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EDITORIAL

This special number of 'School Science' is to commemorate the birth centenary year of Homi Jehangir Bhabha, the 'Father of India's Atomic Energy Programme'. Born on 30 October 1909, Homi Bhabha has been the guiding spirit and flag bearer in initiating and nurturing nuclear science programme in the country till death snatched him away from us in a tragic air accident on 7 January, 1966. Bhabha realised, as early as in nineteen forties, the importance of research in fundamental science for the progress and development of the country. It was through his initiative and concerted efforts that the Tata Institute of Fundamental Research (TIFR) was set up in 1945 in Mumbai. Homi Bhabha was appointed the first Director of TIFR, which was formally inaugurated in December 1945. He envisioned TIFR as an institute that would provide facilities to researchers in all disciplines of science from different parts of the country to pursue their research work on fundamentals of sciences. Bhabha's talent as research scientist was recognised by Pandit Jawaharlal Nehru, the first Prime Minister of Independent India. Bhabha was appointed as the first Chairman of newly created Atomic Energy Commission in 1948 and later became Secretary to the Department of Atomic Energy, Government of India. A programme for applications of nuclear energy for peaceful purposes in India was evolved under the guidance of Homi Bhabha. Bhabha was aware that self sufficiency in nuclear energy programme could only be possible if we create a pool of researchers,

scientists, engineers, and well trained technicians within the country and direct our efforts to indigenous development of nuclear and related technologies. It was his foresight that right from the beginning preparation of human resource with desired capabilities has been an inbuilt component of the nuclear energy programme in the country. The credit for the progress India has made in the field of nuclear energy goes entirely to the vision of Bhabha. Not many among the younger generation be aware that as a member and later as Chairman of the Scientific Advisory Committee to the Union Cabinet of Ministers, Homi Bhabha played a key role in setting up National Committee on Space Research in 1962, which laid the foundation of Space programme in the country. He was also the Chairman of Electronic Committee set up by the Government of India to formulate a comprehensive policy and programme on research and development in the field of electronics for the country apart from provide expert advice and guidance on other aspects. This number of 'School Science' is a humble tribute to this great son of India. The lead article in this issue highlights the life of Homi Bhabha and his work, particularly research on cosmic rays. The article that follows enumerates his life and work as a researcher, a visionary, an able organiser and an administrator. The letter written by Bhabha to Sir Dorabji Trust and his address on the occasion of inauguration of TIFR have been reproduced to provide glimpses of his vision, his faith on science for development and dedication to achieve goals set for himself.

In recent times global warming has become one of the major issues that concern all of us. Many efforts have been made at the international and national levels to tackle the menace of global warming. An article that sums up major decisions taken collectively by all the countries across the world including the actions initiated, both at international and national levels, to effectively deal with global warming and its impact on the environment forms the theme of one of the articles. Children are the decision makers of tomorrow and they are likely to confront with environmental problems on a much wider scale than the present generation.

Environmental education, therefore, now forms a major component of formal curriculum at all levels of education including school education. An article based on the findings of a study on environmental awareness level of students, though for a small sample, has also been included. Nano-technology is another upcoming field, which may occupy

an important place in school curriculum.

We have been including from time to time articles and news items to keep our readers abreast with the developments in this field. Though nano-technology may not be an independent subject of study at school level in near future, views about the rationale, content and coverage of a curriculum on nano-technology forms the main theme of another article. The issue also includes articles on other areas like bio-technology, reducing carbon emissions and computers in education in addition to the regular columns like science news, web watch and you have asked.

It has been our endeavour to present in each issue articles, features and news items that we believe our readers would find interesting and educative. Your comments and suggestions would indeed give us encouragement and guide us to bring further improvement in the quality of the journal.

BHABHA'S CONTRIBUTIONS TO ELEMENTARY PARTICLE PHYSICS AND COSMIC RAYS RESEARCH*

Virendra Singh

Professor Virendra Singh is a renowned theoretical physicist of the country, whose research interests include S-Matrix theory, unitary symmetry, strong coupling theory, foundations of quantum mechanics and a variety of other areas. A Ph. D. from the University of California at Berkeley, Professor Singh joined TIFR in 1957 and was its Director from 1987-1997. After retirement, he continued to work in TIFR as INSA C. V. Raman Chair Professor till very recently.



1. Introduction

Homi Jehangir Bhabha (1909-66) started his career as a theoretical physicist at Cambridge in the nineteen-thirties and distinguished himself in the emerging areas of elementary particles, or high energy physics, and cosmic rays. He worked actively in these areas for a period of about two decades (1933-1954) and made many significant contributions. His name is commemorated in these fields through the electron-positron scattering process being called Bhabha Scattering [1] Bhabha-Heilner cascade theory of cosmic ray Showers [2] was a signal contribution to the cosmic ray studies. His name is also associated to Bhabha-Corben theory of relativistic spinning

classical particles [3]. The Bhabha equations[4] investigated possible relativistically invariant linear wave equations for elementary particles. Bhabha was also responsible for the nomenclature *meson* for the bosonic elementary particles of 'intermediate' mass, along with N. Kemmer and M. H. L. Pryce [5]. The terminology *orthochronous* for those Lorentz transformations, which do not change the sign of time-coordinate, also originated with him in his work on Bhabha equations [6]. Bhabha also initiated experimental work on cosmic rays, when he was at the Indian Institute of Science, Bangalore and continued it further at Tata Institute of Fundamental Research, Bombay (now Mumbai). We propose to discuss here his various scientific contributions.

* Reproduced with permission from *Physics News*, Bulletin of Indian Physics Association, January 2009, No.1, Vol.39.

2. Cambridge Period

Bhabha went to Cambridge in 1927 and joined Gonville and Caius College as a student of mechanical engineering. Around the time the excitement was rather high there in the theory of elementary particles and radiation especially in quantum electrodynamics. Dirac, at Cambridge, had proposed his quantum theory of emission and absorption of radiation in 1927. This was followed by his Dirac equation. This described relativistically the electron in the same sense as Maxwell equation describe the radiation. Dirac equation was seen to incorporate the phenomenon of electron spin and magnetic moment quite naturally and was shown to lead to experimentally correct Sommerfeld formula for the energy levels of the Hydrogen atom. The main new feature of the Dirac equation was the existence of negative energy states for electrons and this was rather puzzling as electrons in these states were predicted to move in a direction opposite to that of the external applied electromagnetic force. To get out of this quandary, Dirac proposed, in 1930, that all the negative energy states are filled with one electron each in accordance with Pauli principle. An unoccupied negative energy state, i.e. a *hole*, would behave as charged particle with an electric charge opposite to that of an electron. This *hole* theory of Dirac was the first introduction of the concept of *antiparticles* in physics. These particles, now called positrons, were observed experimentally by C.D. Anderson in 1932 and have the same mass as electron.

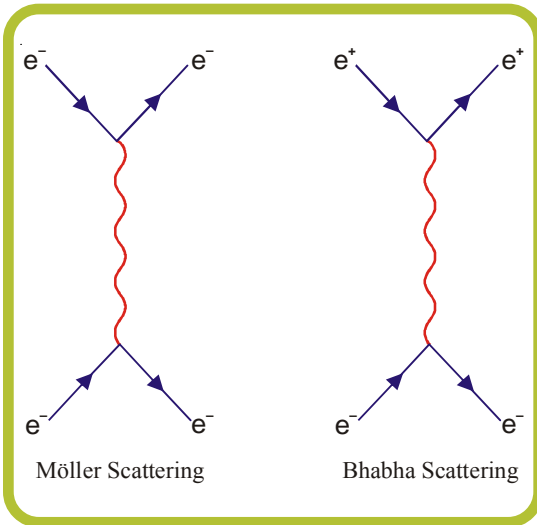
Bhabha was swept with all this intellectual excitement in quantum electrodynamics. He wrote to his father asking his permission to change to theoretical physics. As he wrote, "I seriously say to

you that business or a job as an engineer is not the thing for me. It is totally foreign to my nature and radically opposed to my temperament and opinions. Physics is my line, I know I shall do great things here". His father was agreeable to let him pursue theoretical physics, and get a mathematics tripos, provided Bhabha devoted himself first to his mechanical tripos, and obtained a first class. Bhabha did that in June 1930 and was free to devote himself to his interest in theoretical physics thereafter. His initial interests were mainly in the positron theory and cosmic rays physics. We shall describe some of his main work in these areas before going on to describe his later work in meson theory.

2.1 Positron theory : Bhabha Scattering

Bhabha investigated positron interactions in a number of his papers using Dirac's hole theory. The first of these dealt with "Annihilation of Fast Positrons by Electrons in the K-shell" which was received by Royal Society on 4 May 1934. [7]. The work on this paper was begun at Cambridge with H.R. Hulme, and finished by Bhabha at Institute of Physics in Rome where he was visiting Enrico Fermi on his Rouse Ball Travelling studentship in Mathematics which he held for 1932-1934. The next electrodynamic process he considered was the creation of electron-positron pairs by fast charged particles [8]. He was holding an Isaac Newton studentship (1934-1936) at this time.

The crowning achievement of this group of papers on positron interactions was Bhabha's investigation of electron-positron scattering, a process now known as "Bhabha Scattering". The



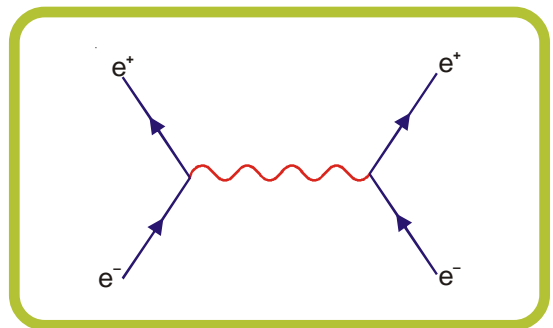
paper is titled 'The Scattering of Positrons by Electrons with Exchange on Dirac's Theory of Positron' [1] and was received by the Royal Society on 20 October 1935.

Mott had earlier considered exchange effects in non-relativistic electron-electron scattering. He had found that exchange effects are considerable except that the effect vanishes when the 'two electrons have antiparallel spins' [9]. Moller had generalised these results to the relativistic electron-electron scattering, now called Moller Scattering [10] and found that the exchange effects are non-vanishing even when electron spins are antiparallel except in the non-relativistic limit.

Now, if a positron is regarded as an independent particle, which also obeys Dirac equation, then the positron-electron scattering should show no exchange effects. If, on the other hand, positron is regarded as an electron in an unoccupied negative

energy state then we should expect exchange effects. These two hypotheses would lead to different results. To quote Bhabha, "The difference would be due to the effect of exchange between the electron we observe initially and the virtual electrons in states of negative energy" [11]. Except in the non-relativistic limit, the effect of the exchange was found considerable. It was not completely clear at this time whether such an exchange effect is simply not an incorrect prediction of the Dirac theory as the exchange was between an observable electron of positive energy and another virtual one of negative energy.

Bhabha, however, pointed out that another way of looking at this extra exchange contribution was to regard it as due to annihilation of an electron-positron pair, followed by simultaneous creation of a new electron-positron pair and that such terms should be present in the scattering of any two particles which can annihilate each other and be created in pairs. He noted that such



▲ Anihilation of electron-positron pair

terms were present in a recent theory of Pauli and Weisskopf [12] having particles which obey not the exclusion principle but rather obey Einstein-Bose statistics.

A consequence of this calculation was an expected considerable increase in the number of fast secondaries for positrons of high energies. Bhabha's theory was beautifully confirmed by experiments. Our faith in the correctness of Bhabha scattering formulas is such that they are now routinely used to calibrate the beams at large accelerators using positron or other antiparticle beams.

It should be noted that the discovery of substitution law or crossing symmetry property of local quantum field theory allows us to get the matrix elements for Bhabha Scattering from those of the Moller scattering and vice versa [13]. Of course, the discovery of the substitution law itself owes much to these earlier calculations of the related processes.

2.2 Cosmic Ray

In 1936, Bhabha was awarded a Senior Studentship of the Exhibition of 1851. This was also the year in which he and W. Heitler, from Bristol, met together. They had common interest in high energies. Indeed the very first publication of Bhabha in 1933, written from Zurich where he was visiting W. Pauli from Cambridge, was 'On the Absorption of the Cosmic Rays' [14] and he had discussed the role of electron showers in it. Since that time he had devoted himself to positron processes in quantum electrodynamics. W. Heitler had also been working on similar subjects. Bethe and Heitler had worked on bremsstrahlung

radiation from charged particles and on high energy photon induced pair production. Heitler



◀ Heitler

had published the first edition of his book "Quantum Theory of Radiation" in 1936. The result of this collaboration between Bhabha and Heitler was their celebrated cascade theory of electron showers [2].

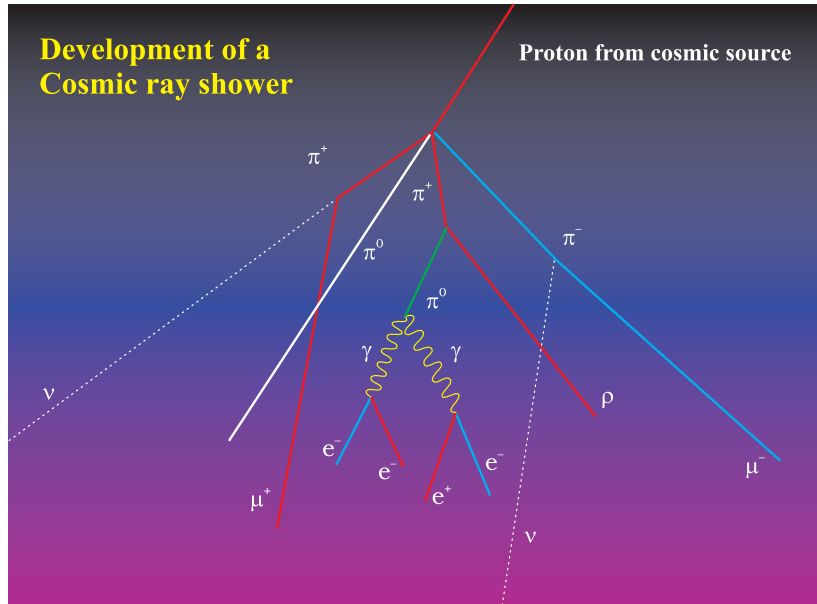
2.2.1 Bhabha-Heitler Theory

The Bethe-Heitler theory predicted large cross sections for energy loss of electrons or positrons passing through the field of a nucleus by bremsstrahlung in a *single* encounter. These hard quanta also have a large probability for materialising as electron-positron pairs. The theoretical "range" of an electron of 10^{12} eV was found to be only about 2 km of air, 2 m of water or 4 cm of lead. It, however, seemed to disagree with the observation of fast electrons at sea level which have traversed 8 km of atmosphere. The common belief was that these observations signify a breakdown of Quantum Electrodynamics. Bhabha and Heitler, however, went on to show, through their cascade theory, that quantum

electrodynamics was quite consistent with the observed phenomenon.

What happens is as follows: A fast electron does lose all its energy after a short distance of travelling through matter just as predicted by Bethe-Heitler formula. This energy, however, reappears in the form of radiation quanta which, for large initial electron velocities, have a large probability of moving in the direction of the original fast electron. There is reasonably high probability that these radiation quanta are hard. Again, in accordance with quantum electrodynamics, these radiation quanta materialise, after traversing a short distance through matter, into electron-positron pairs. Again there is a reasonably high probability that the resulting pair consists of a fast electron and a fast positron moving in the direction of the disappearing hard quanta. This process of conversion into photons and reconversion into electron-positron pairs can take place many times. The total effect is thus as if the original electron was losing its energy much more slowly than implied by the theoretical "range" mentioned earlier.

These Ideas of Bhabha and Heitler provided a natural explanation of the cosmic ray showers.



Development of a cosmic ray shower

The calculated curves for the expected number of electrons $n(E, h, E_0)$, above a certain energy E and at distance h below the top of the atmosphere when an electron with energy E_0 is incident at the top of the atmosphere, agreed well with the observed curves by Rossi [15] and the ionisation curves of Regener [16].

The idea that cosmic ray showers could be explained this way was 'in the air'. L. Nordheim, in a conversation with Heitler in 1934, and Carmichael in a conversation with Bhabha had already considered the possibility but "owing to the ill-founded suspicion in which the theory was then held, it did not seem worthwhile carrying out any calculations" [17]. The cascade theory was also given at about the same time by J.F. Carlson and J.R. Oppenheimer [18].

