and permanent result it has been agreed that our future citizens will have to be influenced when they are young. No moment is more opportune than the school-going period, the time when a child passes through the habit-forming stage. A well planned nutrition education at this stage can bring radical change in the desired direction. The result of such change may not be felt immediately but will definitely bear fruit in the long run.

In planning nutrition education for school children, it is essential to remember the following points:

(i) The insight developed through nutrition education must be helpful to adopt advice and action to suit each new situation.

(ii) As genetic composition of man varies so also does his nutritional requirement. The nutrition education should be such it enables the person to solve his or her own nutritional problems.

(iii) Survey should be made to find out the existing problems in the locality which are due to malnutrition or responsible for malnutrition.

(iv) Clear cut knowledge about dietary practices and prejudices should be ascertained.

Nutrition education must encourage healthy habits and discourage unscientific ones.

(v) Nutrition education should be directed towards the prevention of malnutrition. But at the same time it must deliver information about the clinical aspects, which will help in the better understanding of the preventive measures.

(vi) All methods of teaching should be utilised.

Conclusion

Science and technology helped man in the past to win over a number of problems. The secret of the success was careful planning. But often the solution of a problem has created new problems. Nutrition is one of them. Being the main locus of environmental disaster, it is threatening the existence of mankind. But man is the only animal who can understand the future and is capable of taking necessary steps. If all human beings cooperate, it will be possible to avert the crisis. If ingenuity and patience persist, there is no doubt that in this fight for nutrition, victory will be ours.

Mere increase in food production, its equitable distribution and curbing the exponential growth in world population are not enough. The real strategy to win over this monster is through educating the masses. Battlefields for this crusade are not factories and farmhouses but millions of classrooms all over the world.

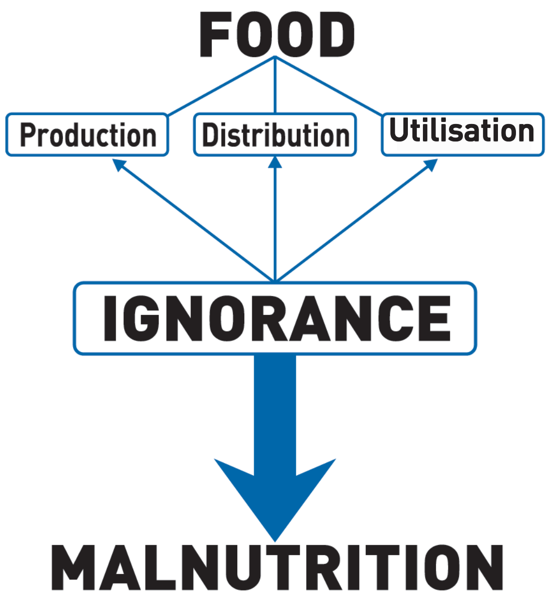

Fig. 1. Showing the possible causes of malnutrition. Ignorance is the most important cause.

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THE FATHER OF WHITE REVOLUTION

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(Late) Dr. Verghese Kurien

Our country has the largest cattle population of any nation in the world. Our people have traditionally venerated cows. Does this mean that we have a very efficient dairy industry? Unfortunately, the answer is *No.* Most of our cattle are deplorably fed and maintained and hence our yield of milk per animal is one of the lowest in the world. Nevertheless, there has been a considerable improvement in the situation over the past 25 years due to a remarkable programme *Operation Flood*, which has become irrevocably linked in the minds of discerning people with the moving spirit behind it, Dr. Verghese Kurien. It has been one of the outstanding successes that we have achieved since Independence.

Verghese Kurien was born in Calicut in Kerala on 26 November, 1921. In 1940 he obtained his Bachelor of Science (B.Sc.) degree and in 1943 the Bachelor of Engineering (B.E.) (Mechanical) degree, both from the University of Madras. He studied further at the Tata Iron and Steel Company Technical Institute in Jamshedpur and graduated from there in 1946.

In the period immediately preceding Independence the British Government offered a number of scholarships to study abroad to young Indian professionals. Kurien applied for it, hoping to study nuclear physics and metallurgy. He was however offered Dairy Engineering. This gave a fateful turn to his career. He studied this subject in the Michigan State University in the U.S.A., obtaining the degree of Master of Science (M.Sc.) in 1948.

Kurien was yet to realise that he was being inexorably drawn into his life's work. On his return to India he was posted as a dairy expert in Anand in Gujarat and he took it up hoping to break free as early as possible and pursue his earlier interests. But he ran into a remarkable man, Tribhuvandas Patel, a freedom fighter and highly committed social worker.

One of the painful facts regarding the economic structure of our country must be mentioned here. In the case of many major commodities, such as grains, vegetables, edible oils etc., only a small fraction of what the customer pays reaches the actual producers. It is the rapacious middle men who take the lion's share. Milk was no exception. But the simple farmers of Kaira district in Gujarat decided to do something about it. On the advice of the inimitable Sardar Vallabhai Patel they formed in 1946 the Kaira District Cooperative Milk Producer's Union, destined to become famous for its brand name AMUL.

But the beginnings were quite humble. A handful of members contributed about 200 litres of milk a day. But the founders had two priceless assets. Firstly, a clear vision of their goal: the highest possible share of what the consumer pays should go to their members, the milk producers. Secondly, they had as their chairman Tribhuvandas Patel. Into this scenario Kurien was propelled by fate.

Close contact between Kurien and Tribhuvandas Patel made each realise the other's importance. Kurien came to appreciate that technological knowledge without an understanding of the farmers' problems and a commitment to their welfare ultimately brought no benefit to society. Patel on his part came to understand that ideals and commitments alone were not enough to raise the economic level of the poor milk producers to a higher level. They had to be backed by solid technical knowledge and professional management.

The gradual solidification of his emotional attachment to the milk farmers made Kurien realise that he could not break away from them as he had originally intended. The persuasion of Patel also played its part. He took great pains to procure the modern equipment that Kurien suggested. These included chillers and milk powder plants. The fact that a huge market, Bombay City, existed nearby also helped.

It is never easy to overcome entrenched vested interests with their supporters in the administration. But Kurien and Patel had the backing of the growing number of the co-operative members who came to realise that the organisation was being run for their benefit. Also the political leadership at the highest level, in particular Prime Ministers Lal Bahadur Shastri and Indira Gandhi gave them powerful backing at the right stage.

Kurien also came to know how unreliable 'experts' are. A foreign dairy specialist asserted that buffalo's milk was unsuited to the production of milk powder. He had to be proved wrong by doing it successfully. This made Kurien form his half-humorous but wholly true dictum: "Listen carefully to the experts and then go ahead and do exactly what you feel is right".

The early period of any project to benefit the disadvantaged is always the most critical since it would have to meet the fierce resistance of vested interests, and powerful popular support to counteract it would not be available at that stage. The Anand Experiment was to have more than its share of teething troubles, but they were gradually overcome by the "enlightened stubbornness" of its leaders and the growing support of its members. Its success attracted the interest of other milk producers in Gujarat and finally the political leadership at the highest level. This latter factor was to prove crucial in its spread to the rest of the country.

In 1964, the then Prime Minister of India, Shri Lal Bahadur Shastri visited Anand and was so impressed that he requested Dr. Kurien to "transplant the spirit of Anand" to the rest of the country. Next year, the National Dairy Development Board (NDDB) was formed to realise this vision.

Dr. Kurien and his associates drew up an imaginative action plan, destined to become famous as Operation Flood. Here the aid extended by the European Economic Community (EEC) is to be acknowledged. The huge surplus of milk powder in the EEC was donated and its sale in India formed the seed capital for the programme. During Phase I of Operation Flood, started in 1970 with Dr. Kurien as the Founder Chairman, 18 of India's best milk producing regions (Milk Sheds in the jargon of the trade!) were linked to the four principal cities, Delhi, Bombay, Calcutta and Madras. The cooperatives established under the programme guaranteed to accept all the milk delivered by the farmers at a mutually agreed price. They also provided the farmers veterinary services, expert advice and means of upgrading their cattle breeds by crossing them with superior milk yielding foreign cattle. But its greatest achievement was in channeling the bulk of the sale proceeds to the actual producers instead of to exploitative middlemen.

It is a well established fact that a change in the physical living conditions of people changes their attitudes too. Operation Flood was no exception to this. Increasing prosperity brought about a remarkable change in the attitude of the cattle farmers of the Cooperatives. They began looking to the future with confidence and realised that their fate lay in their own hands. Improved housing, hygiene and better education for their children followed as a matter of course.

During Phase II of Operation Flood, implemented during 1981-85, 136 milk producing regions were linked to over 290 urban markets. More than 4 million cattle farmers became members of the cooperatives.

Phase III of the project, from 1985-1996, consolidated the gains by building up the basic infrastructure for procurement and distribution of milk and by providing better veterinary services and even health care services to the members. Today more than nine million farmers belong to dairy cooperatives and they pour in more than 11 million litres of milk every day into the network, to be distributed to our cities and also to be converted into milk powder and other products. Today India's per capita milk consumption is double that at independence in spite of a near tripling of the population. India is now the second largest and possibly even the largest producer of milk in the world (still it must be remembered that our per capita milk consumption is far below that of developed nations. There is a long way to go yet).

Dr. Kurien himself emphasises that the success of the programme was not a little due to the integrity and robust commonsense of the mass of simple farmer members. His respect for them increased with the years. He recounts how the belief of the farmers in the efficacy of feeding cottonseed mash to the cattle (which he did not share) was much later confirmed by scientific research. He feels that there is a lot in such folk wisdom that is being ignored or lost due to progress.

The success of Operation Flood led the central leaders to ask NDDB to bring about a similar change with regard to some other critical commodities, namely edible oils, vegetables and fruits, salt and trees for fodder and fuel. Accordingly, the Oil Seeds Growers Cooperative Project was launched in 1979 and now covers nearly a lakh of farmers. In 1986, a pilot project was initiated through Tree Growers Cooperatives. The Sabarmati Salt Farmers Society was set up in 1987. The Fruit and Vegetable Project was initiated in 1988. Thus the revolution in milk production that Dr. Kurien helped to launch is producing an enormous multiplier effect.

Dr. Kurien's basic conviction with regard to technological development can be summed up in one sentence: It must bring prosperity and welfare to the mass of the people (this is precisely what Gandhiji meant when he declared that what India needs is not mass production but production by the masses). Dr. Kurien is strongly against Market Economics which aims at a mindless increase in production (and profits to the big producers!) without regard to its repercussions on the bulk of the population and on the environment. He points out accurately that the advanced nations that shout themselves hoarse about "Free Markets" heavily subsidise their own farmers and protect them from foreign competition. He is all for utilising effective technology developed abroad but is against receiving massive foreign handouts that kill our own initiative. He has a profound respect for the wisdom and integrity of our farmers and feels that they only need expert guidance and effective organisation to succeeed.

Dr Kurien is convinced that as long as the world is divided into haves and have nots there can be no peace. It will only mean the ultimate impoverishment of everybody.

Dr. Verghese Kurien's contributions have been widely recognised both in India and abroad. Among the honours that the nation has bestowed on him are Padma Shri (l965), Padma Bhushan (1966) and Krishi Ratna (1986). Among the International honours are the Ramon Magsaysay Award (1963) and the World Food Prize (1989).

Apart from the success of his efforts, Dr. Kurien has also served the nation greatly by setting a glowing example for the younger generation. In the earlier stages of his career, Dr. Kurien had to repeatedly face the scepticism and contempt of foreign dairy experts who felt that Indian dairy men were incapable of measuring upto modern technological standards. He used to react strongly to such taunts and vowed that he would prove them wrong - and he did. If more Indian scientists and technologists follow his footsteps, the days of India and Indians being treated with condescension will come to an end.

LEARN MORE ABOUT BUCKY- BALL

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Carbon has been known as the king of elements because of its versatility and diversity in all areas. Currently, it has three allotropic forms viz., diamond, graphite and buckminsterfullerene (C_{60}) or bucky-ball, in short. Diamond has been prized for centuries as a gemstone of extraordinary beauty, brilliance and lustre. The word diamond derives its name from the alteration of the Latin word adamas meaning 'untamable' referring to its hardness. The name graphite comes from the greek verb graphian meaning 'to write'. It has been used in lubricants, seals, insulators, filters, refractors, electrodes and writing material. Bucky-ball, the third form of carbon, was synthesised in laboratory by Smalley and Kroto (1985). Scientists have been speculating that bucky-ball might be formed every time we light a candle. They have also suggested that it might be abundant in clouds of interstellar dust (Smalley, 1996). The properties associated with two allotropic forms (diamond and graphite) of carbon have already been investigated thoroughly and researchers are well aware of the properties of these two forms (Gopalkrishnan and Subramanyam, Dec. 2002) and (Ravichandran, Sept. 2001). However, regarding the third new form (bucky-ball) of carbon, there is very little awareness among students till date. This has been realised during the supervision duty in intrernship programme of B.Sc. B.Ed. in different schools. Keeping the above in view, attempts have been made to highlight the properties and derivatives associated with the 'bulky-ball' and also to discuss its structural properties,synthesis methods and applications in this article.

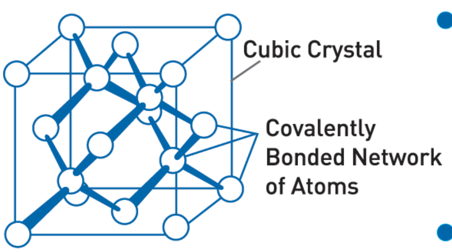
Allotropic Forms of Carbon and their Structures

Carbon has three crystalline allotropic forms viz., diamond, graphite and bucky-ball. Their crystal structures are shown in Fig. 1(a), (b) and (c) respectively. Graphite is the carbon form that is stable at room temperature. Diamond is the stable form at very high pressures. Once formed, diamond continues to exist at atmospheric pressure and below about 900°C, because the transformation rate of diamond to graphite is virtually zero under these conditions. Graphite and diamond have widely differing properties, which lead to diverse applications (Table 1). For example, graphite is an electrical conductor whereas diamond is an insulator.

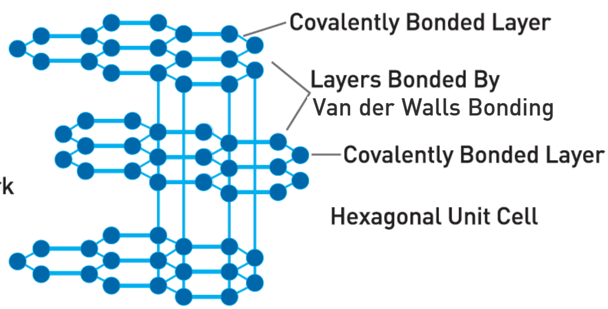
Table 1

Properties of three allotropic forms of Carbon

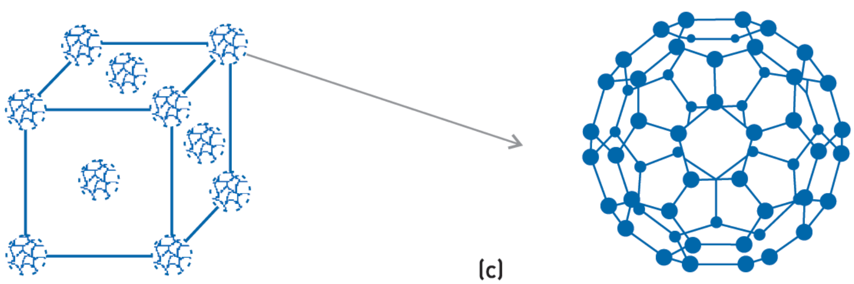
Properties	Graphite	Diamond	Bucky-ball
Structure	Covalent bonding within layers, Van der Waals bonding between layers, Hexagonal crystal structure	Covalently bonded network. Cubic crystal structure	Covalently bonded C_{60} spheroidal molecules held in an face centred cubic crystal structure by Van der Waals bonding
Electrical	Good electrical conductor	Very good electrical insulator	Semiconductor compounds with alkali metal (e.g. K_3C_{60}) exhibit super-conductivity
Thermal	Thermal conductivity comparable to metals	Excellent thermal conductor, about five times more than Copper	
Mechanical	Lubricating agent, Mechanable. Bulk graphite Y = 27 G Pa ñ~2.25 g cm-3	The hardest material Y = 827 G Pa ñ = 3.25 g cm-3 except boron nitride	Mechanically soft.Y = 18 G Pa ñ = 1.65 g cm-3



(a) Diamond



(b) Graphite



(c)

The FCC Unit Cell of the Bucky-ball

Bucky-ball Molecule (C_{60})

The bucky-ball (C_{60}) is the most symmetric molecule having icosaludral point group with 120 symmetry operations. It has a shape of a soccer ball in which 60 carbon atoms bond with each other to form a perfect soccer ball type molecule. This molecule has 12 pentagons and 20 hexagons, joined together to form a spherical molecule with each carbon atom at a corner as depicted in Figure 1 (c). It has been established that solid C_{60} forms a face centred cubic (F.C.C.) lattice with a lattice constant 14.17 A° at room temperature. In this structure the distance between the nearest neighbour C_{60} cluster is 10A° and thus the intercluster separation is 2.9A°. Scanning tunneling microscope (Fig. 2 a and b) and scanning electron microscope (Fig.3) pictures clearly show the hexagonal arrays of closely packed spherical balls. (Grigoryan et. al. (1992), Sharma et. al. (1992), Kratschmer et. al. (1990) and Baggot (1991).) Table 2 provides x-ray diffraction parameters for a crystal of bucky-ball. The typical properties of bucky-ball are summarised in Table 3.

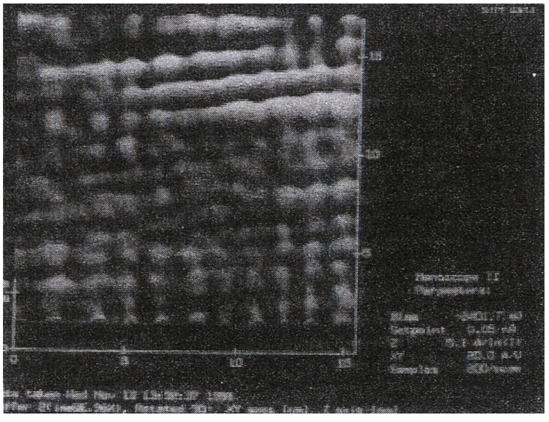


Fig. 2(a): Scanning tunneling micrograph of molecularly resolved buckyball image in 3D perspective. Bias voltage and current are shown in scanning tunneling micrograph.