2.2.2 Penetrating Component of Cosmic Radiation

It was very suggestive from the work on absorption of cosmic rays in lead by Rossi and others that cosmic rays consist of two components: a soft component and a penetrating component [19]. The intensity of the soft component is reduced by about 30 per cent in passage through about 10 cm of lead. There are, however, also single charged particles, belonging to the penetrating component, which can traverse one metre of lead. The properties of the soft component could be completely accounted for, by Bhabha-Heitler theory, if it consisted of electrons. The penetrating component was, however, still an enigma. It was not possible for quantum electrodynamics to account for the penetrating component if these particles were electrons. There was therefore a breakdown of quantum electrodynamics for higher energies and/or the penetrating components was not composed of electrons.

Bhabha, in a remarkable paper submitted to the Royal Society on 4 October 1937, carried out a powerful analysis of both the theoretical and the observational situation about the penetrating component of cosmic radiation [20].

He first showed that a “breakdown” of quantum electrodynamics for the energy loss of electrons was not a viable alternative for the observed phenomenology of cosmic radiation. He showed that if the breakdown energy is around 10 GeV or higher for electrons then no latitude effect would be there at sea level. The shape of the transition curve for large showers also led to a similar conclusion.

It therefore seemed that a viable alternative is to regard the penetrating component of cosmic radiation as consisting of particles other than electrons. Could they be protons? Initially Bhabha and Heitler had inclined to this view while Blackett was of the view that they are electrons. It, however, gradually became clear that these particles could not be protons either in view of Blackett’s arguments against the proton hypothesis [21].

Bhabha therefore investigated in this paper the hypothesis that “There are in the penetrating component of Cosmic radiation new particles of electronic charge of both signs, and mass intermediate between those of the electron and proton” [22]. He called them heavy electrons. The illustrative mass values considered were 10 and 100 times the electron mass. We quote “A comparison with the measurements of Auger and others therefore allows one to conclude that if the hypothesis of new particles is right, *the majority of the penetrating particles must have masses nearer to a hundred times the electron mass rather than ten times the same*” [23]. Thus Bhabha had, in a brilliant piece of cosmic ray phenomenology, essentially predicted the existence of a new particle. Similar conclusions had also been reached by Neddermyer and Anderson, and by Street and Stevenson [24]. These particles are now called muons and the first clear case of their track was observed in Cosmic rays in 1938 by Anderson and Neddermyer [25]. Their mass is about two hundred electron masses.

2.3 Meson Theory

Bhabha, when he predicted the “meson” in October 1937, was not aware of Yukawa’s meson

theory [26], which was brought to his attention by Heitler in a discussion about cosmic radiation presumably some time between 4 October 1937 and 13 December 1937, when he sent his first note on meson theory for publication [27]. It was natural for Bhabha to identify Yukawa's mesons with those indicated by cosmic ray phenomenology.

2.3.1 A Test of Relativistic Time-dilation

It was first pointed out by Bhabha, in his note to the *Nature* [27] that positive (negative) mesons should spontaneously decay into a positron (electron). In this note he also pointed out "This disintegration being spontaneous, the U-particle may be described as a 'clock', and hence it follows merely from considerations of relativity that the time of disintegration is longer when the particle is in motion". The U-particles referred to the mesons. Thus the lifetime of a particle, T, moving with a velocity v should be given by

$$T = \frac{T_0}{\sqrt{1 - \left(\frac{v}{c}\right)^2}}$$

where T_0 is the lifetime of the particle at rest and c is the velocity of light. This was nicely confirmed by experiments and constitutes one of the most beautiful tests of the special theory of relativity.

2.3.2 Vector-Meson Theory

The identification of Yukawa's mesons with those required by cosmic ray phenomenology allows one to couple the problem of nuclear forces with

that of the cosmic rays. It may be noted that, the particles required by cosmic ray phenomenology are now identified with muons, while the Yukawa mesons are identified with the pions which were only discovered in 1948 by C.F. Powell. However, this confusion of the Yukawa mesons with muons was very fruitful as it gave a great impetus to the development of the meson theory which had not received much attention till that time. The earliest major workers on Meson Theory, apart from those in Yukawa's group i.e. S. Sakata and Taketani, were Bhabha at Cambridge, N. Kemmer in London, H. Frohlich and W. Heitler at Bristol.

The original Yukawa theory had considered the mesons to be scalar particles, i.e. having no spin and with positive parity. This assignment does not give rise to a satisfactory nuclear force between nucleons i.e. protons and neutrons. Mesons, further, have to have integral spin and must obey Bose-Einstein statistics. Bhabha therefore considered the generalisation that the mesons are vector particles i.e. having spin one and odd parity. He used Proca's wave equation to describe the meson field. The coupled nucleon-meson field system was then quantised and nucleon-nucleon interaction calculated using second order perturbation theory. Bhabha was gratified that "The interaction is therefore just of the required form consisting of Heisenberg and Majorana forces of the right sign so as to allow one to make the triplet state of the deuteron the lowest stable state. We would emphasise the fact that since only the squares of g_1 and g_2 enter into this expression, the sign of the Majorana force is beyond our control, and it is to be looked upon as a strong argument in favour of this theory that it allows only that sign of the force which actually occurs in

nature” [28]. Bhabha also calculated meson-nucleon scattering cross-sections in the lowest order. There were at that time no data for this process. Related investigations were also carried out by other workers.

2.3.3 Classical Meson Theory

The vector nature of the meson fields gave rise to large probabilities at high energies for multiple processes. Also the theory had more severe divergence problems compared to quantum electrodynamics. There were apprehensions that these imply the breakdown of either quantum mechanics or meson theory, even for lower energies comparable to meson mass. All of these were essentially based on second order perturbative calculations in meson-nucleon coupling constants. It is to be remembered that these coupling constants are rather large as the meson-nucleon interaction is strong. As such these calculations are not necessarily reliable.

In order to escape the limitations of the perturbation theory in coupling constant, in dealing with quantum meson-field theory, Bhabha decided to investigate the classical meson field theory in interaction with a fermion [29]. The meson field was described, as earlier, by the Proca wave equation, except that now the meson field components were taken as commuting variables. The fermion was taken as a point classical particle having spin and moving along classical world-lines. This entailed a generalisation of the method of Dirac used in treating the behaviour of a classical point electron in the field of electromagnetic radiation [30].

The meson-fermion scattering cross-sections were calculated. These are analogous to Thomson

scattering for zero mass photons and were found to smoothly go to that limit as meson mass went to zero. Indeed it was found that at high energies, i.e. energies much larger than meson mass, the behaviour was essentially the same as that in Dirac’s case. Before the advent of the Chew-Low theory, these were among the best theoretical attempts to deal with the meson-nucleon scattering problem.

3. Bangalore Period

Bhabha was in India, in 1939, on a holiday when the second world war broke out. The subsequent war conditions made it impossible for him to return to England. His earliest communications to the Proceedings of the Indian Academy of Sciences are from this period and were received by them in October 1939. The second of these two papers deals with the classical theory of the electron and is still bylined as Gonville and Caius College. In early 1940 Bhabha joined Indian Institute of Science, Bangalore as special Reader in-charge of a Cosmic Ray Unit.

3.1 Classical Relativistic Spinning Point Particle Theory: Bhabha-Corben Equations

Bhabha was originally drawn to the classical theory of relativistic point particles as a way to take into account the reaction of the emitted or scattered radiation, whether of electromagnetic quanta or of mesons, i.e. radiation reaction, on the motion of fermions. The quantum treatment of the interaction of point particles with fields, which depended on the perturbation theory in the coupling constant, was not very satisfactory. It was even more so when the explicit spin

dependant interaction, e.g. Pauli anomalous moment term for interaction with electromagnetic field or similar for vector meson fields, were taken into account. The interactions tend to increase with energy. It was pointed out by Bhabha that these effects are due to neglect of the radiation reaction and that the quantum treatment can be trusted only in the region of energy where this neglect of radiation reaction is justified. Faced with this situation it was natural to go back to the classical limit where it is, in principle, possible to take radiation reaction into account either exactly or with controlled approximations. For spinless charged particles it was possible to do this by using Dirac's work on the point electron theory [30]. The electron theories had been in existence since Lorentz's work in 1892 but Dirac's work of 1938 was the first logically correct relativistic classical point electron theory.

In Dirac's work the spin of the electron was not taken into account. It was therefore necessary to generalise Dirac's work to the case of spinning point particles. Bhabha had already begun some work on this problem with H.C. Corben before leaving Cambridge and it was continued at Bangalore. A preliminary note on this work was sent to *Nature* on 17 March 1940 and was his first research note from Indian Institute of Science, Bangalore. The definitive paper on this work, giving Bhabha-Corben equations, was titled "*General Classical Theory of Spinning Particles in a Maxwell field*" [3]. The case of a meson field was treated in a sequel which followed immediately after this paper [3].

The point electron theories previous to the work of Dirac, and related work of Pryce, had approached the problem of a point electron as the

limit of a finite-size electron. This procedure is not very satisfactory in view of the conflict between the concept of a rigid body and relativity. In the procedure of Dirac and Pryce one assumes the validity of field equations right up to the point particle world line but one modifies the definition of the field energy in the presence of singularities. This is also the procedure adopted by Bhabha and Corben.

The effect of radiation reactions was, as expected by Bhabha, to reduce the scattering cross section. Indeed for large energies it was found to decrease inversely as the square of the incident photon frequency for the Compton-process.

Bhabha was elected as a Fellow of the Royal Society, London in 1941.

3.2 Meson Theory and Nucleon Isobars

Before the discovery of the pion in 1947 the muon was confused with Yukawa's meson. The meson theorists had the unenviable task of explaining as to why the meson-nucleon scattering is weak — since muons do not scatter much on the nucleons — and yet at the same time the nuclear forces arising from the exchange of the same mesons is strong.

It was noted by Bhabha that the scattering of the longitudinally polarised *neutral* vector mesons on nucleons shows a decrease as E^{-2} , E being the meson energy, for large energies in contrast to the scattering of longitudinally polarised *charged* mesons whose scattering on nucleons increases as E^2 . This difference was traced by Bhabha to what we would refer in modern terminology as

being due to the cancellation between direct channel nucleon pole and the crossed channel nucleon pole in case of neutral mesons and a lack of such a cancellation for charged mesons. For charged mesons we do not have both direct and crossed channel exchanges possible if only nucleons of charge +1 and 0 exist. In order to have the cancellation mechanism available, Bhabha therefore suggested that the nucleon may exist in charge states +2 and -1 also. The contribution from these charged states was needed to provide the cancellation. In general, nucleon isobars may have any charge and neutron and proton are only the lightest ones occurring in nature [31]. This was the first suggestion of the existence of the nucleon isobars.

Bhabha communicated the idea to Heitler and he also pursued it. This mechanism, referred to as Bhabha-Heitler mechanism, for reducing the mesons cross-sections, was one of the major reasons for a study of the strong coupling theory of nucleon isobars. The first nucleon isobar N^* (1240 MeV) was discovered by Fermi *et. al.* in the pion-nucleon scattering experiments in 1952.

3.3 Cosmic Rays

In his capacity as special reader in charge of cosmic ray unit at Indian Institute of Science, Bangalore, Bhabha planned to pursue both theoretical and experimental work in the area of cosmic rays. The unit was set up as part of the department of Physics which was headed by Nobel Laureate Sir C.V. Raman. Given his pioneering work on cosmic ray showers with Heitler, and the scope offered by the experimental work on cosmic rays to study high energy interaction, involving particle production, it was a

natural choice. India also offered a tremendous geographical advantage of comprising magnetic latitudes ranging extensively from equator to 25° North within its confines for studying high energy cosmic rays.

3.3.1 Cascade Theory

The initial cosmic ray work in the cosmic rays concerned itself with refinements of the classic Bhabha-Heitler theory. They had made a number of simplifying assumptions. In particular it was assumed that one can ignore collision loss below a certain critical energy, i.e. the energy at which collision loss is equal to radiation loss. Further, if the energy is above this critical energy it was assumed that it would lead to an absorption of the cascade. In view of the improvement in the quality of the observational data it had become necessary to improve the theoretical treatment.

There had been previous attempts, notably by Snyder and Serber, to give an improved treatment taking collision loss into account [32], but there were some doubts about the convergence of their series solutions. Bhabha and Chakrabarty gave a solution of this problem in the form of a rapidly converging series [33].

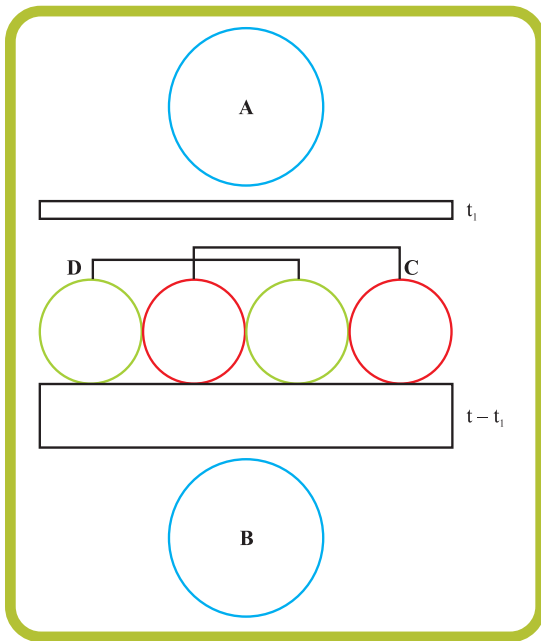
In all these treatments the lateral spread of the shower is neglected. The collision loss is taken as a constant B independent of the energy of the charged particle. Actually it is not strictly constant but in the whole relevant energy range of 5 to 150 MeV it increases less than by a factor of 1.5 and it is thus reasonable to treat it as a constant. For radiation loss and pair creation one can use the exact expressions of Bethe and Heitler. An exact solution of the Landau-Rumer equations [34], describing the longitudinal evolution of the

shower, for the number of charged particles and radiation quanta was given by K.S.K. Iyengar [35]. His solution was, however, not easily amenable to extracting numerical results. Bhabha and Chakrabarty, used the asymptotic form of the Bethe-Heitler expressions, in their solution. Using Mellin transform techniques it was then possible to obtain a series solution which was rapidly convergent. It is possible to regard the Bhabha-Chakrabarty solution as an analytic continuation of the results of Snyder and Serber.

latitude effect for mesons. The soft component of the cosmic rays, consisting of electrons, positrons and gamma rays, was described quite correctly by the cosmic ray shower theory. The hard component of the cosmic rays, consisting mainly of mesons, was much less understood theoretically and needed experimental observations. The hard component would also include high energy protons.

In order to devise experimental set up to study the hard component of the cosmic rays, containing mesons, it was necessary to devise procedures to discriminate between the soft and the hard components experimentally. Bhabha studied this problem in 1943. He came to the conclusion, using recent detailed work of Bhabha and Chakrabarty [33] on the cosmic ray showers, that the usual method of separating the two components of cosmic rays by interposing absorbers, such as lead, of different thickness, and measuring the cosmic ray absorption, is not sufficiently reliable.

Bhabha devised a new method (Bhabha method) for this purpose. The absorber of total thickness t is divided into two of thickness t_1 and $t-t_1$. Between the two parts of the absorbers are interposed a set of counters C and D in anti-coincidence. The whole sandwich is then placed between the set of counters A on one side and counters B on the other side. The set of counters A,B and C (or D) are in coincidence. Bhabha showed that such an arrangement would be able to take better advantage of shower multiplication by soft component to better discriminate the soft and the hard component [36].



 Bhabha Method

3.3.2 Experimental Cosmic Ray Work

The first problem which Bhabha decided to tackle experimentally in cosmic rays was to study

The experimental measurements of the vertical intensity of mesons were carried out in two

aeroplane flights at Bangalore with magnetic latitude of 3.3° N [37]. The first flight carried two sets of counter telescopes viz. (i) with total thickness of lead absorber equal to 5.25 cm and divided into two absorber one of 1.25 cm and other of 4.0 cm. The arrangement here used Bhabha method and (ii) a quadrupole coincidence counter telescope with 3.0 cm of lead absorber. The measurements were taken up to 15000 ft. The second flight carried a quadrupole coincidence counter with 20 cm of lead and carried out measurements up to 30,000 ft. A comparison of the experimental measurements by Bhabha and his group in these flights with those of Schein, Jesse and Wollan [38] carried out at Chicago, magnetic latitude 52.5° N, showed that for meson intensity there was "no marked increase even to attitudes corresponding to 275 millibars Pressure". This was quite in contrast to the total cosmic ray intensity which showed a marked increase of latitude effect up to these heights.