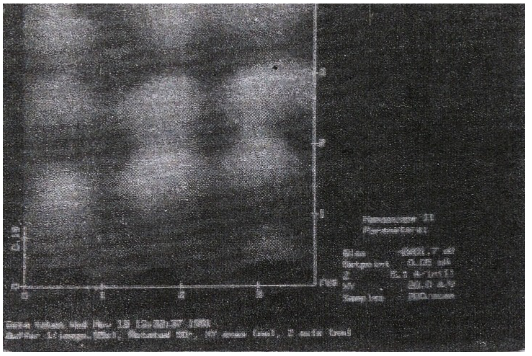


Fig. 2(b): Same micrograph at higher magnification

Table 2: X-ray diffraction parameters

Measured 2 Θ (degree)	Measured d spacing (A°)	Calculated d spacing (A°)	Assignment miller indices (hkl)
10.2	8.70	8.68	(100)
10.81	8.18	8.18	(002)
17.69	5.01	5.01	(110)
20.73	4.28	4.28	(112)
21.63	4.11	4.09	(004)
28.1	3.18	3.17	(114)
30.8	2.90	2.90	(300)
32.7	2.74	2.73	(006)

Fig. 3: Scanning electron micrograph of a film of bucky-ball. Magnification, scale and operating voltage are shown on the micrograph.

Table 3
Some properties of bucky-ball

Shape	Spherical (20 hexagons and 12 pentagons)
Dimensionality	3D
Density	1.7 g/cm^3
Crystal structure	Face centered cubic
C - C bond length	1.44 A°
State of Hybridisation	Intermediate between SP^2 & SP^3
Nearest neighbour distance	10.04 A°
Diameter	7.1 A°
Lattice parameter	16.2 A°
Index of refraction	2.2
Infrared active modes	1429, 1183, 577, 528 cm^{-1}
Bulk modules	18 giga Pascals
Ionisation potential	7.6 ev
Cohesive energy for C_{60} molecule	1.5 ev
Cohesive energy for atom	7.4 ev
Electrical resistivity	10^{11}-10^{14} ohm
Magnetic susceptibility	260 g ppm
Electron band gap	1.5 ev
Effective mass of conduction	1.3 m_e
Band electron	
Superconducting transition	19K
Temperatures for K_3C_{60}	
Rb_3C_{60}	29K
Cs_2 Rb C_{60}	33K
$Rb_{2.7}$ $Tl_{2.3}$ C_{60}	42.5K
Colour	Black
Doping metal	Intercalation of alkali
Coherence length	100 A°
Penetration depth	2000-4000 A°
Fermi energy (E_f)	0.3 ev
V_f	~ 2×10^7 cm/s
Isotope effect	0.3 – 1.2
Critical magnetic field [H_{e2}(O)]	50 tesla
Density of states [N (E_F) RB_3C_{60}/N(E_F) K_3C_{60}]	1.21
2Ä/K_BT_C	5.3

Synthesis of Bucky-ball (C_{60})

Synthesis of bucky-balls has been carried out by using mainly two techniques viz. (i) graphite arc welding, and (ii) laser ablation.

Graphite Arc Welding Technique

In this technique graphite rods of spectroscopic pure grade are butted together and a high current of the order of 100 amperes is passed through them in a controlled inert gas (He/Ar) atmosphere. The apparatus consists of a vacuum chamber, which is evacuated and then filled with inert gas (He). To the evaporated graphite condenses on the inner surface of a glass cylinder surrounding the graphite electrodes from which it is scrapped off. It has been noticed that the He pressure is very crucial for optimising the yield of bucky-ball (C_{60}). By this method solid C_{60} is prepared in the form of graphite soot. The C_{60} has been separated from the soot using liquid chromatography.

Laser Ablation

Laser ablation deposition technique has also been used to prepare the C_{60} films. In this technique, the laser beam enters the vacuum chamber through a window and is focused on a target of graphite of spectroscopic pure grade. During evaporation under the energy of the laser beam, the emitted matter forms a plume that carries the vaporised graphite to the substrate. The process works in very high vacuum as well as in inert atmosphere. By this technique very good quality homogeneous films of bucky-balls have been prepared.

Properties of Bucky-ball

Chemical properties of bucky-ball have depicted that it is a highly stable molecule. Ion beam experiments with 250 eV impact energy have shown high inelasticity of the ions but gave no evidence of impact induced fragmentation. Bucky-ball possesses a vanishingly small ð-electron ring current and hence has magnetic susceptibility far below that of graphite or benzene. Electrochemical studies have proved that bucky-ball is very strong oxidising agent and does not react with electrofiles. Rather it is easily reduced and reacts readily with nucleophilic agents like alkali metals.

Superconductivity in Bucky-ball

Bucky-ball (C_{60}) doped with potassium formed a new metallic phase known as 'buckide' and resulted in its maximum electrical conductivity when there were three potassium atoms intercalated to each bucky-ball. If too much potassium is added, however, the material becomes insulating. K_3C_{60}, a metal, becomes a superconductor when cooled below 18K. When rubidium was substituted for potassium, the critical temperature (T_c) was found to be 30K. Recently, superconductivity at 42.5K for rubidium-thallium doped material has been reported.

Derivatives of Bucky-ball

The synthesis of bucky-balls C_{60} to C_{266} in very high yield (upto 44% extractable) by plasma discharge technique has been reported by Parker *et. al.* (1991). They have characterised the extracted samples by time of flight mass spectrometry and Fourier transform mass spectrometry and concluded that almost one-third of the extractable material is composed of bucky-balls C_{84} to C_{200} (Parker *et. al.* 1991). Similar to discovery of bucky-ball, a major breakthrough came in 1991 when the synthesis of carbon nano tubes (CNTs) was announced by Ijiyama. Careful analysis revealed that these carbon nano tubes are long tubes made from a planar sheet of graphite that is wrapped into a seamless tube, nanometer in diameter and few microns in length. They are very stable and found to be good yield emitters and can be operated at lower electric field giving larger currents (Purandare and Patil, 2002).

Future Projection and Application of Bucky-ball

Bucky-ball research has immense scope in nanoscience and technology. The most technologically interesting property of bulk bucky-ball is electronic in various forms of the compound. Since, By playing with the doping concentration of alkali-metal, it functions as an insulator, conductor, semi-conductor and super-conductor. Bucky-ball and its derivatives and CNTs can be the potential source of use in catalytic chemistry, bimolecular recognition, nanoreactors, flat panel display technology, electron microscope and atom force microscopy. Also it can be used as molecular sieves and also as inhibitions to the activity of HIV virus. Some scientists even believe that the silicon technology may be replaced in future by bucky-balls cluster based devices.

Conclusion

The bucky-ball, hollow cage-shaped huge molecule composed of 60 carbon atoms (the third crystalline allotropic form of carbon after well known diamond and graphite), started to attract an increasing attention of scientific community. The existence of higher derivatives (C_{60} to C_{266}), synthesised by the time-of-flight mass spectroscopy and Fourier transform mass and spectrometry. In future, the bucky-ball and its higher derivatives including carbon nano tubes can be considered as potential candidates for applications in electronics, nano-science, atom force microscopy, catalytic chemistry, etc. In particular, the occurrence of superconductivity in alkali metal doped bucky-ball continues to be a fascinating aspect of bucky-ball.

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A GAME ON THE PERIODIC TABLE

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Modern pedagogy offers numerous methods to help students participate in the process of discovery. Problem solving is the best known way and is used by both traditional and avant garde teachers of Mathematics and Physics. Games with the principle 'Learn while playing' are one of the strategies to make the subject more interesting, to supplement the classroom teaching, to attract truants to the class, to use leisure more effectively and meaningfully and to educate the students according to their natural instincts. In these games, the teacher offers students the excitement of participation, discovery, healthy competition, etc. Gibbs (1975) defines 'game' as an activity which is carried out by cooperating or competing decision makers, seeking to achieve their objectives within a framework of rules. One such game is the subject of this article.

Objectives

1. To arrange different elements in their Groups and Periods in the Periodic Table using their electronic configurations.
2. To identify some physical and chemical properties of elements in some groups in the Periodic Table.
3. To explain the trends observed among the properties of elements along a Period and down the Group.
4. To familiarise students with the electronic configurations of elements in the Periodic Table.

Prerequisite

Students should know—

1. About the noble gases and their electronic configurations.
2. That the metals and non-metals are placed on the left side and the right side respectively in the Periodic Table.

Materials Required

Paper, pen/pencil, ruler, cards.

Guidelines for Teachers

Upto 50 students may play this game. If the game is played by more than one student, they should be divided into groups and all the groups can play at the same time. If the group is not familiar with the Periodic Table, the information about the names of the elements, their symbols and their electronic configurations may be written directly on cards. However, for the group which is familiar with the Periodic Table the elements may be symbolised differently and the names of the elements should not be written on cards. For example, the elements such as sodium and strontium may be symbolised as A_1, A_2 respectively and their electronic configurations may be given against their symbols. The information about the names of the elements, their symbols and their electronic configurations to be given on each card is shown in Appendix A.

The teacher can help the students if they face any difficulty in understanding the rules of the game and the electronic configurations of the elements. Rules for the game can be written on the blackboard or on plain paper and should be explained to all groups. One mark each may be awarded for placing the element in the correct group.

After constructing the Periodic Table, students may be in a position to explain some of the trends in the properties of some elements. This can be checked by administering a test on the Periodic Table. Points may be assigned to reward their efforts. Some sample questions are given in Appendix B. These questions can be written on blackboard or on plain paper and should be given to all groups. 30-45 minutes may be given to answer these questions.

Procedure

The students are to be instructed to discuss and cooperate among themselves during the game. They are also to be told to go through the following rules carefully and take assistance from the teacher if they find difficulties in understanding the electronic configurations and the rules of the game:

1. Arrange the elements into different groups in accordance with their electronic configurations.
2. Place the element B_3 (helium, He) in a group of elements which have $ns^2\ np^6$ configuration.
3. Arrange the elements which have ns^{1-2} (s-block, groups 1 and 2) and ns^2np^{1-6} (p-block, groups 13-18) electronic configurations on the left hand side and the right hand side of the periodic table, respectively. Place the remaining elements (d-block, groups 3-12) in between s-and p-block elements.
4. One mark may be awarded for placing the element in the correct group.
5. Designate the groups 1, 2, 3, 4, 5, 6, 7, 11, 12, 13, 14, 15, 16, 17 and 18 as IA, IIA, IIIA, IVA, VA, VIA, VIIA, IB, IIB, IIIB, IVB, VB, VIB, VIIB and VIII group or zero group, respectively. Symbolise the remaining groups such as 8, 9 and 10 as VIII A (Triads).
6. Maximum time allowed to play the game is 60 minutes.
7. Hand over the response sheet to the teacher for correction / scoring.

Evaluation of the Effectiveness of the Game

A questionnaire consisting of 11 items covering the opinion and interest of the students about the game on Periodic Table is developed and the format is given in Appendix C. The responses of the students are analysed and presented in the results and discussion.

In order to assess the students' knowledge and understanding of Periodic Table, a test is administered after the construction of periodic table by the students. The test is administered only for students of Classes VIII and X as both graduate and post-graduate students of chemistry are familiar with the properties of the elements. The results of the test are discussed and shown in Table 1.

Table 1

Students' Responses to the Questions on Periodic Table

Question Number	Percentage of Correct response	
	Class VIII	Class X
1	64(12)	84(63)
2	_	69(57)
3	_	51(15)
4	24(4)	87(72)
5	44(12)	81(63)
6	24(24)	84(84)
7	60(60)	81(81)
8	_	45(27)
9	56(28)	72(54)
10	68	90
11	_	54(36)

Note: The numbers given in parentheses indicate the percentage of correct responses, with explanations except for question number 10.

Results and Discussion

This game was administered to Class VIII and X students of a local school (25 and 33, respectively), I B.Sc.Ed. (40) and II M.Sc.Ed. (2) chemistry students of Regional College of Education, Mysore. Initially, the game started off slowly in the case of Class VIII students as they attempted to apply the rules of the game and planned to construct the Periodic Table. Thirty-two per cent of Class VIII , 36 per cent of Class X and. 20 per cent of B.Sc.Ed. students placed the elements Cu, Ag and Au (G_5, A_4 and N_3) in the I A Group and Zn, Cd and Hg (M_1, G_6 and I_4) in the II A Group of s-block elements instead of in d-block, since IA and IIA elements have one and two-electrons, respectively. The reason for placing these elements in d-block was explained to them during post-game discussion. However, all the M.Sc.Ed. students placed these elements correctly since they were familiar with their electronic configurations and properties. Sixty-four per cent of Class VIII, 33 per cent of Class X, 27 per cent of B.Sc.Ed and 15 per cent of M.Sc.Ed. students failed to place the elements such as Cr, Mo, Nb, Ru, Rh, Pt and Pd (G_3, I_2, H_2, E_4, E_5, D_3 and D_2) in the correct Groups simply because they have slightly deviated electronic configurations from the regular electronic configurations. In these cases, they have considered only d-electrons. For example, the element Chromium (G_3), which has electronic configuration [Ar] $3d^5 4s^1$, is placed in Group 5 of d-block (VII A or 7 from the beginning) elements which means that it has 7 valence electrons, which is not true. This element should be placed in Group 4 of d-block (VI A or 6 from the beginning) elements as it has 6 valence electrons (five 3d-electrons and one 4s-electron). The students are told that the element can have valence electrons which is equal at the most to the group number but not more than that. The students later arranged the other elements correctly by extending the above logic. The explanation for placing the element, helium (He, B_3), in the group of noble gases was offered during the discussion.

The responses along with the explanation given for each test item by both Class VIII and Class X students have been analysed. The Class VIII students felt difficulty in answering the questions given in Appendix B. They were not able to answer some questions namely 2, 3, 8 and 11. Sixty-four per cent of Class VIII students indicated that sodium is more reactive than neon, but only 12 per cent of students have written the correct explanation for question number 1. Twenty- four per cent students of this class stated that beryllium and radium have the smallest and the largest size respectively in IIA group of the Periodic Table by considering their electronic configurations. However, out of 24 per cent students who responded correctly twenty per cent failed to relate the size factor with the number of shells/orbitals in question number 4. For question number 5, only 12 per cent of the students explained the similarities in the properties of the elements in terms of the same number of valence electrons. Most of the students (76 per cent) stated that the elements are arranged in accordance with their electronic configurations in question number 6. Remaining 24 per cent of the students related the electronic configurations with their atomic numbers/ number of electrons. For question number 9, 28 per cent of students mentioned that the IIA and VI A group elements lose and gain two electrons, respectively to attain the nearest noble gas configurations, though 56 per cent of students have given the correct answer without explanation. A large percentage of students (68) answered question number 10 rightly whereas others mentioned the number of electrons as 2 or 4.

In contrast to Class VIII students' performance, the performance of Class X students is found to be good. All the students attempted all the questions. About 15-90 per cent of students have given the correct answers with explanations for all the questions.

The responses of the students given in the questionnaire (Appendix C) have been analysed. All the students have stated that they never had the experience of playing such games at school. Both B.Sc.Ed. and M.Sc.Ed. students indicated that they had sufficient chemistry knowledge to play this game. A large percentage of Class VIII (84), Class X (93), B.Sc.Ed. (90) and M.Sc.Ed. (95) students mentioned that the game helped them to construct the Periodic Table. However, most of the Class VIII students stated that they faced difficulty in answering the questions after constructing the Periodic Table, though it was well received by Class X students. Both Class VIII and Class X students wanted 10-15 minutes more (though they constructed the periodic table within 60 minutes) to verify their answers as they are more particular about points/marks. Majority of the students preferred to have 3-6 members in the group for ideal cooperation and discussion. More than 85 per cent of students found this activity interesting and a novel way of approaching the subject of Periodic Table. They expressed willingness to play this game more than once, and some other games in chemistry in the subsequent classes.

Conclusions

From the foregoing discussion, it is clear that though the game of constructing the Periodic Table is more suitable for Class VIII and higher students, it is more suitable for Class X and above, as students need to understand and explain the properties and trends in the properties of elements along a Period and down a Group. This game can be played with members possessing different abilities. The game may be played by making the rules and questions) more easy or difficult depending on the level of the players.

Note: Lanthanides and actinides are not included in this game. These elements cannot be placed in one group in accordance with their electronic configurations though they are known to have similar properties.