Another flight making such measurement later extended the results up to an attitude of 40,000 ft above Bangalore with similar results.

4. Bombay Period

During the five year period in Bangalore "he found his mission in life" [39] as an institution builder. As a result of correspondence with J.R.D. Tata and Sir Sorab Saklatvala, he founded the Tata Institute of Fundamental Research at Bombay in 1945. The institute started functioning in June 1945 with H.J. Bhabha as its Director and was formally inaugurated on 19 December 1945. Initially the work at the Institute was carried out in the areas of mathematics, theoretical physics and

a continuation of the experimental work in cosmic rays. He was appointed as the first chairman of the Atomic Energy Commission when it was founded in 1948 and became Secretary to the Department of Atomic Energy of the Government of India in 1954.

4.1 Bhabha Equations

The first research paper from Tata Institute dealt with "*Relativistic Wave Equations for the Elementary Particles*" and appeared in an issue of *Reviews of Modern Physics* to commemorate the Sixtieth birthday of Prof. Niels Bohr [4].

Dirac, as mentioned earlier, had given his relativistic wave equation in 1928 which described the behaviour of electrons with spin one half and had successfully predicted the existence of positrons. Dirac equation was a first order equation and its success encouraged similar attempts to find wave equations describing particles with a spin having a value other than one half. Duffin, Kemmer and Petiau had given similar first order wave equations describing particles with spin-0 and spin-1. The spin-1 equations were Proca equations. Dirac, and Fierz and Pauli had proposed relativistic wave equations for particles having any integral or half-odd integral spin. An unsatisfactory feature of the equations proposed by Dirac, and Fierz and Pauli for spin greater than one, was the presence of subsidiary conditions. These subsidiary conditions created difficulties when one considered these particles in interaction with electromagnetic fields. The difficulty was connected to the fact that these could not be derived from a variational principle.

Bhabha therefore proposed to investigate general first-order relativistic wave equations, without any

subsidiary conditions, i.e. equations for wave field of the form $(\alpha^k p_k + \chi)\psi = 0$

where $p_k = i \frac{\partial}{\partial x^k}$, α^k are four matrices ($k = 0, 1, 2, 3$) and χ is an arbitrary constant. Such equations have come to be known as Bhabha equations. Sometimes the nomenclature "Bhabha equations" is used to refer to a restricted subclass of equations where six Lorentz generators, together with four α^k s, form an SO(5) algebra. This restricted subclass was investigated by Bhabha in detail and from now on in this section we shall mean this subclass when we refer to Bhabha equations.

As Bhabha equations involve an SO(5) algebra they can be completely classified by using the representation theory of the SO(5) algebra. Bhabha was among those few physicists of his time who were at home with group theory. His essay "*The Theory of the Elementary Physical Particles and their Interactions*", for which he was awarded Adams Prize in 1942, had contained a fair amount of the theory of orthogonal groups. Bhabha equations were found to contain Dirac equation for spin one-half and Duffin-Kemmer-Petiau equations for spin-0 and spin-1 as special cases. These equations were special cases for Dirac-Fierz-Pauli equations also. Bhabha equations, for spin greater than one, were, however, from Dirac-Pauli equations, and led to multiple mass states.

4.2 Cosmic Rays

4.2.1 Cascade Theory and Stochastic Processes

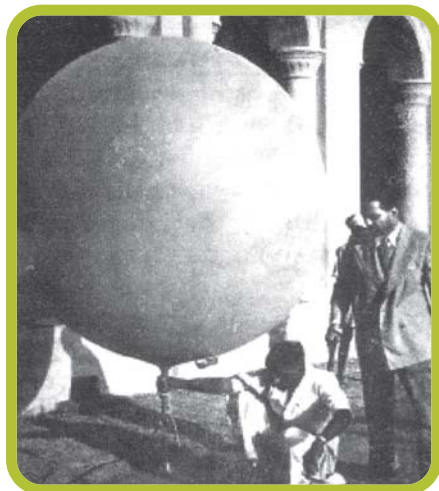
Bhabha and Chakrabarty extended their calculations of the number of charged particles

and quanta, in 1948, to cover the case of showers in thin layers. They brought to completion this part of their work on cascade theory which deals only with mean numbers of shower particles at various depths.

The study of the fluctuations of the number of shower particles is also of great importance in the study of cosmic ray showers. One of the conceptual difficulties in attacking the problem was that it involved a system whose state space was continuous and not discrete. The electrons and photons do have a continuous variation in energy. Bhabha therefore derived the product density function method for the continuous parametric systems and applied it to derive the equations for the cosmic ray cascade theory which determine the mean numbers (i.e. Landau-Rumer equations) and the mean square deviations of the numbers [40]. These equations were solved in a subsequent paper with Ramakrishnan [41].

4.2.2 Experimental work in Cosmic rays

The program of measuring the hard component of the cosmic ray intensity, at various Indian latitudes and its variation with altitudes was continued at Bombay. Towards this objective Bhabha organised a High Attitude Studies group whose main program was to organise Balloon flights for these studies. The balloon flights were initially made from Bangalore and Delhi. Bhabha reported these results at a conference at Kyoto-Tokyo in 1953 [42]. Later flights were also made from many other locations as well. Bhabha made a preliminary beginning for nuclear emulsion work with cosmic rays by flying in an airplane a Ilford C2 plates loaded with Boron at an average altitude of 8000 ft for 72 hours in 1948. An example of "meson" scattering with nuclear excitation was recorded and published with his



Homi Bhabha working on an early cosmic ray experiment using a balloon in Bangalore (courtesy TIFR)

student Roy Daniel [43]. Later Bhabha induced Bernard Peters, of Rochester University, to take over the Nuclear emulsion group at Bombay in December 1950. Peters was well known for his discovery of heavy nuclei in primary cosmic rays. A 12" diameter cloud chamber, similar in design to one at Blackett's laboratory at Manchester, which Bhabha had got built at Bangalore was also moved to Bombay and work on meson scattering continued. Prof. Sreekantan took over the further developments here [44]. Bhabha also started thinking about Kolar Gold Fields as a facility for deep underground experiments on cosmic rays around 1950. Prof. M.G.K. Menon joined the Cosmic ray group from Prof. Powell's group in 1956.

4.3 Multiple Meson Production

This is essentially Bhabha's last piece of theoretical research Work [45]. His work in

Bangalore and Bombay had been decidedly more mathematical as compared with his work at Cambridge which had been on the whole, phenomenological. In his work on multiple meson production he again displays a phenomenological strain.

In the centre of mass system the two colliding nucleons suffer relativistic contraction in the direction of motion and appear as colliding discs. Different mechanisms were invoked by Fermi and Heisenberg as to how the nucleon energy is converted into mesons. Bhabha suggested the hypothesis that the strong interactions get localised both due to relativistic contraction as well as due to the time of interaction being very small. On this picture the energy available for meson production is much less than the total available c.m. energy.

The real surge of interest in multiple meson production had to wait till early nineteen seventies when sufficient high energy data became available. In Bhabha's picture it is somewhat natural to assume that not only the strong interaction gets localised but the production of mesons also gets localised, leading to a damping of transverse momenta [46]. Bhabha's model thus can be regarded as a precursor of the parton model.

5. Concluding Remarks

Bhabha's work in theoretical physics was carried out in a wide variety of styles. His work, with Heitler, on cascade theory, is of a kind which would now be described as phenomenology. Some of his work had speculative components,

e.g. his work on penetrating component of cosmic rays where he suggested the existence of "muon" like particles and his work on meson-nucleon scattering where he suggested the existence of "nucleon isobars" especially those having electric charge of +2 and -1 in the units of proton charge. His work on the theory of relativistic spinning particles in classical physics was originally motivated by the problem of radiation reaction. One cannot, however, help feeling that this motivation was strongly reinforced by the aesthetic appeal of this investigation. Here one has a well defined "complete" theory in a world described by classical physics. The finer aspects of this theory cannot be tested in the real world as there are important quantum corrections which vitiate any testing. His work on relativistically invariant wave equations, though motivated by a possible application to "nucleons", could be regarded as almost pure mathematical group theory. In fact work on these equations provided the background for the later important work on the

theory of noncompact groups by his collaborator Harish-Chandra.

Though Bhabha's main scientific work and achievements were in theoretical physics, he was sensitive to the importance of experimental work as well. His cosmic ray experiments were not carried out by using techniques used in similar work elsewhere but used a novel method devised by himself.

We have restricted ourselves in this paper to the research contributions of Bhabha in physics. This hardly exhausts Bhabha's contribution to science. He played an important role as a developer of scientific institutions in India. He was also an excellent science administrator with an innovative style of management. More than any other person, Bhabha was responsible for introducing and nurturing modern nuclear science and technology in India. His role in the emergence of Bombay school of modern Indian painting has also been taken note of. But, in a sense, all these later achievements of Bhabha have their origins in the excellence he achieved in his scientific research.

Bibliographical Notes

This article overlaps in some places with author's earlier related writings :

1. Bhabha, H. J. 1985. His Contributions to Theoretical Physics, in Homi Jehangir Bhabha : Collected Scientific Papers, (Editors : B. V. SREEKANTAN, VIRENDRA SINGH AND B. M. UDGAONKAR), pp. xxii-xlvi, TIFR, Mumbai.
2. Bhabha, H. J. 2000 in The Scientist in Society, pp. 181-193, Thema, Calcutta .

References

1. BHABHA, H.J. 1936. Proc. Roy. Soc. 154A, 195, London.
2. BHABHA, H.J. and W. HEITLER. 1937. Proc. Roy. Soc. 159A, 432, London.
3. BHABHA, H.J. and H.C. CORBEN. 1941. Proc. Roy. Soc. 178A, 273, London
BHABHA, H.J. 1941. Proc. Roy. Soc. 178A, 314, London.
4. BHABHA, H.J. 1945. Rev. Mod. Physics 17, 200.
5. KEMMER, N. 1965. Suppl. Progr. Theor. Physics, 30th Anniversary of Meson Theory Issue, pp. 602-608.
6. BHABHA, H.J. 1949. Rev. Mod. Physics 21, 451.
7. BHABHA, H.J. and H.R. HULME. 1934. Proc. Roy. Soc. 146A, 723, London.
8. BHABHA, H.J. 1935. Proc. Roy. Soc. 152A, 559, London.
BHABHA H.J. 1934. Proc. Camb. Phil. Soc. 31, 394.
9. MOTT, N.F. 1930. Proc. Roy. Soc. 126A, 259, London.
10. MÖLLER, C. 1932. Ann. Physics 14, 531. Ref. 1, p. 196.
11. Ref. 1 p. 196.
12. PAULI, W. and W. WEISSKOPF. 1934. Helv. Physics Acta, 7, 709.
13. BAUMANN, K. 1953. Acta Physica Austriaca 7, 96.
14. BHABHA, H.J. 1933. Zeits. f. Physik 86, 120.
15. ROSSI, B. 1934. Int. Conf. on Nucl. Physics, London.
16. PFOTZER, G. and E. REGENER. 1935. Nature 136, 718. Ref. 2 p. 434, London.
17. Ref. 2 p. 434.
18. CARLSON, J.F. and J.R. OPPENHEIMER. 1937. Phys. Rev. 51, 220.
19. ROSSI, B. 1934. Ric. Scient. 1, vi. 559 ; P. AUGER AND L. LEPRINCE-RINGUET, 1934 C.R. Acad. Sci. Paris 199, 78.
20. BHABHA, H.J. 1938. Proc. Roy. Soc. 164A, 257, London.
21. BLACKETT, P.M.S. 1937. Proc. Roy. Soc. 159A, 1 London.
22. Ref. 20 p. 258.
23. Ref. 20 p. 281.
24. NEDDERMEYER, S.H. and C.D. ANDERSON. 1937 Phys. Rev. 51, 884.
J.C. STREET and E.C. STEVENSON. 1937. Phys. Rev. 51, 1004.
25. NEDDERMEYER, S.H. and C.D. ANDERSON. 1938 Phys. Rev. 54, 88.
26. YUKAWA, H. 1935. Proc. Phys.-Math. Soc., 17, 48, Japan.
27. BHABHA, H.J. 1938. Nature 141, 117, London .
28. BHABHA, H.J. 1938. Proc. Roy. Soc., 166A, 501, . See p. 524, London.
29. BHABHA, H.J. 1939. Proc. Roy. Soc., 172A, 384, London.
30. DIRAC, P.A.M. 1938. Proc. Roy. Soc., 167A, 148, London.
31. BHABHA, H.J. 1940. Proc. Ind. Acad. Sci. 11 A, 347, 468
BHABHA H.J. 1940 Phys. Rev. 59, 100.

32. SNYDER, H. 1938. *Phys. Rev.* *53*, 960.
SERBER R. 1938. *Phys. Rev.* *54*, 317.
33. BHABHA, H.J. and S.K. CHAKRABARTY. 1943. *Proc. Roy. Soc.* *181A*, 267, London and 1942 *Proc. Ind. Acad. Sci.* *15A*, 464.
34. LANDAU, L. and G. RUMER. 1938. *Proc. Roy. Soc.* *166A*, 213, London.
35. IYENGAR, K.S.K. 1942. *Proc. Ind. Acad. Sc.* *15A*, 195.
36. BHABHA, H.J. 1944. *Proc. Ind. Acad. Sc.* *19A*, 530.
37. BHABHA, H. J., S. V. CHANDRASEKHAR AIYA , H.E. HOTEKO and R.C. SAXENA. 1945. *Current Science* *14*, 98, *Phys. Rev.* *68*, 147, 1945 and *Proc. Nat. Inst. Sci. India* *12*, 219, 1946.
38. SCHEIN, M., W.P. JERSA, and E.O. WOLLAN. 1940. *Phys. Rev.* *47*, 207 (1935) and *57*, 840.
39. MENON, M.G.K. 1967. in "Homi Bhabha Jehangir" 1909-1966, The Royal Institution of Great Britain, p. 17, London.
40. BHABHA, H.J. 1950. *Proc. Roy. Soc.* *202A*, 301, London.
41. BHABHA, H.J. and A. RAMAKRISHNAN. 1950. *Proc., Ind. Acad. Sc.* *32A*, 141.
42. BHABHA, H.J. 1954. *Proc. Intl. Conf. on "Theoretical Physics", Kyoto-Tokyo (1953)*, Sc. Council of Japan, p. 95.
43. BHABHA, H.J. and R.R. DANIEL. 1948. *Nature*, *161*, 883, London.
44. SREEKANTAN, B.V. in "Homi Jehangir Bhabha : Collected Scientific Papers".
45. BHABHA, H.J. 1953. *Proc. Roy. Soc.* *219A*, 293, London.
46. NARAYAN, D.S. 1971. *Nucl. Phys.* *B34*, 386.

HOMI JEHANGIR BHABHA



R. Joshi

*Department of Education in Science and Mathematics
NCERT, New Delhi*

Introduction

The year 2009, is being celebrated as the centenary year of Homi Jehangir Bhabha. Bhabha has been instrumental in putting independent India firmly on the path of research and development in the field of nuclear energy that has enabled us to be a member of a select group of countries having successfully developed nuclear capability. Scientific journals and magazines have published special numbers and articles highlighting the outstanding contributions in the field of theoretical physics by Bhabha and his role in initiating and promoting research in the field of cosmic rays in India to coincide his birth centenary. Our younger generation, particularly in schools, and common people may not be aware of the contributions made by Homi Bhabha in the field of cosmic ray research apart from pioneering India's nuclear energy programme. It is largely due to Bhabha that India could become the centre for extensive research on various aspects of

cosmic rays during the decades of 1950's and 1960's. The key role played by him in sowing the seeds of space research and developments in the area of electronics in the country may not be known even to many students of science. Even those among present generation who had heard about Homi Bhabha know him to be the 'Father of India's Atomic Energy Programme' as his name is associated with the Bhabha Atomic Energy Research Centre (BARC).

Born on 30 October 1909, at Bombay (now Mumbai), Homi Jehangir Bhabha was son of the Parsi couple Jehangir H. Bhabha and Meherbai Framji Panday. His father was a reputed advocate and served at the Tata Enterprise while his mother was the grand-daughter of Sir Dinshaw Petit, First Baronet, widely respected for his philanthropic endowments. His paternal grandfather, Dr Hormusji Bhabha, has been the Inspector General of Education in the then State of Mysore (now Karnataka). Thus, Bhabha belonged to a family that had a long tradition of learning and education.