APPENDIX A

Element	Symbol	Electronic 1 Configuration	
Sodium	Na	(A_1)	[Ne] $3s^1$
Strontium	Sr	(A_2)	[Kr] $5s^2$
Scandium	Sc	(A_3)	[Ar] $3d^14s^2$
Silver	Ag	(A_4)	[Kr] $4d^{10}5s^1$
Silicon	Si	(A_5)	[Ne] $3s^23p^2$
Sulphur	S	(A_6)	[Ne] $3s^23p^4$
Selenium	Se	(A_7)	[Ar] $3d^{10}4s^24p^4$
Hydrogen	H	(B_1)	$1s^1$
Hafnium	Hf	(B_2)	[Xe] $4f^{14}5d^26s^2$
Helium	He	(B_3)	$1s^2$
Iridium	Ir	(B_4)	[Xe] $4f^{14}5d^76s^2$
Iodine	I	(B_5)	[Kr] $4d^{10}5s^25p^2$
Indium	In	(B_6)	[Kr] $4d^{10}5s^25p^1$
Lithium	Li	(C_1)	$1s^22s^1$
Lanthanum	La	(C_2)	[Xe] $5d^16s^2$
Lead	Pb	(C_3)	[Xe] $4f^{14}5d^{10}6s^26p^2$
Potassium	K	(D_1)	[Ar] $4s^1$
Palladium	Pd	(D_2)	[Kr] $4d^{10}$
Platinum	Pt	(D_3)	[Xe] $4f^{14}5d^96s^1$
Phosphorus	P	(D_4)	[Ne] $3s^23p^3$
Polonium	Po	(D_5)	[Xe] $4f^{14}5d^{10}6s^26p^4$
Rubidium	Rb	(E_1)	[Kr] $5s^1$
Radium	Ra	(E_2)	[Rn] $7s^2$
Rhenium	Re	(E_3)	[Xe] $4f^{14}5d^56s^2$
Ruthenium	Ru	(E_4)	[Kr] $4d^75s^1$
Rhodium	Rh	(E_5)	[Kr] $4d^85s^1$
Radon	Rn	(E_6)	[Xe] $4f^{14}5d^{10}6s^26p^6$
Beryllium	Be	(F_1)	$1s^22s^2$
Barium	Ba	(F_2)	[Xe] $6s^2$
Boron	B	(F_3)	[He] $2s^22p^1$
Bismuth	Bi	(F_4)	[Xe] $4f^{14}5d^{10}6s^26p^3$
Bromine	Br	(F_5)	[Ar] $3d^{10}4s^24p^5$
Cesium	Cs	(G_1)	[Xe] $6s^1$
Calcium	Ca	(G_2)	[Ar] $4s^2$
Chromium	Cr	(G_3)	[Ar] $3d^54s^1$
Cobalt	Co	(G_4)	[Ar] $3d^74s^2$
Copper	Cu	(G_5)	[Ar] $3d^{10}4s^1$
Cadmium	Cd	(G_6)	[Kr] $4d^{10}5s^2$
Carbon	C	(G_7)	[He] $2s^22p^2$
Chlorine	Cl	(G_8)	[Ne] $3s^23p^5$
Nickel	Ni	(H_1)	[Ar] $3d^84s^2$
Niobium	Nb	(H_2)	[Kr] $4d^45s^1$
Nitrogen	N	(H_3)	[He] $2s^22p^3$
Neon	Ne	(H_4)	[He] $2s^22p^6$
Magnesium	Mg	(I_1)	[Ne] $3s^2$
Molybdenum	Mo	(I_2)	[Kr] $4d^55s^1$
Manganese	Mn	(I_3)	[Ar] $3d^54s^2$
Mercury	Hg	(I_4)	[Xe] $4f^{14}5d^{10}6s^2$
Actinium	Ac	(J_1)	[Rn] $6d^17s^2$
Aluminium	Al	(J_2)	[Ne] $3s^23p^1$
Arsenic	As	(J_3)	[Ar] $3d^{10}4s^24p^3$
Antimony	Sb	(J_4)	[Kr] $4d^{10}5s^25p^3$
Astatine	At	(J_5)	[Xe] $4f^{14}5d^{10}6s^26p^5$
Argon	Ar	(J_6)	[Ne] $3s^23p^6$
Titanium	Ti	(K_1)	[Ar] $3d^24s^2$
Tantalum	Ta	(K_2)	[Xe] $4f^{14}5d^36s^2$
Technitium	Tc	(K_3)	[Kr] $4d^56s^2$
Tin	Sn	(K_4)	[Kr] $4d^{10}5s^25p^2$
Tellurium	Te	(K_5)	[Kr] $4d^{10}5s^25p^4$
Tungsten	W	(K_6)	[Xe] $4f^{14}5d^46s^2$
Thallium	Tl	(K_7)	[Xe] $4f^{14}5d^{10}6s^26p^1$
Oxygen	O	(L_1)	[He] $2s^22p^4$
Osmium	Os	(L_2)	[Xe] $4f^{14}5d^66s^2$
Zinc	Zn	(M_1)	[Ar] $3d^{10}4s^2$
Zirconium	Zr	(M_2)	[Kr] $4d^25s^2$
Gallium	Ga	(N_1)	[Ar] $3d^{10}4s^24p^1$

Germanium	Ge	(N_2)	[Ar]	$3d^{10}4s^24p^2$	Vanadium	V	(O_3)	[Ar]	$3d^34s^2$
Gold	Au	(N_3)	[Xe]	$4f^{14}5d^{10}6s^1$	Iron	Fe	(O_4)	[Ar]	$3d^64s^2$
Yttrium	Y	(O_1)	[Kr]	$4d^15s^2$	Fluorine	F	(O_5)	[He]	$2s^22p^5$
Francium	Fr	(O_2)	[Rn]	$7s^1$	Krypton	Kr	(O_6)	[Ar]	$3d^{10}4s^24p^6$
					Xenon	Xe	(O_7)	[Kr]	$4d^{10}5s^25p^6$

APPENDIX B

1. Between sodium and neon, which one is more reactive? Give reasons.
2. Among s-block and p-block elements which are more electropositive and which are more electronegative? Explain.
3. Explain the nature of forces in gaseous fluorine, liquid bromine and solid iodine.
4. Which element has the largest size and which one has the smallest size in the II A group of the Periodic Table? Why?
5. Do the elements of a group have almost similar properties? Why?
6. What is the Periodic Law or, how are elements arranged in the Periodic Table?
7. Where do you place the element with electronic configuration $4d^{10}5s^0$ in the Periodic Table? (Give the group number).
8. Mg2+ is smaller than Ca2+. In which case is more energy required to ionise further? Justify your answer.
9. How many electrons can II A and VI A elements lose or gain and why?
10. How many valence electrons are present in VI B Group elements?
11. Among Fe2+ and Fe3+ which one has the larger size and why?

APPENDIX C

Put tick (✓) in the box that best describes your feelings.	Highly agree	Moderately agree	Disagree
1. The details given on the card are enough to play the game.	( )	( )	( )
2. The rules of the game are easily followed.	( )	( )	( )
3. The game is interesting.	( )	( )	( )
4. A good knowledge of chemistry is required to play this game.	( )	( )	( )

5.	The game is helpful in understanding the Periodic Table.	( )	( )	( )
6.	The game inspires us to play more than once.	( )	( )	( )
7.	This type of game is played for the first time in a science class.	( )	( )	( )
8.	The time given to play this game is enough.	( )	( )	( )
9.	The ideal number of students in a group should be small (that is, 1 to 2).	( )	( )	( )
10.	The ideal number of students in a group should be large (that is, 3-6).	( )	( )	( )
11.	The questions on periodic table are easy to answer.	( )	( )	( )
	Any other suggestion(s).			

FASTER FITTING FOR ARTIFICIAL LIMBS

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A new technique for making the sockets for artificial legs by a semi-automatic process is shortening waiting times from several months to a matter of days.

When people have a leg or an arm amputated, a socket has to be made to match the stump before an artificial limb can be fitted. Producing them has, so far, been expensive and time consuming, requiring the skills of a team of craftsmen. Conventionally, the procedure is to carve the appropriate shape out of a block of wood, or to beat an aluminium alloy sheet to fit; a third, more recent technique, is to build up layers of glass-reinforced plastics, applied in the form of bandages, over a plaster cast of the stump. With considerable numbers of patients waiting to be fitted, delivery of a completed artificial limb may take months, and the finished article is even then not always shaped to the stump as accurately as it really needs to be to avoid undue discomfort.

For some years it has been apparent that the potential advantages of thermoplastics, which become soft and workable when heated, were significant if only they could be exploited reliably. For example, thermoplastic sockets could be made in a small fraction of the time taken to produce the conventional ones, they would do away with corrosion problems, be more hygienic and would allow the cast shape to be reproduced with a high degree of accuracy. Moreover, they would be significantly cheaper.

Individual

Techniques for plastics forming require a mould or pattern, of the shape that is to be reproduced, into which the thermoplastic material is injected or formed. The cost of making such a tool and setting it up on a machine makes the technique uneconomical unless a large number of parts are to be made to that particular shape. But every patient has individual physical characteristics that have to be matched by the socket so no two sockets can have identical shapes; it is essential too, that each socket is a good fit. This rules out the usual large-scale production techniques.

Because the prosthetic socket forms a vital interface between the artificial limb and part of the body and is a load-bearing structure that must withstand high stresses applied in a complex way, merely reproducing the desired shape is not enough. The socket must be anatomically compatible to avoid damaging the tissue, and must have predictable mechanical properties, especially with regard to fatigue.

There are several ways of forming a thermoplastic material into a desired shape and there is a big choice of materials. When they are heated they soften, but harden again when they are cooled, so the forming process consists of softening the substance, shaping it and then cooling it to a rigid structure in its new shape. During the process, chemical and physical changes may occur which might adversely affect the mechanical properties even though the shape is correct. Materials offer various characteristics, with corresponding advantages and disadvantages. Theremoplastics consist of a basic polymer with various additives such as plasticisers, fillers and so on. The additives serve to modify the forming properties and eventual mechanical characteristics of the material, but they may themselves be adversely affected by the process unless it is properly controlled.

Change

The structure of the thermoplastic material inherently influences the mechanical properties that the socket will finally have, and the forming operation may considerably change that structure: for example, in partially crystalline materials the degree of crystallinity may be changed by the heat cycle, especially by the cooling rate. Furthermore, deformation and drawing almost certainly introduce anisotropic properties, that is, the mechanical properties of the material differ when measured in different directions. Forming and cooling may also cause stresses to become 'frozen' into the newly shaped material. In addition, with many thermoplastics the deformation has to be performed within a critical temperature range if they are not to be severely degraded. All these factors have to be taken into full account.

The most obvious approach to our problem was to use a sheet of thermoplastics material and employ conventional, well-established techniques to form it by vacuum on to a replica of the patient's stump. The replica was a plaster cast that had been suitably corrected to ensure that the loadings on the various parts of the stump were acceptable. But the deformation the material had to withstand was so large, and the variation in sizes and shapes of the sockets required was so great, that it was obvious there would be a high risk of introducing considerable differences in structure, which meant there would be sockets with unreliable mechanical strength. For example, extreme anisotropy can weaken a structure in certain directions by a factor of as much as ten. This coupled with the danger of large variations in wall thickness, meant that sockets made by conventional means would not be reliable enough in this application.

The problem was to find a process in which it was possible to control the amount of anisotropy and variation of wall thickness. We decided to develop pre-moulded thermoplastic cones that could subsequently be shaped in a specially designed vacuum-forming machine. The preform was to be of the size and rough shape of the required socket, thereby keeping draw ratios to a reasonable figure (the draw ratios are a measure of the deformation). It was also essential to control the forming conditions precisely, so that the best possible mechanical properties could be obtained by ensuring the optimum thermal cycle and deformation conditions. Such processing is beyond the scope of most machine operators, so the complete process had to be automatically controlled; there is now no need for any skilled operators at all.

We evolved the shape of the standard preform experimentally. And were able to find one size and shape that would do for all patients who had below-the-knee amputations. To produce above-the-knee sockets needed more than one size of preform because that part of the limb varies so greatly in size. We found that careful control has to be exercised during the injection moulding of the preforms, to make sure that they were of good, consistent quality.

The Machine

The forming machine that we have developed takes up an area of about one-half of a square metre. Its electrically-heated oven is servo-controlled; below it the cast stands upon a servo-controlled ram which has a small tube through it leading to the interface between the cast and the preform. The other end of the tube is connected to a vacuum pump by way of a control valve. The preform is placed in position over a hole in the base of the oven.

The entire thermal cycle, strain and cooling rate are controlled by a micro-processor system that reads a coded programme card and steps the machine through each part of the process until it finally turns out the formed socket.

There are a large number of materials that may be formed for our purpose. We compiled a short list of them after rejecting those that were obviously unsuitable through being, for example, not elastic enough, too brittle to withstand impact satisfactorily, or prone to fatigue in the working temperature range.

The material also had to be suitable for injection moulding and vacuum-forming, and capable of withstanding a double heating cycle without undue loss of quality. After considerable experimentation, we selected one of the modified polypropylenes which, incidentally, was so cheap that the cost of a preform was only about one pound sterling. It is likely that there are other suitable materials. We are grateful for the support of the Polymer Engineering Directorate of the UK Science Research Council, and the Cranfield Institute of Advanced Technology, in assessing various materials and generally helping us in the project.

We have now been able to make sockets with excellent and reproducible mechanical properties. Their weight, about 0.35 kg, is less than half that of earlier types. The process takes about 15 minutes and the machine can be used continuously, unattended, once the casts and preforms have been loaded into it—a job that needs a special skill. At first we used microwave heating to dry the plaster casts quickly before the forming took place, but experience showed it was not necessary; the system quite easily copes with wet casts.

Trials

A clinical trial began in June 1977, on 12 patients who had undergone a below-the-knee amputation. It has since been extended to 25 patients. Some of them have now worn their sockets regularly for more than 27 months. All the patients are wearing the original polypropylene sockets that we supplied and so far there have been no failures, mechanical breakdowns or need for refitting. We tried as far as practicable to include a representative cross-section of patients in the trial, that is, patients with long, short and average stumps. In spite of the considerable range in the size and shape of the stumps, the one size of preform has been found good enough. The condition of all the patients' stumps is very good indeed, though several did join the trial with problems. The trial is being expanded to include a much larger sample of patients.

The new process has opened the way to making high quality sockets cheaply and quickly. This means that it is usually a great deal cheaper and quicker to make a new socket than to repair or adjust an old one.

Research is going on into other materials, especially their fatigue and deformation properties, and we intend to conduct a finite-element stress analysis of structures of various shapes and sizes. In a computer based analysis of this type, the stresses are calculated separately for each small element of the structure and integrated to give an overall result. This is expected to lead to still better mechanical properties and even greater confidence in the product. Research is also going on to introduce our general ideas and semi-automatic techniques to making complete artificial limbs. Eventually, we hope limbs will be made cheaply and fitted on the same day that the cast of the patient's stump is taken.

Courtesy : *Spectrum*

CRYOGENICS

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Just as the quest for Atomic Energy enabled us to achieve very high temperatures (of the order of hundreds of thousands of degrees) and gave us what is now called the Plasma State, our exploration of the outer space has brought us in contact with temperatures reaching almost absolute zero (-273 C). The coldest spots on the face of this earth have a temperature around -68°C (in the Arctic Circle).

The term 'Cryogenics' applies to the study of materials at temperatures ranging from -100°C to almost absolute zero (-273°C). This is the range where gases turn into liquids; steel, even rubber, becomes as brittle as glass; metals become super-conducters and even living cells pass into a state of suspended animation.

The cryogenic range may be further subdivided into two parts—cold (up to-200°C) and very cold (below -200°C). The most common atmospheric gases, oxygen, nitrogen and argon, etc., when liquefied, reach temperatures around -200°C whereas hydrogen and helium, reach temperatures below-250°C.

It has been observed that oxygen and nitrogen, when cooled to liquid hydrogen or liquid helium temperatures, acquire the appearance and mechanical properties similar to that of sand.

These days most of these liquids are being manufactured in millions of tonnes per year and used for a variety of purposes. This article discusses some of the applications, such as:

(i) Improved performance of oil wells.
(ii) Manufacture of more compact computer memories.
(iii) Breeding of better cattle by artificial insemination.
(iv) Economic transport of food, etc.
(v) Super-conductivity of metals.
(vi) Study of frozen free radicals.
(vii) Use in Maser, Laser, Infrared Detectors.
(viii) Catalysis at low temperatures.
(ix) Powdering chemical products.

Methods of Producing Low Temperatures

Joule-Thomson Effect: The first landmark in the production of low temperatures was the discovery that sudden expansion of a gas lowers the temperature. This is due to what is known as Joule-Thomson Effect.

This was followed by the realisation that gases could not be liquefied unless they were cooled below the critical temperature.

Making use of these two principles, scientists succeeded in liquefying all the gases which were considered permanent, i.e., unliquefiable at that time.

Claude Expansion Engine: The real breakthrough in the production of low temperatures on a large scale came in 1902, when Claude pioneered the use of the expansion engine. This engine was based on the principle of removing heat as mechanical work.

Kapita's Improvement: Kapita, a Russian physicist and a colleague of Rutherford, the celebrated British nuclear scientist, extended the basic principle used by Claude. He made use of a turbine, instead of an engine.

Properties of Materials at Low Temperatures

A striking demonstration of a tremendous change in the properties of materials, when they are cooled to very low temperatures, can be given by dipping a hollow rubber ball in liquid air and then smashing it to pieces by striking it against a wall or a hard floor.

Man's flight into space where there are temperatures of the order of -200°C or less has initiated a systematic and quantitative study of the various physical and chemical properties of materials.

Tensile Strength of Metals

It has been observed that metals, which have a body-centered-cubic lattice, show a pronounced increase in yield strength and a corresponding loss of ductility with decreasing temperature. The important examples are iron, tungsten and molybdenum. Obviously, these metals are unsuitable for the construction of a low-temperature apparatus. On the other hand, metals which have a face-centered-cubic lattice, show only a slight increase in yield strength and retain their room temperature ductility up to a temperature as low as 77°K. The important examples are copper, nickel and aluminium or their alloys. Consequently, they are used for the construction of low temperature apparatuses.

However, ductility alone is not an adequate guide to the suitability of materials; impact strength must also be considered.

Ours is the age of plastics. Plastics are replacing the conventional materials in almost all branches of human experience. Though Teflon and glass fibre laminates have stood up well in performance tests, more remains to be learnt about the behaviour of plastics.

Thermal Properties

Before discussing thermal properties, it must be remembered that specific heat is not a constant quantity, particularly in the case of metals. It increases with the rise in temperature. For example, a piece of copper requires 6000 times as much heat in raising its temperature from 300° to 301°K as from 2° to 3°K. Some of the metals show thermal conductivity maxima in the range 20° to 50°K. In this range, pure metals have conductivities 100 times as much as their alloys.

The figure given below shows the thermal conductivities of three principal types of solids, namely metals, alloys and dielectrics, particularly sapphire. Sapphires are now made synthetically from aluminium oxide through the technique of growing single crystals. Sapphires are used as gems, as support rods in fire apparatus, as windows and domes for microwave and infra-red systems. They possess high flexural strength at increased temperatures, low loss characteristics and zero porosity.

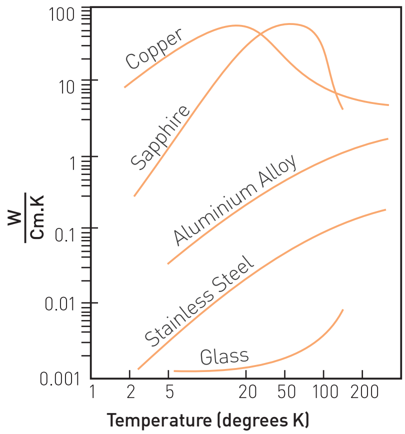

Fig. 1 : Thermal conductivities of some solids of cryogenic temperatures

Properties of Cryogenic Gases

1. Argon: It is present in atmospheric air to the extent of 1 % and can be easily produced in the normal process for the fractionation of air, for oxygen and nitrogen, by putting a few extra plates in the fractionating column. Since it is less expensive than helium, it will gradually replace helium in the shielded arc-welding applications. Of course, we are familiar with its use in electric bulbs and vacuum tubes.