School Education

Bhabha was educated at Cathedral and John Connon High School, where he was considered a brilliant student and won many prizes. Bhabha passed senior Cambridge examination at the age of 15 and then joined Elphinstone College and the Institute of Science in Bombay and obtained his graduation degree at the age of seventeen. His parents took keen interest in shaping Bhabha's love for science from an early age. He was provided with a small library that had a good collection of books on science. As a boy, he also had access to his grandfather's large library which also had the fine collection of books on painting and arts. Bhabha made full use of this facility so much so that the books became his best friends. Thus, a good foundation was laid for his scientific career. It is said that at the age of 15, Bhabha was able to read Einstein's book on Relativity though he could not fully comprehend its contents. Even as a boy Bhabha was a lover of Nature. He was deeply interested in painting, music and literature. By the age of 17, Homi Bhabha was ardent listener of the recorded symphonies, concertos, quartets and sonatas of Beethoven and Mozart, and of the recorded operas of Wagner and Verdi for which he took advantage of the vast collection of records of his father and his aunt. He used to enjoy listening to recorded music with his younger brother and boyhood friends. But, he was not much interested in sports and games.

In Cambridge

Physics and mathematics were the two subjects that Bhabha loved and was keen to pursue them

at higher levels. However, his father wanted him to become an engineer so that he may join the Tata Iron and Steel Company at Jamshedpur, a company owned by his uncle Dorabji Tata. Bhabha respected the wishes of his father and left India, in 1927, to join Caius College, Cambridge in England to study engineering. Bhabha passed the mechanical engineering Tripos in the first class in 1930. After completing his Mechanical Tripos as desired by his parents, he persuaded them to let him do a Mathematical Tripos as his own interests were in physics. He completed his Mathematical Tripos too with distinction.

Bhabha, apart from his interest in books and scientific research also had an inborn taste for appreciation of music and arts. He possessed sensitive and trained artistic gifts of the highest order, especially in painting, pencil portraits, and music. He made good use of his stay in England and Europe, to visit many art galleries, museums, palaces and gardens. He never missed a good musical concert. Bhabha has an innate urge to express his creativity through paintings. Many of his paintings even now grace the walls of art galleries in England. Devotion to art and the study of science went hand-in-hand in Bhabha's life.

The Researcher

Homi Bhabha's career as a researcher in theoretical physics began at Cambridge in the nineteen-thirties. In a span of next ten years or so he earned his place amongst leading scientists of that time through his contributions in the emerging areas of elementary particles, or high energy physics, and cosmic rays. Bhabha was awarded the Rouse Ball Travelling Studentship for two years in 1932. In 1934, he was awarded the

Isaac Newton Fellowship followed by the 1851-Exhibition Studentship in 1936. During this period Bhabha extensively travelled to many laboratories in Europe to work and interact with the researchers in his areas of interest. He worked for a short duration with W. Pouli in Zurich and Enrico Fermi in Rome. Bhabha also had the opportunity to come in close contact with famous scientists like Rutherford, Dirac, Niels Bohr and Heitler. This association greatly influenced his research and way of life.

The first major work on cosmic rays by Bhabha, in collaboration with Heitler, was presented in 1937. This is known as 'Cascade Theory of Electron Showers'. It is also called the 'Bhabha-Heitler Cascade Theory'. This theory explains the process of formation of electron showers when cosmic rays enter the Earth's atmosphere. Cosmic rays are high energy, sub-atomic particles like protons, electrons and gamma rays moving in outer space. When some of them happen to approach the earth and enter its atmosphere, they

collide with atoms in the air. They then give rise to newer particles. Bhabha's new theory explained clearly the processes and effects of the mutual reaction. It threw light on one of the most puzzling mysteries of his time about the cosmic rays. Bhabha recognised elementary particles in cosmic rays that have a mass larger than that of electrons. These bosonic elementary particles of 'intermediate' mass were given the name 'Meson' by Bhabha along with N. Kemmer and MHL Pryce. His name has also been associated with Bhabha-Corben theory of relativistic spinning classical particles, which shows his mastery of mathematics. The Bhabha equations investigated possible relativistically invariant linear wave equations for elementary particles. These were unique contributions to the world of physics, which brought fame to Bhabha.

At IISc Bangalore

Bhabha returned to India in 1939 for a holiday but could not go back to England due to outbreak of

About on Cosmic Rays

At the beginning of the twentieth century, the rate of discharge of an electroscope due to the presence of a radioactive source was used as a measure of the level of radiation. Thus, the electroscope was a standard instrument for studying radiation and radioactive materials at that time. However, physicists noticed that electroscopes get slowly discharged even in the absence of radioactive matter. The cause of this residual discharge appeared to be some type of background radiation. Victor. F. Hess, an Austrian physicist, decided to measure radiation levels at places away from the known sources of radiation. He measured radiation levels at different altitudes up to a height of 17,000 feet (5182 m), with electroscopes aboard a balloon. Surprisingly, he found that the radiation levels increased with altitude. Hess interpreted this result to mean that radiation is entering the atmosphere from outer space. He gave this phenomenon the name "Cosmic Radiation", which later given the name "Cosmic Rays" by Robert Millikan. Hess was awarded the Nobel Prize in 1936 for his discovery of cosmic rays. The term "Cosmic Rays" refers to very high energy elementary particles, nuclei, and electro-magnetic radiation of extra-terrestrial origin. These may include exotic, short-lived particles such as muons, pi-mesons or lambda baryons.

Second World War, which turned out to be a blessing in disguise for the people of India as is evident from the events that followed. His stay back in India has been instrumental, to a large extent, for the setting the pace of research and development in science, particularly in cosmic rays and nuclear energy, in India immediately after it's independence.

In 1940, Bhabha joined the Indian Institute of Science (IISc), Bangalore (now Bangaluru) as a Reader in Theoretical Physics. In keeping with his interests, Bhabha was assigned the responsibility of establishing a new department to undertake research on cosmic rays. Bhabha became a Professor in the Institute in 1942. After his arrival at Bangalore, Bhabha was asked to deliver a lecture on modern physics. The audience including Sir C. V. Raman who was presiding over the programme, were amazed at his scholarship. In his remarks as the Chairman, Raman observed that the presentation by Bhabha has been a treat not only for the learned mathematicians present here and the speaker but also for him. His stay in Bangalore provided Bhabha an opportunity to have a deeper understanding of the cultural milieu and socio-economic problems of the country. His analysis of these aspects convinced him that modern science was the only means for the progress of the country and to modernise it. The young Bhabha dreamt of the 'great adventure' of building a modern India.

In 1941, Bhabha was elected a member of the Royal Society; he was just 31 years old at that time. He is among a few scientists who have been conferred this distinction at such a young age by the Royal Society. The University of Cambridge also awarded the Adams Prize to him.

Institute of Fundamental Research: A Vision

With an innate desire to bring India at the forefront of research in science to reap the benefits of economic prosperity and social change based on science and technology for his people, Bhabha began to shape his vision. This broad vision led him to write a letter to Sir Sorab Saklatvala, Chairman of the Sir Dorab Tata Trust. The following passage in this letter provides glimpses of depth of his understanding of the issues and the vision to address them.

There is at the moment in India no big school of research in the fundamental problems of physics, both theoretical and experimental. There are, however, scattered all over India competent workers who are not doing as good work as they would do if brought together in one place under proper direction. It is absolutely in the interest of India to have a vigorous school of research in fundamental physics, for such a school forms the spearhead of research not only in less advanced branches of physics but also in problems of immediate practical application in industry. If much of the applied research done in India today is disappointing or of very inferior quality it is entirely due to the absence of a sufficient number of outstanding pure research workers who would set the standard of good research and act on the directing board in an advisory capacity. Moreover, when nuclear energy has been successfully applied for power production in, say, a couple of decades from now, India will not have to look abroad for its experts but will find them ready in hand. I do not think that anyone acquainted with scientific development in other countries would deny the need in India for such a school as I propose.'

It is evident that Bhabha rightly perceived the potential of nuclear energy even before the technology to harness it safely became available or its use for destruction were known to the world as this letter was written on 12 March 1944, almost a year before the first atom bomb was dropped in Hiroshima. The initiative taken by Bhabha sowed the seeds for setting up of the Tata Institute of Fundamental Research (TIFR) on 1 June 1945, which is now one of the premier research institutes of the country. The institute also received grants and support from the then Government of Bombay (now Maharashtra) and the Government of India.

The TIFR was formally inaugurated on 19 December 1945 in Bombay (now Mumbai) with Homi Bhabha as its first Director, the position he occupied until his untimely death in 1966. The TIFR became the fountain head for research and development in the field of nuclear science in the country. Bhabha himself often used to say that TIFR was the 'Cradle of the Atomic Energy Programme' of India. Thanks to the guidance and tireless efforts of Homi Bhabha, the TIFR is indeed a symbol of scientific tradition in India and is considered to be one of the major centres for the advancement of science and technology in the world. The research activities for the first few years at TIFR were confined to pure mathematics, theoretical and applied physics and geophysics. The studies on the basics of atomic explosion, the production of isotopes and the purification of uranium also formed the part of the work at the Institute. His experience of working with renowned researchers and physicists during his stay in England and Europe came handy for Bhabha in creating an intellectual environment in India.

Mission: Self Reliance in Nuclear Energy

Bhabha at no point of time deviated from his vision of creating facilities to fully exploit the benefits of nuclear energy. His address to the Atomic Energy Research Committee on 26 August 1947, merely 11 days after India got independence, reaffirms his faith on his vision. He said, "We meet today at the beginning of a new chapter in our history. We have great hopes that this new chapter will be a glorious one. The development and use of atomic energy is a question of national importance. We hope to establish soon an Atomic Research Centre comparable with those in the most advanced countries." It was due to his efforts that the Atomic Energy Commission was constituted by the Government of India in 1948 and Bhabha was the natural choice to be the Chairman of the Commission. The Commission was entrusted the responsibility to undertake a survey of Indian soil for the materials required for nuclear research, construct atomic reactors, develop facilities for purification of atomic materials, and promote fundamental research besides formulating of training programmes for creating a pools of experts at various levels. The expertise available with the TIFR was utilised by the Commission to accomplish its assigned tasks and to shape the Atomic Energy Programme for the country.

The Department of Atomic Energy (DAE) thus came into being as a separate department of the Government of India in 1954 due to concerted efforts of Bhabha. The Department was under the direct control of the Prime Minister Nehru with Bhabha as its Ex-officio Secretary. The

formation of the Department of Atomic Energy paved the way for the creation of the Atomic Energy Establishment for application of atomic energy for peaceful purposes. Inauguration of the Atomic Energy Establishment in 1957, with Bhabha as its Director, marked the beginning of a new era of atomic energy in the country. Self reliance in the area of nuclear energy has been one of the cherished goals of Bhabha for which he always emphasised on the development of indigenous know-how.

Bhabha received tremendous support and encouragement from Pandit Jawaharlal Nehru, the Prime Minister of India and J. R. D. Tata, noted industrialist, who gave him freedom to carry out his work. The level of confidence that Pandit Nehru had on Bhabha could be assessed from the fact that his suggestion to consider the proposal from Canada to build a Reactor in India got the approval of the Prime Minister within a few days. Pandit Nehru very much appreciated the efficiency, farsightedness and patriotism of Bhabha. This allowed him to establish himself as a science administrator of highest level. The rules and regulations framed by Bhabha for carrying out research as also day-to-day administration at TIFR, Atomic Energy Commission and the Department of Atomic Energy reflect his deep understanding of management practices desirable for such institutions.

The Beginning

The programmes initiated by the Atomic Energy Commission and later by the Department of Atomic Energy under the guidance of Bhabha led to the commissioning of three reactors to facilitate research and developmental activities on various

aspects of nuclear energy and related technologies. These reactors were built at the DAE headquarter located in Trombay. India's first nuclear reactor 'Apsara' became critical on 6 August 1956. The reactor was designed to provide basic facilities to fulfill the needs in the fields of neutron physics, radiation, chemistry and biology and also the production of radio isotopes for which the fuel, uranium, was procured from U.K. The erection of 'Apsara' not only boosted self-confidence of Indian scientists and engineers but also gave them enough confidence in handling technical issues during the building up of the next two experimental reactors namely, 'Cirus' and 'Zerlina'. The 'Cirus', a joint collaboration between Canada and India, was built in 1960 while 'Zerlina', the reactor dedicated to research, attained criticality on 14 January 1961.

The planning for design and construction of the first atomic power plant was initiated by Bhabha soon after having successfully acquired these reactors. This atomic power plant, commissioned on 2 October 1969 at Tarapur in Maharashtra, is the first in the country to produce electricity on a commercial scale. The other power plants situated at Rawatbhata in Rajasthan, Kalpakkam in Tamil Nadu, Narora in Uttar Pradesh, Kaiga in Karnataka, and Kakrapar in Gujarat are the living symbols of Bhabha's imagination and dynamism although planning for many of them began long after his death.

The Tragic Demise

One of Bhabha's major concerns for achieving self sufficiency in nuclear energy has been to create indigenous facilities for design, development and production of electronic instruments that were vital for the development of atomic energy

programme and also in defence. He realised that facilities for research and development in the field of electronics were practically non existence in the country. Bhabha persuaded the Government of India to constitute a committee who could advise it to take appropriate measures to undertake planned development of electronics, which led to the formation of a Committee with Bhabha as its Chairman. Unfortunately, the report of Bhabha Committee could be submitted only after his untimely death. One of the major follow up of the Bhabha Committee was creation of Department of Electronics by the Government and subsequently setting up of the Electronic Corporation of India Limited (ECIL) in 1967.

Bhabha died in an air crash on 24 January, 1966 at the young age of 56 years. Bhabha was on board the Air India's aircraft, Kanchanjunga, to attend a meeting of the Scientific Advisory Committee of the International Atomic Energy Agency scheduled in Vienna when it crashed on Mount Blank in the European Alps. The debris of the crash and the mortal remains of Bhabha still lie buried under thick layers of snow. The news of the air crash caused an immense sense of loss to the people of India and the scientific community across the world. The rich tributes that poured from people from all walks of life across the world reflect their bewilderment at the loss of this outstanding scientist, visionary, science administrator and above all a wonderful human being. The atomic energy centre at Trombay was renamed as Bhabha Atomic Research Centre (BARC) after Bhabha's death as a tribute to one of the greatest sons of the country. Bhabha is among the few scientists for

whom a special postage stamp has been issued by the Indian Government.

Honours and Awards

Bhabha was bestowed with many honours and awards for his outstanding contribution to science by institutions, universities and the Governments across the world all through his life. The foremost among them perhaps was being elected as the Fellow of Royal Society in 1941. He received the Hopkins Prize of the Cambridge Philosophical Society in 1948. He was elected the President of the Indian Science Congress in 1951. The President of India honoured him with Padma Bhushan in 1954 for his outstanding contribution to nuclear science. In 1963 he became the President of the National Institute of Sciences of India. He was awarded honorary doctorates by several Indian and foreign universities and was an honorary fellow of many renowned institutions. Bhabha was a member of many scientific advisory committees of the United Nations and the International Atomic Energy Agency. He also served as the Chairman of the Scientific Advisory Committee to advise the Government of India. In 1955 Bhabha was elected as the President of the first International Conference on the 'Peaceful Uses of Atomic Energy', organised by the United Nations at Geneva. Bhabha was the first to advocate, from international forums, the peaceful uses of atomic energy.

Special coins have been issued to coincide with the birth centenary of Homi Bhabha. Special stamps have also been issued by Department of Postal to honour Bhabha.

Bhabha's life and work is a glaring example as to how devotion and dedication towards work coupled with a clear vision of a person can transform the course of research and developmental activities in science of a country within a short span of a little over two decades.

He always insisted on excellence and had full faith in self-reliance. He believed in meticulous planning and in executing the plans. He showed to the world that Indian scientists could stand up to the best in the world if they receive proper guidance and an inspiring leader.



Facsimile of a coin issued on birth centenary of Homi Bhabha



Stamp issued on the occasion of Golden Jubilee year of TIFR with inset of Bhabha

A LEAF FROM HISTORY – BHABHA'S LETTER TO SIR SORAB SAKLATVALA CHAIRMAN OF SIR DORABJI TATA TRUST

R. Joshi

Department of Education in Science and Mathematics
NCERT, New Delhi



My Dear Sir Sorab,

I have for some time past nurtured the idea of founding a first class school of research in the most advanced branches of physics in Bombay. I had intended putting my scheme before you in person on my next visit to Bombay, but as a result of a letter from Professor Choksi, I am now sending it in writing for your consideration, and I would be glad to have your views on it. If you so desire I am prepared to come to Bombay to explain the scheme to the Trustees in person.

The scheme, I am submitting now is not one which has been hastily conceived. It has been germinating in my mind for nearly two years, and I recently discussed it at length with Professor A.V. Hill both at Delhi and Bombay. Professor A.V. Hill, Senior Secretary of the Royal Society apart from being an eminent scientist himself, is one who has a great and intimate knowledge of the organisation of science and scientific

institutions in England, and the many valuable suggestions he made have been incorporated in the scheme as it stands now. The scheme has been set forth on the accompanying schedule and is a simple one, but I should like to make a few remarks to explain the background.

There is at the moment in India no big school of research in the fundamental problems of physics, both theoretical and experimental. There are, however, scattered all over India competent workers who are not doing as good work as they would do if brought together in one place under proper direction. It is absolutely in the interest of India to have a vigorous school of research in fundamental physics, for such a school forms the spearhead of research not only in less advanced branches of physics but also in problems of immediate practical application in industry. If much of the applied research done in India today is disappointing or of very inferior quality it is

* Reproduced from *Physics News*, Bulletin of Indian Physics Association, No.1, Vol.39, January 2009

entirely due to the absence of sufficient number of outstanding pure research workers who would set the standard of good research and act on the directing boards in an advisory capacity. (For example, while the Department of Scientific and Industrial Research was founded in Great Britain in 1914, it was soon felt that it could not function properly without the appointment of an adequate advisory council for the organisation. The Scientific Advisory Council was founded in Great Britain in 1915 and has consisted mainly of eminent scientists like Lord Rutherford, Sir W. L. Bragg, Sir R.H. Fowler, Lord Rayleigh, Sir James Joans, Professor A.V. Hill and others. Without the availability of a sufficient number of pure research works of this standing on the Advisory Council, the work of the Department would have suffered as it suffers in India). Moreover, when nuclear energy has been successfully applied for power production in say a couple of decades from now, India will not have to look abroad for its experts but will find them ready at hand. I do not think that any one acquainted with scientific development in other countries would deny the need in India for such a school as I propose.

The subjects on which research and advanced teaching would be done would be theoretical physics, especially on fundamental problems and with special reference to cosmic rays and nuclear physics, and experimental research on cosmic rays. It is neither possible nor desirable to separate nuclear physics from cosmic rays since the two are closely connected theoretically.

For the location of the school I think Bombay would be the most suitable place in India for the following reasons. Firstly, it is an advantage for a

cosmic ray laboratory to be situated near the sea, for it is often necessary to make measurements at considerable depths under water. Secondly, Bombay as one of the first and most progressive cities in India has not yet got the scientific institutions necessary for its population and worthy of its position. People in educational circles in Bombay have long felt and expressed the urgent need for a good school of physical research. Thirdly, I feel that once a laboratory like the one proposed is established in Bombay, it will be easier to collect further money for it in addition to what the Tata Trusts may give. I am confident that both the Government and the University would be prepared to give regular financial support.

In connection with the third reason I may mention confidentially that the Director of Public Instruction has on several occasions asked me if I would accept a chair at the Royal Institute of Science if one were created there for me with specially favoured conditions for research. He, I am sure, would get the Government to help a scheme of the type I propose. The Institute would be affiliated to the Bombay University. The Bombay University could also send its advanced research students to the laboratory for work on their doctoral thesis, and for attending the few advanced courses of lectures that we would give.

I also hope that in time we shall receive liberal support from the Board of Scientific and Industrial Research whose avowed policy includes support of pure research, as publicly stated by Sir Ramaswamy Mudaliar when he presided at a lecture given by me to the Delhi University this January. It would neither be feasible nor advisable to try to do research such as I plan under the same

roof as applied physical research and routine testing, and it would be in the interest of efficiency if the Board of Scientific and Industrial Research decided to subsidise us to carry on pure research which is its intention to foster by paying us say ten per cent of the annual expenditure it contemplates the projected National Physical Laboratory. Professor Hill, when he was in Bombay, repeatedly stressed the fact that all research has in the beginning to be built round a suitable man, and at the present moment there is no one else in India to be able to do the type of research proposed. The same principle has guided the financing of research in Germany to quote the words of the Director of Kaiser Wilhelm Society¹ which runs many of the biggest research institutions all over Germany.

In order that its ideals may be fulfilled, it is necessary that the Society should keep an intelligent watch on the newer currents in scientific investigations and try to further its ideals by creating facilities for the new lines of investigations and by getting the right man for them. The object has thus been expressed by the President, Adolf V. Harnack, "The K. W. Society shall not first build an institute for research and then seek out the suitable man but shall first pick up an outstanding man, and then build an institute for him." Experience has often shown that it is rather useful not only to call an outstanding man to the headship of an institution, but also to a group of associate institutions at one place and under a loose federation. Professor A. V. Hill expressed the same views and added that, that was exactly the way in which

outstanding schools of research has been built up in the United Kingdom, as for example the celebrated schools of physics and physiology at Cambridge. He saw no reason why the same thing could not be done here.

Financial support from the Government need not, however, entail Government control for to quote Professor Hill in his lecture to the Science Congress at Delhi: "Many of these (independent scientific institutions in Great Britain) now-a-days are receiving substantial state support; but nearly always when this is done a buffer of some kind is interposed to prevent Government support from becoming government control." (Hill's underlining).

It might at first be supposed that the absence of a good school of physical research in Bombay at the moment would make it an unsuitable place for the object I have in mind. This is not so. The best and the most promising students desirous of studying theoretical physics or cosmic rays who for the last three years have been sent to me in Bangalore from all parts of India, would come to Bombay instead. I am convinced that within five years we could make Bombay the centre of fundamental physical research in India.

Lastly, I would like to add a few personal remarks. It was while I was on holiday in 1939 that the war broke out and stopped my return to my job in Cambridge. For some time after that, I had the idea that after the war I would accept a job in a good university in Europe or America, because universities like Cambridge or Princeton provide an atmosphere which no place in India provides at the moment. But in the last two years I have come

¹ The society was renamed Max Planck Society for Advancement of Science in 1948.

more and more to the view that provided proper appreciation and financial support are forthcoming it is one's duty to stay in one's own country and build up schools comparable with those that other countries are fortunate in possessing. In 1941, I was offered the Physics Chair at the University of Allahabad with specially favourable conditions, and in 1942 the professorship at the Indian Association for the Cultivation of Science in Calcutta, but I refused both, because I was not convinced that they

afforded sufficient scope for ultimately building up an outstanding school of physics. The scheme I am now submitting to you is but an embryo from which I hope to build up in the course of time a school of physics comparable with the best anywhere. If Tatas would decide to sponsor an Institute such as I propose through their Trusts I am sure that they would be taking the initiative in a move which will be supported soon from many directions and be of lasting benefit to India.

With kind regards,

Yours sincerely

Homi J. Bhabha

LECTURE BY DR H. J. BHABHA*

*At the inaugural function of TIFR on Wednesday
19 December 1945*



Your Excellency, Sir Sorab Saklatvala and Gentlemen
It has fallen to my lot as Director to enlarge a little on the nature of the work of the Institute. I would like to speak, rather, on the lines on which fundamental research is proceeding today and of the progress of physics in the world as a whole, towards which we hope this Institute will make its own humble contribution. In few months since it commenced work in June, eight papers have been published by the members of the Institute, but I shall only mention some of these in passing as the occasion arises. You will all realise that when a new institution is started there is a great deal of organisational work to be done. That we have been able to devote so much of our time to research from the very beginning is due to the great help we have received from the Director and the staff of the Sir D. J. Tata Trust. I would like to thank them all, for taking so much of the burden of administration off my shoulders.

According to our present views of nature, the whole physical world, including every single thing in it which is perceived by our senses, and a whole host of other things which are beyond the perception of our senses but which can be detected and measured by special apparatus, is made up of about six types of fundamental entities known as the elementary particles. These are the electron, the smallest unit of negative electricity known in nature; the proton, or the nucleus of the atom of hydrogen which has a positive electric charge equal to that of the electron; the neutron, the only other constituent of the nuclei of atoms; the meson, a new particle discovered a few years ago in cosmic radiation; the neutrino, and the photon which constitutes light. The theory of the elementary particles concerns itself with an exact mathematical formulation of the laws governing the behaviour of these different fundamental physical entities. If

* Reproduced from *Physics News*, Bulletin of Indian Physics Association, No.1, Vol.39, January 2009

these basic laws are known, then one could, in principle, deduce from them by mere calculation the behaviour of every other object in nature. For example, the idea of valency and of the chemical bonds between atoms is fundamental for chemistry. The chemist, however, takes them for granted and he cannot explain their origin. But on the basis of the mathematical equations of quantum mechanics describing the behaviour of electrons and nuclei we can calculate in simple cases the type of chemical linkages that can take place and even the strength or energy of the bonds. Thus was revealed for the first time on the basis of the laws of physics, the mechanism of the homopolar bond, binding for example, two hydrogen atoms together in a molecule. There is little doubt that the same basic equations of quantum mechanics contain all the information necessary for a deduction of the properties of the largest molecules, were our mathematical prowess sufficient to solve the complicated equations which then arise. Such problems will be solved in time as new and more powerful mathematical methods are developed.

We have progressed a considerable way in having a mathematical description of the behaviour of the known elementary particles. The photon, for example, is certainly described by a set of equations given by Maxwell in the middle of the last century provided the theory is extended to take into account the quantum nature of phenomena, and the electron by an equation given by Dirac in 1928. It is interesting to recall that in both these instances theory was able to predict new phenomena and point the way to experiment. On the basis of his equations Maxwell predicted the existence of long electromagnetic or wireless waves some three decades before they were

discovered by Hertz. Dirac's theory predicted the existence of a new particle of properties identical with those of the electron but having a positive instead of a negative electric charge. This particle was discovered later by Anderson and is one of the most important discoveries of recent times.

The position is less clear with regard to the proton. It is possible that it is described by the Dirac equation. But in two recent papers I have given a new set of equations which equally well describe all the facts that are known about the proton so far, and in addition predict that it will show at very high energies new properties not yet observed of any of the elementary particles. According to one of these equations, the proton in certain circumstances should be able to suddenly treble its rest mass or weight. It is of great importance to know which the correct theory is for describing the proton, and the question can only be settled by a reference to Nature. We shall have to study the behaviour of protons when they are travelling with very nearly the velocity of light, and have energies much greater than a thousand million volts. Such energies are only possessed today by cosmic ray particles. One of the papers I have mentioned, containing the first piece of research to be done under the auspices of this Institute, has just appeared in a number of the *Reviews of Modern Physics* which has been brought out in commemoration of Professor Niels Bohr's sixtieth birthday and to which physicists of all nations and from all over the world who have had the privilege of working at his Institute in Copenhagen have, contributed. I would like to take this opportunity to pay my tribute to that great man, contact with whom has been such a

source of inspiration to physicists in all parts of the world, and express the hope that we may in the future welcome him to this Institute as one of our visiting professors.

In the nineteenth century, fundamental research was a curiosity pursued by men with a deep interest in nature and looked upon rather as cranks by the rest. Today, we all know of the great importance of fundamental research and the recent release of atomic energy for practical purposes has brought forcibly before the public how entirely new avenues can be opened up by fundamental research, mainly the study of nature for itself unhampered by any preconceived practical ends. The pursuit of science and its practical application are no longer subsidiary social activities today. Science forms the basis of our whole social structure without which life as we know it would be inconceivable. As Marx said "Man's power of nature is at the root of history" and we have in our own time seen the history of the world shaped by those countries which have made the greatest scientific progress. Science has at last opened up the possibility of freedom for all from long hours of manual drudgery and today we stand at the beginning of an age when every person will have the opportunity to develop himself spiritually to his fullest stature. With the mastery of atomic energy and the accelerating progress of science in other fields the world in a hundred years time will look as different, from today as today is different from the middle ages.

The progress of science has also been of great philosophical importance in widening our mental horizon and showing the limitations of commonsense ideas based upon the world

immediately perceived by our senses. Our senses perceive only a very small fraction of the phenomena, of nature around us. For example, electromagnetic waves range from wireless waves, several thousand metres in wavelength, through heat waves, infrared rays, light, ultra violet light, X-rays, the gamma rays of radium to the gamma rays in cosmic radiation of wavelength less than the thousand million millionth part of an inch, and yet in this enormous spectrum our senses can directly perceive only a minute fraction, that which we feel as heat, and that which we see as light. Similarly in the matter of length, man and the world he lives in lies midway between the sub-microscopic world of the atom consisting of structures which are less than a hundred millionth part of an inch on the one hand and the cosmological world of the stars and the nebulae on the other, involving distances larger than a million million million miles. When we deal with such small or large objects we must expect that their behaviour will be very different from that of the objects of medium size to which we are used on the surface of this earth. The comprehension of their laws requires an extension of our ideas and an abandoning of common sense views based on everyday experience. For example, our everyday experience accustoms us to think, of phenomena as existing independently of the means, used for observing them. The mere fact of being observed does not cause a car to change its velocity. In the world of the atom, however, we meet with the principle of complementarity, which expresses, as Bohr has said, "the fundamental limitation, met with in atomic physics, of our ingrained idea of phenomena as existing independently of the means by which they are observed." To deal with this situation a new mathematical apparatus has

to be used, the mathematics of operators and non-commutative algebra.

On the other hand when we come to the large distances involved in astronomy we meet with a situation unfamiliar in another way. We have to give up the common sense idea that the directions of two lines at two distant points can be compared with each other. This is possible in a flat space, or for small distances where the curvature of space can be neglected. Put in mathematics we can deal with a space which is curved, and indeed, such a space forms the basis of Einstein's theory of gravitation. Over the vast distances of inter-nebular space a small curvature can tell, so that in the end, space folds back on itself. In the Einstein universe we can travel for ever in any given direction without coming to its boundary, although the total size of the universe is finite and not infinite.

In addition to the fact that our senses perceive only a small fraction of the phenomena around us, our common sense ideas are further limited by the circumstance that we normally observe matter in rather special conditions. For example, temperatures can range from the absolute zero, namely -273 degree centigrade, to temperatures of several millions of degrees in the interior of stars, and yet life is only possible if the temperature lies within a range, much less than a hundred degrees. At temperatures of several million degrees, matter as we know it cannot exist at all, and even the nuclei of atoms, which are normally stable begin to take part in nuclear transformations. Thus, it comes about that the sun and the stars derive the energy for their prodigal radiation not from chemical combustion, but from the transformation of one element into

another, which has come to be known to the public today as atomic energy. At temperatures near absolute zero, on the other hand, other strange phenomena appear. Certain substances, for example, suddenly cease to show any resistance to the flow of electricity and become superconducting. A current in a ring of these substances at temperatures near absolute zero seems to flow for days without stopping. Similarly, Kapitza has recently discovered that at these low temperatures Helium loses all viscosity, or resistance to flow. At these low temperatures, therefore we appear to approach the phenomenon of perpetual motion on a macroscopic scale.

I shall content myself with one more example. Human beings always move relative to each other with velocities which are small compared with the velocity of light- $186,000$ miles per second. They are therefore used to regarding the rate of the flow of time, as measured by different clocks, as constant and independent of their motion. However, if they could move with velocities approaching that of light they would notice that the passage of time as measured by different observers depends very much on their state of motion. They would look upon as natural, not only the relativity of different directions in space, but also the relativity of space and time, and the fusion of the two into one entity, space time. They would treat as common place one of the predictions of the theory of relativity that clocks in motion go slower. In cosmic rays we have been able to confirm this prediction made nearly forty years ago by showing that for certain cosmic ray particles moving with speeds very nearly that of light, the passage of time is slowed down to

one-tenth the normal rate and even less. Such an idea is difficult to comprehend from the common sense point of view based on the very limited range of direct human experience. I dare say there are many laymen who must feel after what I have said that a modern physics institute should have nailed over its door the inscription "Leave ye common sense behind, ye who enter here."