It is also being used for providing an inert atmosphere in those furnaces which heat metals at very high temperatures.

Some Characteristic Properties of Cryogenic Gases

Sl. No.	Gas	Boiling Point	Freezing Point	Range	Production	Main Uses
1.	Argon	-186°C	-189°C	3°C	120 ton/day	(i) Electric bulbs and vacuum tubes (ii) Shielded arc welding torch
2.	Neon	-246°C	-249°C	3°C	—	Electric sign industry
3.	Krypton	-153°C	-157°C	4°C	—	Electronic and lamp industries
4.	Xenon	-163°C	-169°C	6°C	—	Scintillation counters
5.	Hydrogen	-253°C	-259°C	6°C	200 ton/day	(i) Rocket fuel (ii) Thermo-nuclear explosives
6.	Helium	-269°C	Solidifies under high pressure (25 atm)		—	Aeroplane tyres, inert protective atmosphere
7.	Methane	-162°C	-184°C	22°C	—	Manufacture of butyl rubber
8.	Ethylene	-104°C	-169°C	65°C	—	
9.	Nitrogen	-196°C	-210°C	14°C	40-60 billion cubic feet/year	— —
10.	Oxygen	-183°C	-218°C	35°C	150,000 tons/ day,	(i) Welding industries (ii) Steel manufactures (iii) Chemical manufactures

Note: Compare the boiling point-freezing point range of the above cryogenic liquids vis-a-vis normal liquids, e.g. water 100°C, benzene 84°C.

2. Neon: Because of its high density and high heat of evaporation, neon provides three and-a-half times more refrigeration than an equal volume of liquid hydrogen and 40 times more than an equal volume of liquid helium.

3. Krypton: It is 4 times as heavy as neon, 3 times as heavy as nitrogen and 2.6 times as heavy as oxygen. Its high atomic weight reduces evaporation and heat losses from filaments, thus extending their life in addition to enabling them to be operated at higher temperatures.

4. Xenon: The electrical properties of xenon are close to those of mercury and since it does not condense readily, it is used to supplement vapour in some THYRATRON tubes.

5. Helium: Helium is used these days in:

- balloons for weather observation, cosmic-rays studies.
- inert protective atmospheres for welding and metallurgical processing.
- rockets and missiles.
- Aeroplane tyres.

6. Hydrogen: Hydrogen is a favoured propellant because its low density results in higher velocities of the exhaust gases as they emerge from the rocket nozzles and consequently more thrust for a given rate of consumption.

7. Nitrogen: The combination of the low boiling point (-198°C) and the high heat of vaporisation makes liquid nitrogen an economical refrigerant. Nitrogen is used for:

- Bright annealing of stainless steel.
- Flushing, precooling and testing of rockets.
- Supplying an inert atmosphere in the manufacturing of chemicals and metals.
- Artificial insemination.

8. Oxygen: Its use is very widespread. About one-third of total oxygen production is used in steel manufacture, about half in other chemical manufactures and the remaining in the oxyacetylene flames for cutting and welding.

9. Methane: Though not as useful in cryogenics as other cryogenic gases, it is being shipped in large quantities after being liquefied. It is one of the most important and least expensive (since it is available in huge quantities as a constituent of natural gas) raw materials for many industrial materials based on organic compounds.

10. Ethylene: Manufacture of butyl rubber is the only large-scale synthetic organic chemical process which is operated at cryogenic temperatures i.e., -100°C or -148°C. Boiling liquid ethylene is used as the coolant in this process. Perhaps it is the only hydrocarbon gas, which is also used as a low-temperature refrigerant in addition to its being an important starting raw material. Cryogenic techniques are employed in separating it from cracked hydrocarbon gases.

Electrical Properties

It is well known that resistance of metals falls sharply as the temperature is lowered. They can stand a higher current without any damage.

Alloys do not follow this pattern at all. The drop in their resistivity is much lower. For example, constanton – an alloy of 60 parts copper and 40 parts nickel 95% of its resistance retains at cryogenic temperatures (i.e., below -100°C).

Semi-conducting materials such as silicon and germanium offer an interesting combination of properties at low temperatures. They possess a high thermal conductivity and low electrical conductivity.

When we plot electrical resistance as a function of temperature at a certain temperature (different for different metals), there is a sudden drop in electrical resistance and the metal becomes a super-conductor. Many theories have been advanced for this frictionless flow of electricity through solids. A recent theory postulates that electrons move in pairs instead of as individuals and the vibrations of metallic atoms are unable to break the pairs. Obviously, these electrons must be having opposite spins.

This phenomenon is of immense practical value for the operation of high field electromagnets for high energy accelerators.

Measuring Low Temperatures

The ordinary mercury thermometer becomes useless near a temperature of –39°C, its freezing point. Liquid toluene may be used up to –78°C and liquid pentane up to about –180°C. Below this temperature, electrical, magnetic or some other property of substances must be used. The most common property used is the resistivity of some noble metals like platinum or those of the semi-conductors.

Platinum Resistance Thermometer

Variation of the electrical resistance of platinum metal with temperature is quite sensitive and reproducible even up to a temperature of 20° K. The resistance may be measured either by a wheat stone bridge or by a potentiometer. Recently pure Indium has been used up to temperatures as low as 4°K.

Thermistor

One of the advantages with super-conducting materials is that their resistance varies exponentially with temperature. Moreover, they have a negative temperature coefficient; thus lower temperatures give higher resistances and greater sensitivity. In fact, the resistance of a thermistor increases so rapidly as the temperature decreases that it may limit the range of temperatures which can be measured with these devices. Initially carbon was used as the sensing material, but now doped germanium is being used.

Thermocouples

Thermocouples, in which two dissimilar metals fused together generate a voltage at a junction, which is placed at a different temperature than the ends, is a common device for measuring temperatures over a wide range. Though easier to build, they have been found to be less sensitive at lower temperatures. The cold junction used for measurement of low temperatures is liquid nitrogen (-95°C).

Copper-constanton thermocouples have been successfully used up to a temperature of 12°K (-200°C).

Containers for Cryogenic Liquids

Realising that most cryogenic liquids have a low heat of vaporisation, the need to ensure a very effective insulation for any container for them becomes evident.

Liquid	Latent Heat of Vaporization		
Hydrogen	107	cal/gm	
Nitrogen	50	,,	
Oxygen	50	,,	
Neon	20	,,	of water
Helium	5	,,	540 cal/gm

Dewar Vessels: We are all familiar with Thermos flasks which are nothing but double- walled vessels with a high vacuum between the walls and a highly reflecting surface facing the vacuum side. The walls may be made of glass or copper.

Vessels made from Plastic Foams: Blown out plastic materials which contain many small cells, not inter-connected, are good insulating materials. But their efficiency is not as good as that of the evacuated glass or copper vessels, on account of the former's inability to stand repeated thermal expansion and contraction.

Vessels with Annular Space filled with Evacuated Powders: If in addition to evacuating the annular space, it is also filled with fine light powder, such as a silica aerogel, carbon black, perlite, etc., the insulation efficiency is improved further, but it requires the annular space to be at least 10 cm wide. In addition, there are some other operational problems.

Super-Insulation: For handling liquid hydrogen or liquid helium, a considerably improved insulation is required. One way is to make the light aerosol powder opaque to infra-red radiation by mixing it with finely divided copper or aluminium; the other way is to provide radiation-reflecting shields separated from the vessel surfaces and from one another by low conductivity filters. Alternate layers of aluminium foil and glass filter-mats in sandwich fashion, having as many as 80 layers per inch, are being used in commercial storage and transport containers. The space filled with these should be evacuated to 10^{-4} cm Hg.

Application of Low Temperatures

A. Space Research: Space research is a major consumer of the cryogenic fluids using oxygen as a chemical reactant; hydrogen both as a chemical fuel and also as a working medium for nuclear rockets; nitrogen for precooling, flushing and cold flow-testing of rockets; and helium for cryopumping of space simulator chambers (Fig. 2).

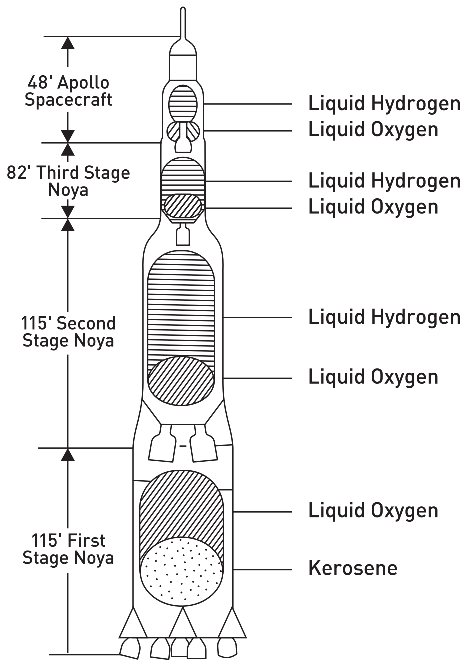

Fig. 2: Section of the Noya-Apollo Spacecraft

B. Biology: Though still quite a few lives are lost due to exposure to cold, particularly by sub-zero temperatures, yet low temperature production has proved a preserver rather than a destroyer of life. It is impossible to think of maintaining Blood Banks without using some cryogenic fluid to preserve the blood.