To discover new secrets of nature we have to study matter in still unfamiliar conditions. Use only ordinary energies and we would still believe that one element cannot be transformed into another. It is only by bombarding matter with particles having energies of a million volts and more that we have been able to unravel the secrets of the nucleus and succeed at last in liberating atomic energy. To study the transformations of the elementary particles themselves and perhaps to discover new ones, we have to bombard matter with particles of still greater energies, more than a thousand or ten thousand million volts. Such particles cannot be produced in the laboratory today, and this is the reason for the great importance of cosmic rays for physics. There are cosmic rays having an energy as high as a hundred million million volts, a million times greater than the energy liberated from the fission of Uranium. It is only at these very high energies that new particles and new properties reveal their existence. In cosmic rays Nature has provided us with the biggest atom smashing instrument in the world, and the whole surface of the earth is our laboratory. The study of cosmic radiation has already resulted in several fundamental discoveries which have lead to a great extension of our knowledge of nature. We have been able to study the creation of matter in the form of

electrons and positrons, and we have discovered a new elementary particle, the meson. The study of cosmic radiation forms the main field of experimental research at this Institute, though I hope and trust that in the near future experimental work will also extend to nuclear physics. The two branches are very closely knit and indeed the elucidation of an important problem in nuclear physics, namely the origin of nuclear forces, owes its existence to the discovery of the meson in cosmic radiation. The Institute has already to its credit an important experiment on cosmic rays. By the courtesy of the 84th Air Depot of the U. S. Army, Air Force at Bangalore who put a specially prepared plane at our disposal, we were able to measure the intensity of cosmic rays penetrating 30 cms of lead to an altitude of 40,000 feet. Important results were obtained and are in course of publication. I would like to take this opportunity to express my appreciation of the wholehearted cooperation we have received from the commanding officers of the 84th Air Depot and their staff. The apparatus used on the flight has been arranged for your inspection at the end of this function.

To deal with this vastly increased range of human experience our philosophical and logical background has had to be widened and mathematics has provided the most powerful vehicle for the exact transcription of thought which cannot be expressed in words. On the one hand, the progress of physics has necessitated and will necessitate in the future the development of newer mathematics and the introduction of ever new fundamental concepts. On the other hand, pure mathematicians have often in the past created logical structures which

were only of interest to the pure mathematician and without any practical application. But the progress of science decades later has found a use for this mathematics without which its development would have been retarded. Much of the mathematics used in the theory of relativity and in quantum mechanics was created by mathematicians in the last century long before it came to be used by physicists. I shall content myself with giving but one example, that of non-commutative algebra mentioned earlier. When we deal with ordinary numbers we know that two times three is equal to three times two. This equation holds for all arithmetical numbers and we can express all such statements in the general equation $a \times b = b \times a$ which forms the foundation of the mathematics which is taught to us at school. But the basic assumption of ordinary algebra is not a necessary one, and consistent algebras were created by mathematicians in the last century in which it played no part. In this mathematics, a times b is not equal to b times a . The order of the factors cannot be changed or commuted and it is therefore known as non-commutative algebra. Strange as it may seem to you, when we come to deal with many of the less familiar phenomena in

nature, the use of non-commutative algebra is indispensable and papers on theoretical physics today are full of it. Indeed, there are many operations in life which are non-commutative and unless one is aware of their non-commutative nature, one may find oneself in a difficult situation!

I have touched on the philosophical aspects of science because ideas are some of the most important things in life, and men are prepared to suffer and die for them. Theoretical work, both the creation of new mathematics and the use of it in the description of nature is to form an important part of the work of this Institute. Theory not only unifies the existing experimental facts into one coherent body of thought but points the way to new discoveries in the future. Many of the most radical discoveries in physics today were predicted on the basis of theory. I am convinced that it is ultimately these exact theories, embodying in concentrated form our knowledge of nature which will form the basis of the mental discipline of the youth of future generations rather than the study of dead languages or limited and archaic forms of logic.



The west face of TIFR

HOMI JEHANGIR BHABHA*

R. N. Rai

*Department of Education In Science and Mathematics
NCERT, New Delhi*

Dr Homi Jehangir Bhabha, whose premature death on 24 January 1966 in an air crash resulted in a grievous loss to science, was born in Bombay (now Mumbai) on 30 October 1909. He was educated in the Cathedral and John Connon High School, Bombay and later at the Elphinston College and the Institute of Science, Bombay. At the early age of 17 he proceeded to Cambridge for higher studies where he joined the Gonville and Caius College and in 1930 passed the Tripos in Mechanical Science. He studied theoretical physics for two years under the supervision of Professor Dirac and Professor Mott of Cambridge.

He was awarded the Rouse Ball Travelling studentship in Mathematics of Trinity College, Cambridge from 1932 to 1934 which he utilized in working with Wolfgang Pauli at Zurich, Enrico Fermi at Rome and for a brief period with H.A. Kramers at Utrecht in Holland. In 1935 he was awarded the Isaac Newton Studentship and in

1939 appointed as a theoretical Physicist in Prof. Blackett's laboratory at Manchester. He was appointed a Reader in theoretical physics at the Indian Institute of Science, Bangalore and was professor from 1942 to 1945 when he founded the Tata Institute of Fundamental Research in Bombay.

Dr Bhabha's main work concerns cosmic rays and elementary particles. Cosmic rays are from the outer space. In the atmosphere, they produce secondary particles which cause ionisation and thus their path can be observed in Wilson cloud chambers. The secondary radiation consists of two parts. One the soft component and the other the hard component. The soft component consists of electrons, positrons and X-rays which are easily absorbed by matter. During their absorption some of the very high energy electrons and photons give rise to a large number of particles whose paths become visible in cloud chambers and these are known as cascade

* Reproduced from *School Science*, Vol.5, No.1, March 1967

showers. Bhabha and Heiler and simultaneously Carlson and Oppenheimer explained these showers as arising from the absorption of high energy electrons and photons. A shower is usually initiated by an electron of energy of many billions of electron volts. It emits a photon of comparable energy by a process known as bremsstrahlung. These photons are absorbed and produce an electron-positron pair which then produce more photons by the same process. This goes on until a large number of electrons and positron have been produced and the energy of each particle is comparatively low. This energy difference is used in lifting a negative energy electron to a positive energy state, thus creating a hole or positron. Bhabha's theoretical calculations have been experimentally verified and provide a test for the hole theory.

The scattering of mesons by nucleons is similar to the scattering of light by electric charge, the only difference being that the scattering cross-section depends on the mass of the meson and not on the mass of the nucleon.

Dr Bhabha will be best remembered for his efforts in developing atomic energy in India. An atomic Energy Commission was established in India in August 1948 and in 1954 a separate Ministry, the Department of Atomic Energy, was set up under the Prime Minister with Dr Bhabha as its secretary and under his leadership the country made a significant advance in the development of atomic energy for peaceful purposes.

Before a programme for the generation of energy from nuclear fission can be undertaken, it is necessary to combine the experience of the various processes involved by working with a

research reactor. Therefore the Department of Atomic Energy began the construction of a research reactor called Apsara in July 1955 with help from the United Kingdom Atomic Energy Authority. This reached criticality on 4 August 1956. Later two more research reactors were built; one the Canada-India Reactor with Canadian help and the other the Zerlina which was designed and built entirely by Indian personnel.

It had been decided in 1954 to embark upon an atomic power programme, and in 1958 the Planning Commission approved the setting up of an atomic power plant during the Third Plan period. Later in 1962, the Government decided to set up a second atomic power plant during the Third Plan. It is expected that the first power plant located at Tarapur, 60 miles north of Bombay which is using ordinary water as moderator and coolant and enriched uranium as fuel, will be producing power by October 1968. The second atomic power station located near the Rana Pratap Sagar Dam, which will use heavy water as moderator and coolant and ordinary uranium as fuel, is expected to be in operation in 1969. A plant for producing 14.5 metric tonnes of heavy water per annum is already working at Nangal in the Punjab and it is proposed to set up a plant with a capacity of 200 tonnes per annum.

As is well known, the generation of nuclear power depends on the fission of an isotope of uranium of mass number 235. This isotope is only 0.7 per cent of natural uranium. However, the other isotope of mass number 238 can be converted in a nuclear reactor into another element plutonium which is also fissionable. A vigorous search was undertaken by the Department of Atomic Energy to

locate useful deposits of uranium and considerable reserves of uranium have been located in Bihar. A uranium mill for processing 1000 tonnes of ore a day is being built at Jaduguda in Bihar which is expected to begin production in the later half of 1966. When in full production this mill will produce 200 tonnes of uranium oxide per annum which will be enough to sustain a generation of about 10 million kW of nuclear power. According to present estimates this rate of production of nuclear power will be reached about the year 1981.

The plutonium that is formed in a nuclear reactor has to be separated from the uranium and the fission products. A plant to extract plutonium has already been completed at Trombay and is in operation. This will be used to extract plutonium from the irradiated rods of the Tarapur station and

recover the enriched uranium thereby reducing the import of enriched uranium from USA.

However, India does not possess very large deposits of uranium. On the other hand it possesses large deposits of thorium of mass number 232 which can be converted into uranium of mass number 235 which is fissionable. It is proposed to use plutonium to do this and the Department of Atomic Energy has decided to build a breeder reactor at Kalpakkam near Madras (now Chennai) where the third nuclear power station is to be built.

Although the generation of nuclear power in India is small in comparison with UK where 5 million kW of nuclear power is to be produced by 1975, India occupies an important position on the nuclear map due to the foresight of Dr Bhabha and his death at this juncture is a great loss to the country.



Facsimile of first day cover issued on 4 August 1966

BIOTECHNOLOGY— A BOON TO THE NURSERY INDUSTRY

Muzafar Gul Wagay

*Research Scholar, Bio-technology Division
Regional Research Laboratory, CSIR, Srinagar*



Making the best use of it means reaping the maximum harvest and ensuring in all round development in agriculture.

Plant Biotechnology has become especially important in the agricultural community over the past few decades. During this time of period, plant tissue culture has effectively moved from the confines of small laboratories and has taken its place among some of the mainstream, broad-scale techniques employed by the agriculture Industry. Plant tissue culture, more technically known as micro-propagation, can be broadly defined as a collection of plant cells, in vitro, in an aseptic and closely controlled environment.

This technique is effective because almost all plant cells are totipotent meaning there by that each cell possesses the genetic information and cellular machinery necessary to generate an entire organism. Micro-propagation, therefore, can be used to produce a large number of plants

that are genetically identical to parent, as well as one another.

Plant tissue culture techniques broadly involve the culture of plant cells, tissue and organs under aseptic conditions. These techniques have an important role to play in the production of agricultural, horticultural and ornamental plants and in the manipulation of plant for improved agronomic performance. Plant tissue culture research is a multidimensional science that offers exciting prospects to future improvements in crop productivity while most nursery men have introduced the techniques of micro-propagation, other dimensions of tissue culture research have been less well publicised for example: the potential for selecting pathogen or stress-resistant plant clones, the creation of novel genetic combinations through somatic hybridisation are some of the novel techniques that have not been frequently transposed to the nursery industry.

In this article, rapid overviews of some development which can have a deep impact on the nursery industry are presented. These plant biotechnological techniques will be seen as the most important techniques in modern day plant biotechnology and can entirely change the look of otherwise sick nursery production system prevalent in our country. The use of these techniques especially for the production of disease - free planting material will be obvious in the new WTO regime which stresses largely on the production of good quality disease – free planting material. Some of the most important plant biotechnological techniques are:

1. Micro-propagation
2. Meristem Culture
3. Somatic Embryogenesis
4. Somatic Variation
5. In Vitro Selection
6. Protoplast Culture and Somatic Hybridisation

Micro-propagation

One of the main applications of micro-propagation is the mass propagation of superior plants. In many instances, conventional propagation is a slow process during which disease and pest problems can limit production. Micro-propagation offers the potential to produce thousands or even billions of plants per year. Micro-propagation offers several advantages not possible with conventional propagation techniques.

Once established, actively dividing cultures are a continuous source of micro-cuttings which can

result in plant production under green house conditions, without seasonal interruption. Using methods of micro-propagation, the nursery men can rapidly introduce selected superior clones of ornamental plants in sufficient quantities to have an impact on the landscape market. Micro-propagation allows the production of large number of plants from small pieces of a stock plant in relatively short periods of time.

Depending on the species, the original tissue explants may be taken from shoot tip, leaf, lateral bud, stem or root tissue. In most cases, the original plant is not destroyed in the process, a factor of considerable importance to the owner of a rare or unusual plant. Once the explants are placed on an appropriate culture medium, proliferation of buds and adventitious increase in the number of shoot is repeated until many plants are produced, all having the genetic characteristics of the original specimen.

The mean proliferation rate depends on the species treated. Shoots are generally separated every four weeks and transferred onto a fresh proliferation medium. Induction of the root system on individual shoot may be induced on appropriate medium. Rooted “micro-cuttings” or “plantlets” of many species have been established in production situations and have been successfully grown either in containers or in field plantings.

Meristem culture and production of pathogen-free plants

Another purpose for which plant tissue culture is uniquely suited is in obtaining, maintaining and mass propagation of specific pathogen-free plants by meristem culture, which was pioneered

by Morel (1960) and usually involves the removal of the meristem and subsequent culture on a nutrient medium. The meristem is a dome of actively dividing cells, about 0.1mm in diameter. Endogenous contaminants do not easily invade in the meristem, often resulting in the formation of a disease free plant. When combined with micro-propagation techniques, large number of disease free plants may be produced from meristematic explants. Meristem culture has been used successfully in the removal of viruses from many plants (potato, sugarcane and strawberry) and is now used routinely for the eradication of many viral diseases from plant material.

Somatic embryogenesis

Somatic embryogenesis refers to the development of embryo-like structures from cells of somatic (non-sexual) origin onto an appropriate medium. Somatic embryo occurs either directly on the explants or more often in callus culture.

There are several advantages of recovery of plants from cells via somatic embryogenesis compared to micro-propagation.

Somatic embryos can be produced from cells growing in suspension, thereby making possible batch culture techniques which can be scaled-up with minimum handlings cost. The multiplication rate is very high and in some species like carrot and tomato the embryos can be encapsulated and treated as artificial seeds.

Whole plants develop from the somatic embryo and only require growth to maturity. When organogenesis occurs, shoots or roots develop and the induction of the complementary structures frequently requires different culture

media formulations. However, many problems remain with somatic embryogenesis. Some of the major problems are: Although callus proliferation is relatively easy for most plant species, regeneration from unorganised cells, such as cell suspensions, is usually a more difficult process.

Moreover, there are numerous reports that show that the regeneration from callus or cell suspensions may lead to genetic variations in regenerated plants. Therefore, it is important that more research be conducted to understand the molecular basis of the genetic changes that occur during the artificial culture of cells.

Somaclonal variation

Although conventional micro-propagation has resulted to a large extent in clonal fidelity; it has become increasingly clear that under the appropriate culture conditions, a great deal of genetic variability can be recovered in regenerated plants. If cultures are established from explants that did not contain a pre-organised meristem, or if cultures are maintained as callus prior to plant regeneration, the regenerated plants are quite variable.

In early reports, most of the variations were attributed to the readily detected chromosome instability of cultured plant cells. In many cases the degree of instability was reported to be proportional to the length of time the cells remained in culture.

Reorganisation of this spontaneous variation inherent in long – term culture led to the use of cell culture for mutagenesis and selection of genetic variants and for direct recovery of novel genotypes from cell cultures via Somaclonal

variation. Indications of Somaclonal variation in several crop plants have stimulated interest in application of this method for crop improvement. There are now several cases where Somaclonal variation had produced useful changes in the progeny in agricultural plants, e.g., eye spot resistance or increase sugar yield in sugarcane and late blight resistance in potato-resistance to fusarium in tomato.

In Vitro selection

Today, one of the most intensively studied area of tissue culture is the concept of selecting disease, insect or stress resistant plants through tissue culture. Significant gains in the adaptability of many species have been obtained by selecting and propagating superior individuals, so the search for these superior individuals can be

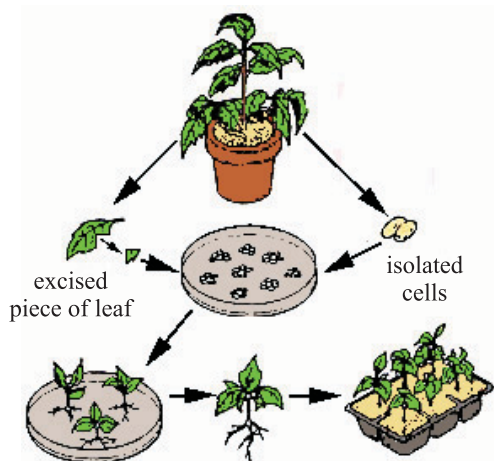
tremendously accelerated using in vitro systems. Such systems can attempt to exploit the natural variability known to occur in plants or variability can be induced by chemical or physical agents known to cause mutations.