Bull semen is preserved for subsequent use in artificial insemination. Human organs are preserved at liquid nitrogen temperatures for subsequent use as spare parts in surgery.

Astronauts may be kept in suspended animation for decades in rockets to explore the universe beyond the solar system. Their biological clock could be started at will after their arrival on the desired planet.

Plants, spores and even animals from other planets could be brought safely to the earth for subsequent investigations.

Study of the relation between life and temperature has brought to light certain interesting facts. For example, it has been observed that man can tolerate only a very small increase above normal temperature before he finally succumbs, whereas he can experience a far greater decrease below normal temperature and still survive.

One may also distinguish between the effects produced by cold. Some effects may be due to mechanical injury caused by crystal formation, while others may be due to chemical injury as a result of the increased concentration of salts and other dissolved substances in the remaining fluid. Some of these undesirable effects may be minimised by the use of additives and by controlling the rate of cooling. For example, blood can be frozen uniformly even at the rate of 35°C per minute, whereas sperms, etc., must be preserved by a slow rate of cooling of the order of 5°C per minute.

Fishes save themselves from cold by producing each autumn certain substances which reduce the freezing points of their blood and tissue fluids. Surprisingly cold has little effect on micro-organisms. Certain species have actually multiplied when held at a temperature of –9°C. Live bacteria were found in the human excrement of Captain Scot left in the Antarctic ice about seven decades after his expedition to the Antarctic.

C. Cryo-surgery: Anaesthesia can also be produced by lowering the temperature of the body. In fact, it has many advantages over the anaesthesia produced by the use of chemicals.

Lowering the body temperature retards the entire metabolic process. The patient's oxygen requirements are cut by 50%, circulation slows down and bleeding becomes much more controlled which makes the surgeon's task much easier. If the inner body temperature is maintained around 20°C, the circulation of the blood by the heart can be stopped for about 10 minutes without causing any damage to the brain and other vital organs of the body.

The most difficult part of the human body to be operated upon is the brain. Cryogenics has made bloodless brain surgery possible.

D. Cryotronics or Cryogenic Electronics: Electrical noise in a circuit can be decreased by a factor of 100, by operating the circuit at very low temperatures. There are certain electrical phenomena which occur only at low temperatures. For example:

(a) Operation of Masers

Masers are devices which utilise transitions between energy states of a molecule or atom for amplification of microwave energy. These molecules may be in any state of aggregation, but the most commonly used form is a crystal. When the Maser crystal is operated at low temperatures, the thermal vibrations of the atoms do not interfere with the absorption emission of microwave energy. At low temperatures, the difference in population of atoms between the energy levels, which is the basis of maser action, is greater. In fact, masers work best at liquid helium temperature, but can operate with moderate efficiency at liquid nitrogen temperatures (Fig. 3).

Masers form the heart of radio telescopes which receive signals from objects many millions of light years more distant in space than those visible in the best optical telescopes. Radio astronomy demands very low noise levels in amplifiers because the signals are so weak. In fact, maser radar devices may allow a few ground stations to control the air space of the whole country.

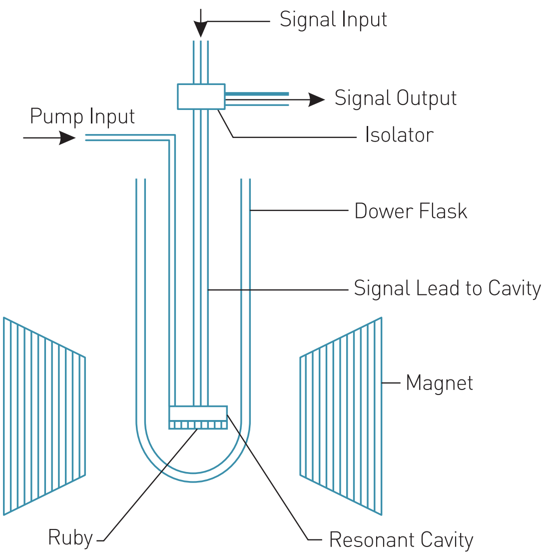

Fig. 3: Typical Maser

(b) Operation of Lasers

Though stimulated emission in the optical region is not as easy as in microwave region, yet when such an emission is produced, the beam is very intense.

Ruby crystals can be used both in masers as well as lasers. The fundamental difference is that in a laser we use the directly excited energy levels of the chromium, while the maser operates on magnetically split levels. Samarium or Uranium ions in a calcium fluoride matrix may prove to be better laser materials than ruby crystals.

Optical frequencies have a number of advantages over radio frequencies for use in communication systems. With more band-width available, more information can be carried. Moreover, since beams are narrow, even smaller antennas can serve the purpose.

Lasers are being used:

(i) As light sources for battle-field illumination.
(ii) As heat sources for welding and cutting of metals.
(iii) In noise-free and interception-proof telephone systems.
(iv) In missile tracking and subsequent destruction.
(v) In communication systems for space.
(vi) In medical sciences for detecting and treating diseases.

E. Infra-red Detectors: Infra-red detectors show improved efficiency and extension of their range to longer wavelengths when they are operated at low temperatures. Moreover, they are simpler, smaller and cheaper than radar equipment. The only disadvantage is that they are subject to interference by fog, etc.

F. Super-Conductivity: Super-conductivity is one of the most intriguing phenomena. It occurs at temperatures very near to absolute zero; the actual temperature varies for different metals and alloys.

There are many theories for the occurrence of this phenomenon, but that of Bardeen and Frohlich, which attributes it to interaction between the conduction electrons and the lattice vibrations of the solid, is the most accepted one.

The first commercial application of super-conductivity was made during World War II. It was for the construction of bolometer, a sensitive thermometric instrument used to detect infra-red rays coming from the equipment of enemy troops.

Super-conductors are of two types: (a) Soft, and (b) Hard.

Aluminium, tin, mercury and lead belong to the first category while inter-metallic compounds like Niobium-tin, Vanadium and Gallium belong to the second.

The soft materials carry the super-conductive current only in a thin surface layer and this super-conductivity is easily destroyed by magnetic fields. The hard materials appear to carry the super-conductive current in thin filaments throughout their structure and are relatively resistant to the effects of magnetic fields. Whereas an ordinary magnet of field strength 50,000 gauss would require an iron core weighing several tonnes and a power supply of 50 kilowatt, a super-conducting magnet of equivalent strength would weigh 200 1bs. (90 kg) including refrigeration and could be operated by a 6-volt storage battery.

Not only super-conducting magnets, but we can also make super-conducting transformers, super-conducting motors and super-conducting switches. Tiny super-conducting switches offer the interesting possibility of scaling down the size of a digital computer without reducing its capacity or speed. In addition to high switching speeds, the cold computers could have a very large memory. In fact, computers which can search 300,000 bits of information in their cryogenic memory and pick out the needed data in 50 micro-seconds are now available.

G. Metal Processing

(i) Steel: Tougher, more ductile steels with improved life characteristics are produced by sub-zero chilling of steel. Those who are familiar with the phase diagrams for steel know that above 204°C steel has a completely austenite structure. As steel cools, the relatively unstable austenite changes slowly to martensite, which is tougher and more ductile. It is most suitable for fabricating dimensionally accurate parts. For example, hacksaw blades, high speed drills, etc.

It is claimed that cold treatment after welding produces a much better finished part because it restores the improvement in strength given by prior cold treatment, which is lost during welding.

(ii) Aluminium: Aluminium alloys which form an important constituent of aircraft manufacture give trouble during machining. Such alloys can be normalised or stress-relieved by subjecting them to low temperatures for an hour or so at temperatures below –100°C. This treatment delays natural hardening.

(iii) Super-alloys: Super-alloys which are finding an increasing use in aircraft and missile industries generate too much heat at the point of contact between the tool and the alloy during machining, with the result that local oxidation of the interface occurs and precise machining becomes impossible. If the solvent which is used to flood the interface is pre-cooled to dry ice temperature (–78°C) and an inert atmosphere from liquid nitrogen provided, tool life can be improved almost 300% in addition to achieving precise machining.

(iv) Miscellaneous Applications

(a) Pulverisation or powdering: To achieve a greater size control, rapid powdering and safety in handling, it is advantageous to pulverise materials like spices, dye-stuffs, pharmaceuticals, insecticides, thermoplastic materials in the frozen state by making them pass in a chamber cooled with liquid nitrogen on their way from the hopper to the pulveriser.

(b) Fire-fighting: Extinguishing fires in the forest is a tedious and laborious job. Use of plastic containers filled with liquid nitrogen as aerial bombs has proved very effective not only in putting out the fire but also in extinguishing cinders. This is probably because of the combination of two effects—cooling and providing an inert atmosphere.

(c) Repairing pipelines without shutting off the main supply: The whole process of cutting and threading the line for installing a local meter does not take more than a few minutes. This can be done by freezing the line with liquid nitrogen.

To Our Contributors

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