In vitro selection usually involves subjecting a population of cells to a suitable selection pressure and recovering any variant lines which have developed resistance or tolerance to the stress. The goal would be to reorganise whole plants from such resistant cell lines. The approach presumes that tolerance operating at the unorganised cellular level can act to some degree of effectiveness, in the whole plant. If the tolerance has a genetic basis then the trait can be transferred to other plants. Current research in this area extends across many interests including attempts to select salt tolerant lines, freezing resistant plants, herbicide resistant agronomic crops and various resistance to chemical molecules such as heavy metal (aluminium, manganese etc).

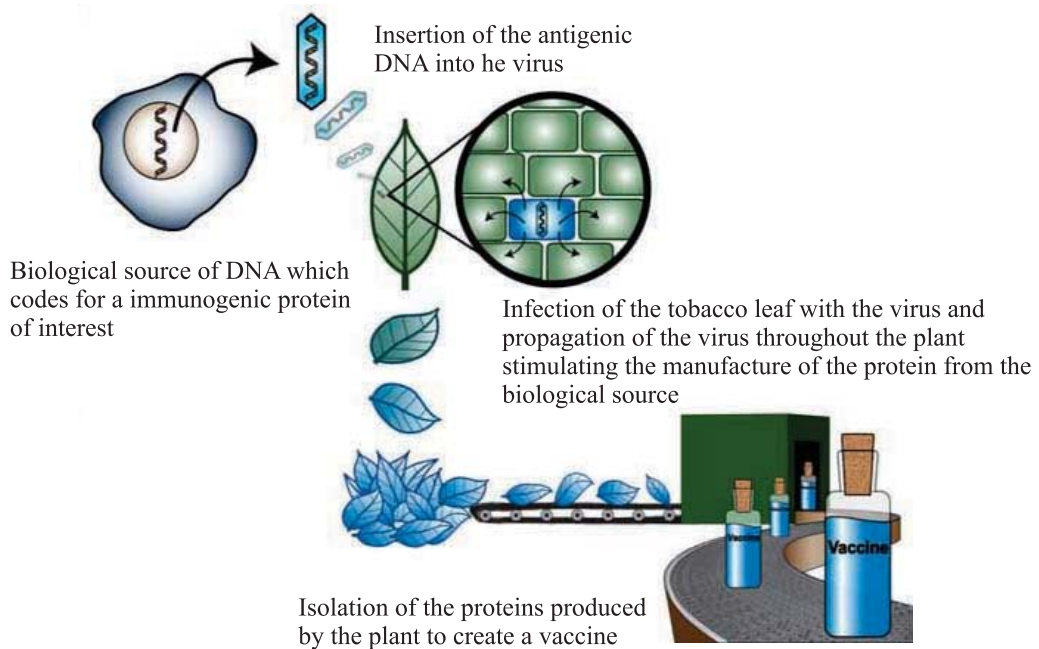
Protoplast culture and somatic hybridisation

Protoplasts are single cells which have been stripped of their cell walls by enzymatic treatment. A single leaf treated under these conditions can give millions of single cells, each theoretically capable to produce a whole plant. The observation, that has provided the impetus for most of this research, is that when cells are stripped of their cell walls and brought into close contact, they tend to fuse with each other.

This "somatic hybridisation" is not subjected to the same incompatibility problems that limit



Overview of the Tissue Culture Process



traditional plant breeding strategies, the ability to fuse plant cells from species which may be incompatible as sexual crosses extend the realm of plant modifications through tissue culture to the limits of the imagination.

The potential use of somatic hybridisation to bring about novel combinations of genetic material had been demonstrated in the genera *petunia* and *Nicotiana*. Further research in this area promises to have a tremendous impact on our concept of plant diversity.

Conclusion

The benefits of plant tissue culture are extensive in the agricultural world.

Micro-propagation is favorable to traditional crop breeding methods in many respects, the first being that it allows for the production of huge number of plants in a very short period of time. In the Netherlands alone, over 100 million plants are produced using micro-propagation each year. Plant tissue culture is also advantageous to growers because overwhelming number of plants can be produced using the tissue collected from a single parent plant – a plant which itself remains unharmed in the tissue harvesting process. Crop production through micro-propagation also eliminates the

possibility or any interruption in the growing season because it can be carried out inside the carefully regulated environment of a greenhouse, because the chemical and physical environment inside a greenhouse can be closely monitored, any lull in production that might typically occur as a result of seasonal change can be avoided.

Micro-propagation will be crucial to the agriculture industry in the future because it is used to produce plants which have been genetically modified and selected for their ability to resist certain indigenous environmental stresses. Currently, scientists and

members of the agricultural community have joined forces to investigate the possibility of creating lines of tomatoes that possess increased salt tolerance (to be grown in areas in which the soil is high in salinity), plants that are completely resistant to various viral, bacterial, algal and fungal infections; tobacco plants whose leaves can withstand freezing temperatures and crops that are entirely resistant to harmful and destructive insects. Plant biotechnology will therefore go a long way in the improvement of techniques for producing good quality planting material.

CLIMATE CHANGE : NATIONAL AND INTERNATIONAL RESPONSES

Pushp Lata Verma

*Lecturer, Department of Computer Education and Technological Aids
NCERT, New Delhi*



Climate change has emerged as one of the most serious challenges. Large dimensions of the problem and seriousness of its impact have shaken the entire humanity. Global warming, rising of sea levels, high level of pollution, erratic rainfall patterns are just a few manifestations of climate change. Attempts have been made both at the national and international levels to restrict the ill-effects of climate change. The United Nations Framework Convention on Climate Change in 1992, the Kyoto Protocol of 1997 and the Bali Action Plan of 2007 are significant steps in this direction.

In India, with 16 per cent of the world's population, contributes only 4 per cent of the total global greenhouse gas emissions. In terms of per capita GHG emissions in the year 2004, India is further lower at only 1.02 MT CO₂. Around 55 per cent of India's population still does not have access to commercial energy. In the energy sector, some of the specific initiatives taken by India include introduction of Compressed Natural Gas (CNG) for public and private transport in metropolitan areas. A great emphasis has also been laid on the development of alternate fuels, namely hydrogen and bio-fuels. Recently a decision has been taken to promote the desert as a hub for renewable energy by establishing a Solar City in the Thar desert area. Besides, steel, aluminium, fertilisers, paper, cement are some of the major energy intensive sectors where India's energy efficiency has attained the global standards.

India have formulated the National Action Plan on Climate Change in 2008. India have introduced specific policies that have targetted conservation of rivers, improvement of urban air quality, enhanced afforestation and a significant increase in the installed capacity of renewable energy technologies. India have enacted the Energy Conservation Act and notified the Energy Efficiency Code for the new commercial buildings. India have also launched the 'Green India' project that will be the world's largest afforestation project covering six million hectares of degraded forest land. Latest Green Index taken out by the 'National Geographic' puts India as the No.1 country in the world on a Green Index.

Introduction

"Climate Change" means a change of climate, which is attributed directly or indirectly to human activity that alters the composition of the global atmosphere and which is in addition to natural

climate variability observed over comparable time period. Climate change is one of the all-encompassing global environmental changes having deleterious effects on natural and human systems, economies and infrastructure. The risks associated with it call for a broad spectrum of

policy responses and strategies at all levels – local, regional, national and global.

Climate Change is a serious global environmental phenomenon, which has been viewed with concern in international academic and scientific circles for many decades, particularly because of the adverse impacts that anthropogenic climate change may have on various sectors of society, eco-system and economy. Of late, it has received high degree of attention at political levels because of its implications for energy security and ecologically sustainable development.

Climate Change is primarily caused by the building up of greenhouse gases in the atmosphere. According to the *Intergovernmental Panel on Climate Change (IPCC)*, the global atmospheric concentrations of carbon dioxide, methane and nitrous oxide have increased markedly as a result of human activities since 1750, and now has far exceeded pre-industrial values. The global increase in carbon dioxide concentration are due primarily to fossil fuel use and land use change, while those of methane and nitrous oxide are primarily due to agriculture.

According to the *Intergovernmental Panel on Climate Change (IPCC)*, the enhanced greenhouse effect will result in additional warming of the Earth's surface. The Fourth Assessment Report of 2007 of the Working Group III of the IPCC states that Global Greenhouse Gas (GHG) emissions have grown since pre-industrial times, with an increase of 70 per cent between 1970 and 2004. The largest growth in global GHG emissions during this period has come from the energy supply sector (an increase of 145 per cent). The growth in direct emissions from transport had been 120 per cent,

industry 65 per cent and Land Use, Land Use Change, and Forestry (LULUCF) 40 per cent.

Future Impact of Global Warming

The Fourth Assessment Report of the IPCC submitted in 2007 has stated that global warming may have a devastating impact on the climate of the earth. It is very likely that climate change can slow down the pace of progress towards sustainable development either directly through increased exposure to adverse impact or indirectly through erosion of the capacity to adapt. The Report predicts that there would be enlargement and increased number of glacial lakes and increasing ground instability in permafrost regions, and rock avalanches in mountain regions. Effects of temperature increase have also been documented in some aspects of human health, such as heat-related mortality in Europe, infectious disease vectors in some areas, and allergenic pollen in Northern Hemisphere high and mid-latitudes. Settlements in the mountain regions are at enhanced risk to glacier lake outburst floods caused by the melting glaciers. Sea level rise and human development are together contributing to losses of coastal wetlands and mangroves and increasing damage from coastal flooding in many areas. Increases in the frequency of droughts and floods are projected to affect local production negatively, especially in subsistence sectors at low latitudes. Coasts are projected to be exposed to increasing risks, including coastal erosion, due to climate change and sea-level rise and the effect will be exacerbated by increasing human-induced pressures on coastal areas. The Report projected that climate change-related exposures are likely to affect the health status of millions of people, particularly those with low adaptive capacity,

through: increases in malnutrition and consequent disorders, with implications for child growth and development; and increased deaths, disease and injury due to heat waves, floods, storms, fires and droughts.

Regarding the Asian region, the Report points out that glacier melt in the Himalayas is projected to increase flooding, rock avalanches from destabilised slopes, and to affect water resources within the next two to three decades. This will be followed by decreased river flows as the glaciers recede. The Report further predicts an adverse impact of climate change on human health as endemic morbidity and mortality due to diarrhoeal disease primarily associated with floods and droughts are expected to rise in East, South and Southeast Asia due to projected changes in hydrological cycle associated with global warming. Increases in coastal water temperature would exacerbate the abundance and/or toxicity of cholera in South Asia.

Impact on India

India is also not immune from the impact of global warming and climate change. Any sharp rise in sea level could have a considerable impact on India. *The United Nations Environment Programme* included India among the 27 countries that are most vulnerable to a sea level rise.

Glaciers in the Himalayas feed important rivers such as the Ganga, the Indus and the Brahmaputra that provide water for millions of people as well as for irrigation and industry. The accelerated melting which these glaciers are experiencing as a result of the earth's warming will have an adverse effect on future water availability. The Gangotri glacier, one of the largest

in the Himalayas, has been retreating since long and more rapidly in recent decades. As the glaciers retreat, they become more fragmented and the smaller glaciers are more sensitive to global warming.

International Response

The international community set up the *United Nations Framework Convention on Climate Change* (UNFCCC) in 1992, which seeks to address the challenge of climate change on the basis of the principle of “*common but differentiated responsibilities and respective capabilities*” of the member Parties. The objective of UNFCCC is to stabilise the concentration of greenhouse gases in the atmosphere at a level that prevents dangerous anthropogenic interference with the climate system. The UNFCCC recognises the legitimate need of developing countries for sustained economic growth and poverty alleviation. Article 3.1 of the UNFCCC mentions that Parties to the Convention should protect the climate system for the benefit of present and future generations of human kind on the basis of equity and in accordance with their “*common but differentiated responsibilities and respective capabilities*”. It is also noted in the Preamble of the UNFCCC, that the largest share of historical and current global emissions of greenhouse gases has originated in the developed countries, that per capita emissions in developing countries are still relatively low, and that the share of global emissions originating in developing countries will grow to meet their social and development needs. The implementation of the Convention is promoted and reviewed through the decisions taken at the annual meetings of the *Conference of Parties* (CoP).

In the year 1997, Parties, adopted the *Kyoto Protocol*, which set legally binding targets for GHG reductions by industrialised countries during the “*first commitment period*”, i.e. 2008-2012. The developed country Parties are expected to reduce, by 2012, their GHG emissions by an order of 5.2 per cent below their aggregate 1990 emissions. The *Kyoto Protocol* is the most significant agreement till date to combat climate change. The Protocol provides for quantified emission limitation and reduction commitments for the developed countries while presenting/suggesting mechanisms to facilitate review of, and compliance with these targets. India is a Party to the *United Nations Framework Convention on Climate Change* and its *Kyoto Protocol*.

India's Response

India has probably the most comprehensive framework of legal and institutional mechanisms in the region to respond to the tremendous challenges to the environment it is facing, owing to population explosion, poverty and illiteracy augmented by urbanisation and industrial development. India is probably the first developing country which has incorporated into its Constitution the specific provisions for environmental protection. **Article 48A** of the Constitution of India provides that ‘*the State shall endeavour to protect and improve the environment and to safeguard the forests and wild life of the country*’. Similarly, **Article 51A(g)** makes it obligatory for every citizen of India, ‘*to protect and improve the natural environment including forests, lakes, rivers and wild life, and to have compassion for living creatures*’.

As a developing nation, India, in its endeavour to

bring millions of people out of poverty cannot accept binding commitments for cutting emission of greenhouse gases. The total emission of greenhouse gases is bound to increase in India in the course of meeting the demands for raising the standards of living and providing access to commercial energy to all. Around 55 per cent of India's population still does not have access to commercial energy.

India and the International Organisations

India is a party to the *United Nations Framework Convention on Climate Change*. India has established the *National Clean Development Mechanism Authority (NCDMA)* on 2 December 2003.

India's CDM potential represents a significant component of the global CDM market. As of April 2009, 420 out of total 1,593 projects registered by the CDM Executive Board are from India, which so far is the second highest by any country in the world. Also, as on 31 March 2009, the National CDM Authority has accorded Host Country Approval to 1,230 projects facilitating an investment of more than Rs 151,650 crore (1516.5 billion). These projects are in the sectors of energy efficiency, fuel switching, industrial processes, municipal solid waste and renewable energy. If all these projects get registered by the CDM Executive Board, they have the potential to generate 574 million *Certified Emission Reductions (CERs)* by the year 2012.

It has been India's stand not to agree to any commitments related to reducing greenhouse gas emissions. In order to meet the demands of rising

standards of living and providing access to commercial energy to those lacking it, the total emission of green house gases is bound to increase in India and also in other developing countries. Developed countries, being responsible for the problem, owing to their historical as well as current emissions, are required to stabilize and reduce their emissions of GHGs. Hence, developed countries should come forward and take further deeper commitments beyond the year 2012.

Climate friendly measures taken by India

India is conscious of the challenge of climate change, and the urgency of actions needed to counter its possible adverse impacts. The past few years have witnessed the introduction of environmental measures in India that have targeted conservation of rivers, improvement of urban air quality, enhanced afforestation and a significant increase in the installed capacity of renewable energy technologies. These deliberate actions, by consciously factoring in India's commitment to the UNFCCC, have realigned the economic development to a more climate friendly and sustainable path.

India believes that adaptation is critical for the developing countries that are most vulnerable to the climate change. India has implemented, in pursuit of this objective, several major programmes addressing the climate variability concerns. These include cyclone warning and protection, coastal protection, floods and drought control and relief, major and minor irrigation projects, control of malaria, food security measures, research on drought resistant crops, etc.

The goal of India's climate change related actions is to ensure sustainable development, which is

inclusive in nature. The policy does not compromise on the developmental imperatives including energy security and poverty alleviation. *India's National Environment Policy, 2006* underlines that "while conservation of environmental resources is necessary to secure livelihoods and well being of all, the most secure basis for conservation is to ensure that people dependant on particular resources obtain better livelihoods from the fact of conservation, than from degradation of the resource".

As India endeavours to increase energy consumption to empower its people, the national policies are designed to ensure that the means are also sustainable. This includes use of market mechanisms and the relevant technology along with the promotion of energy efficiency, conservation, and renewable energy. As a part of such policy, measures have been taken to promote the use of CNG for public transport, introduce Metro rail in cities, enact the Energy Conservation Act, 2001, and notify an Energy Efficiency Code for the new commercial buildings.

India's per capita consumption of energy is 530 kgoe (Kilogram of Oil Equivalent) of primary energy compared to the world average of 1770 kgoe. India's per capita emission of CO₂ is among the lowest in the world: it is approximately 1 tonne per annum as against a world average of 4.2 tonne per annum, while the per capita average for industrialised countries ranges between 10-20 tonne per annum. The fossil fuel CO₂ intensity in India is the same as in Japan, and better than in Germany. This is owing to the fact that, at the national level, an effective regime of policies, regulations and programmes has been set up to address energy efficiency and energy security

concerns. This has had a positive effect on India's development process.

The Government of India has set up an elaborate institutional mechanism to consider and address issues relating to climate change. A Council chaired by the Prime Minister, called *Prime Minister's Council on Climate Change*, was constituted in June 2007, to coordinate national action for assessment, adaptation and mitigation of climate change. The Council provides the overall guidance to climate change related actions taken by various Ministries in the Government and other agencies. An expert committee set up in 2007, under the chairmanship of the Principal Scientific Adviser to Government of India is also looking into the impacts of climate change. The committee is studying the impact of anthropogenic climate change on India and is engaged in identifying the measures that may have to be taken to address the adverse impacts.

Further, a Policy Guidance Group for International Negotiations headed by the Prime Minister and consisting of Ministers concerned and a Core Negotiating Team of officials and technical experts for assisting the international negotiations have also been set up.

National Action Plan on Climate Change

As a part of national voluntary actions to address climate change related concerns, India released its National Action Plan on Climate Change (NAPCC)

on 30 June 2008. The National Action Plan advocates a strategy that promotes, *firstly*, the adaptation to climate change and *secondly*, further enhancement of the ecological sustainability of India's development path. It recognises that climate change is a global challenge and, that it should be successfully overcome through a globally collaborative and cooperative effort based on the basis of the principle of equity. The Action Plan suggests that the long-term convergence of per capita GHG emissions is the only equitable basis for a global agreement to tackle climate change. The Action Plan assures the international community that India's per capita GHG emissions would not exceed the per capita GHG emissions of developed countries, despite India's developmental imperatives.

India's National Action Plan stresses that maintaining a high growth rate is essential for increasing living standards of the vast majority of people of India and reducing their vulnerability to the impacts of climate change. Accordingly, the Action Plan identifies measures that promote the objectives of sustainable development of India while also yielding co-benefits for addressing climate change. It also outlines a national strategy that aims at enabling the country to adapt to climate change and enhances the ecological sustainability of India's development path.

Eight National Missions (*National Solar Mission**, *National Mission on Enhanced Energy Efficiency*, *National Mission on Sustainable Habitat*, *National Water Mission*, *National Mission for*

* In a step forward, Gujarat has decided to promote the deserts as a hub for renewable energy by establishing solar power plants in the Rann of Kutch. The State Government has decided to allocate 1,500 hectares of land to build Solar City in the desert. The incentives offered in the new Solar Power Policy include exemption from electricity duty and demand cut of 50 per cent of the installed capacity. The expected cost of the project is ₹61,019 crore.

sustaining the Himalayan Ecosystem, National Mission for a Green India, National Mission for Sustainable Agriculture and National Mission on Strategic Knowledge for Climate Change), which form the core of the National Action Plan represent multi-pronged, long term and integrate strategies for achieving key goals in the context of climate change. Besides the National Missions, several *Other Initiatives* that are critical to achieve the objective of the NAPCC are to be implemented as a part of agreed national strategy for development and which will have significant co-benefits for climate. The National Missions are to be institutionalised by the respective Ministries and will be organised through inter-sectoral groups. Comprehensive Mission documents detailing objectives, strategies, plan of action, timelines and monitoring and evaluation criteria are being evolved.

International Negotiations

Efforts to counter climate change at the international level are currently focused on the negotiations that are taking place amongst the member countries of the UNFCCC, in pursuance of *Bali Action Plan* (BAP) adopted at the thirteenth *Conference of Parties* (CoP-13), held at Bali, Indonesia in December 2007. The *Bali Action Plan* calls for full, effective and sustained implementation of the UNFCCC through long-term cooperative action, now, up to and beyond 2012. It is a comprehensive dialogue to address the four major building blocks of climate change, *i.e.* GHG mitigation; adaptation to climate change impacts; technology development and cooperation; and finance. This is a particularly significant development as it sets

out differentiated approaches for the developed and developing countries in the key area of GHG mitigation on the basis of ***UN Framework Convention on Climate Change*** and underscores the importance of its principles and provisions, especially the 'common but differentiated responsibilities and respective capabilities'.

Several Meetings of the Parties to UNFCCC were held since the adoption of *Bali Action Plan* in December 2007, *viz.* the UN Climate Change Talks were held at Bangkok from 31 March – 4 April 2008, at Bonn, Germany from 2-13 June 2008, at Accra, Ghana from 21–27 August 2008 while the 14th Conference of Parties was held at Poznan, Poland from 1-12 December 2008. Poznan Conference was intended to enable the Parties to take a stock of the progress made since the adoption of *Bali Action Plan*. The CoP- 14 agreed on a time table for the negotiations to commence and also the modalities for the preparation of a negotiating text that would form the basis of the negotiations. In June 2009, a meeting was held in Bonn to provide a basis for the group to intensify negotiations on further emission reduction commitments.

Accordingly, pre-sessional meetings of the *Ad Hoc Working Groups* of the Convention and the *Kyoto Protocol* (AWG-LCA 5 and AWG-KP 6) were held in Bonn from 29 March to 8 April 2009. The pre-sessional meetings discussed areas of convergence and divergence in the ideas submitted by the Parties for inclusion in the text for negotiations. A meeting was held in Bonn from 26 May to 12 June 2009 in which a negotiation text was prepared by the Chair of the Ad Hoc Working Group on Long term

Cooperative Action (AWG-LCA) to facilitate the negotiations among Parties on the fulfillment of Bali Action Plan. India has been able to project our views adequately and effectively in various meetings.

The UNFCCC talks are crucial for developing countries which are increasingly being subjected to pressures from the developed countries to agree to an emissions pathway in future and a set of internationally monitored, nationally appropriate actions for mitigation (NAMAs). While *Bali Action Plan* does call for NAMAs for *Annex I** and *Annex II: Non-Annex I*** countries, the actions of developing countries is dependent on the support in terms of finance and technology received by such countries from the developed countries. Moreover, the burden of achieving the global goal of stabilization of climate is to be shared equitably on the basis of the principle of the Convention which clearly differentiates between the countries on the basis of their responsibility and respective capability. While EU and most of the other *Annex I* countries including US (which is not a signatory to Kyoto Protocol) have increased their emissions in recent years and failed to achieve the Kyoto targets, they are insisting that countries like India and China should come on board for a new deal to be forged in Copenhagen. While their own declaration of targets for their second commitment period under Kyoto

Protocol are totally inadequate (EU – 20 per cent reduction in emissions over 1990 levels by 2020, US – 14 per cent reduction over 2005 levels by 2020, Australia – 5-25 per cent over 1990 by 2020, Japan – 6-25 per cent over 1990 by 2020 against 40-45 per cent over 1990 by 2020 as recommended by IPCC), they have asked the developing countries also to deviate by 15-30 per cent from their *Business As Usual* (BAU), in order to support the actions of the *Annex-I* countries. India is opposed to such approaches and has argued that an agreement in Copenhagen has to be premised on the principles of the Convention.

As the subject of climate change has gained increasing significance and prominence, it is being discussed in various international groupings such as *Major Economies Meeting* (MEM), G-8, etc. An initiative comprising the major economies, viz. Australia, Brazil, Canada, China, France, Germany, India, Indonesia, Italy, Japan, Mexico, Russia, South Korea, South Africa, United Kingdom, and the EU was launched in May 2007, to develop and contribute to discussions on energy security and climate change. The MEM seeks to complement the existing national, bilateral, regional and international programmes to address the long-term challenge of global climate change and achieve agreement on the actions necessary to counter climate change. In the G-8 and Outreach Countries Summit held in

* Annex I : Parties include the industrialised countries that were members of the OECD (Organisation for Economic Co-operation and Development) in 1992, plus countries with economies in transition (the EIT Parties), including the Russian Federation, the Baltic States, and several Central and Eastern European States.

** Annex II : Non-Annex I : Parties are mostly developing countries. Certain groups of developing countries are recognised by the Convention as being especially vulnerable to the adverse impacts of climate change, including countries with low-lying coastal areas and those prone to desertification and drought. Others (such as countries that rely heavily on income from fossil fuel production and commerce) feel more vulnerable to the potential economic impacts of climate change response measures. The Convention emphasizes activities that promise to answer the special needs and concerns of these vulnerable countries, such as investment, insurance and technology transfer.

July 2008, where India and other major economies were invited, the developing countries stressed their position regarding GHG mitigation as per the differentiated responsibilities and respective capabilities as envisaged in the UNFCCC and called for support in terms of technology and finance.

In the Major Economies Meeting on Climate Change held on the sidelines of G-8 Summit in Japan, the Prime Minister of India, emphasized the importance of enhanced implementation of the UNFCCC decisions through long-term cooperative action in accordance with the provisions and principles of the Convention, especially 'common but differentiated responsibilities and respective capabilities' are respected in these negotiations and their outcomes in letter and spirit.

India has been consistently raising the voice in all world fora that global warming is taking place everywhere and its adverse consequences will impact most heavily on developing countries like India. The reference at the above meeting to a *two degree centigrade* (celsius) increase as a threshold reflects a prevalent scientific opinion internationally and only reinforces what India has been saying about the dangers from global warming. This is for the first time that India has accepted a reference to *two degree centigrade* (celsius) in a document, as a possible threshold guiding global action, but this is entirely in line with our stated position on global warming.

India is a partner in the *Asia Pacific Partnership on Clean Development and Climate* (APP). The partnership consists of key developed and developing countries in Asia and North America across the Pacific - Australia, China, Japan, South

Korea, Canada and the USA besides India. It focuses on development, diffusion and transfer of clean and more efficient technologies and is consistent with the principles of the UNFCCC and complements the efforts under the UNFCCC. Under APP, eight (8) Task Forces in the area of aluminum, buildings and appliances, cement, use of fossil energy, coal mining, power generation and transmission, renewable energy and distributed generation, and steel have been set up to facilitate collaboration in technology development and diffusion.

India engages itself bilaterally with several countries in the field of climate change. An MoU for cooperation in the field of Clean Development Mechanism under the Kyoto Protocol was signed in New Delhi between India and Denmark on 27 October 2008. The Third Meeting of the Indo-UK Structured Dialogue on climate change was held in September 2008, at New Delhi wherein important issues such as Bali Action Plan, Technology Transfer, Forestry, National Action Plan, etc., were discussed.

Policy measures taken by India to mitigate climate change

The past few years have witnessed the introduction of landmark environmental policy measures in India that have targeted conservation of rivers, improvement of urban air, enhanced forestation and a significant increase in the installed capacity of renewable energy technologies. These and similar measures, affirmed by the democratic and legislative processes, have been implemented by committing additional resource, as well as by re-aligning new investments. Besides, several other climate-friendly

measures have been taken in recent years that have a direct bearing on mitigating climate change. India, with 17 per cent of the world's population, contributes only 4 per cent of the total global greenhouse gas emissions against 30 per cent (approximately) of the US and 25 per cent of the EU countries. In terms of per capita GHG emissions in the year 2004, India is further lower at only 1.02 MT CO₂ (about 23 per cent of the global average) as compared with per capita emission of 20.01 MT CO₂ in US and 9.40 MT CO₂ in EU. However, over 700 CDM projects have been approved by the CDM National Designated Authority, and about 300 of these have been registered by the CDM Executive Board. The registered projects have already resulted in over 27 million tones of certified CO₂ emissions reductions.

India's environment policies has been driven by the imperatives of sustainable development, and have, as a co-benefit, led to a decline in the intensity of energy use and carbon dioxide emissions as well. The high ratio of recycling in India, compared to that of other major economies has also limited the growth in energy use, and GHG emissions, because of the lower demand for virgin material such as steel, aluminum and copper.

The Electricity Act, 2003, requires States Electricity Regulatory Commissions to specify a percentage of electricity that the electricity distribution companies must procure from renewable sources. Several Commissions have already operationalised this mandate, and also notified preferential prices for electricity from renewable sources. This has contributed to set the pace for addition in renewable-electricity capacity, and over the past three years, about 2,000 MW of renewable electricity capacity has been

added in India every year, bringing the total installed renewable capacity to over 11,000 MW. Of this, a little over 7,000 MW is based on wind power. India now has the fourth largest installed wind capacity in the world. The National Hydro Energy Policy has resulted in the accelerated addition of hydropower in India, which is now over 35,000 MW.

Currently, the primary energy sector growth rate is around 3 per cent per year, against GDP growth exceeding 8 per cent. Steel, aluminium, fertiliser, paper, cement are some of the major energy intensive sectors where India's energy efficiency has attained the global standards. Especially, in the cement sector, the energy efficiency of Indian plants is among the world's highest.

An Energy Conservation Building Code (ECBC) was launched in May, 2007, which addresses the design of new, large commercial buildings to optimise the building's energy demand. Commercial buildings are one of the fastest growing sectors of the Indian economy, reflecting the increasing share of the services sector in the economy. Nearly one hundred buildings are already following the Code, and compliance with it has also been incorporated into the Environmental Impact Assessment requirements for large buildings.

In the area of off-grid and rural applications, bio-gas and solar-lighting have reached 4 million and 1 million households, respectively, while in the area of solar water heating systems, around 2 million square metre (m²) collector area has been deployed. Besides, Village Electrification Programme is also being implemented to electrify 10,000 villages through renewable energy resources by 2012.

The Government of India has also launched the *Green India* project that will be the world's largest afforestation project covering six million hectares of degraded forestland.

Lastly, the latest Green Index taken out by National Geographic puts India as the No.1 country in the world on a green Index. The Greendex is a comprehensive measure of consumer behavior in 65 areas relating to housing, transportation, food and consumer goods. Greendex 2009 ranks average consumers in 17 countries – up from 14 in 2008, for which changes are tracked – according to the environmental impact of their discretionary and non-discretionary consumption patterns within these four major categories. Environmental concern and engagement among the public has increased, and many programmes and initiatives by Governments and companies were put in place as a result. Overall, environmental concerns have remained strong, and awareness of the issues at hand has increased.

Conclusion

Risks emanating from climate change, caused by anthropogenic greenhouse gas emissions are now widely perceived to be real. Unless addressed expeditiously, these can have adverse

consequences upon those least able to cope, that is, the poor and disadvantaged across the globe, but particularly those residing in the developing countries. The issue of climate change needs to be addressed within the framework of sustainable development, without halting the process of development.

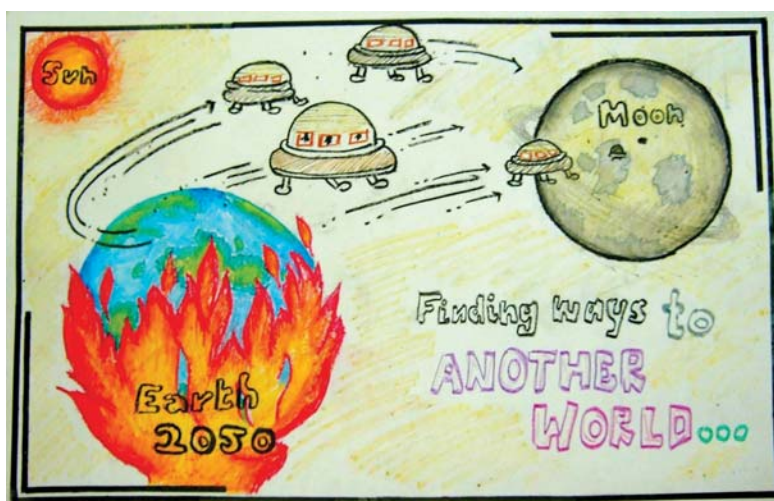
The importance accorded to the subject of climate change in various international forums addressed, many times at the State of Head level itself shows the recognition of the problem. This, in turn, results in paving the way for taking appropriate policy measures at national and international level. There are several means to check the threat which includes exchange of information by all nations, international cooperation in developing environmentally friendly innovative technologies, technology transfer from developed to developing countries and access to environmentally sound services. India's participation in different global environmental negotiations and several domestic initiatives to counter global warming and climate change underlines its commitment and seriousness towards the problem.

References

RANGARAJAN, MAHESH. 2007. *Environment Issues in India*.

LONG, DOUGLAS. 2008. *Global Warming*, 2005 Edition, *Global Environment Outlook*, UNEP. *Annual Report*, 2008-2009. Ministry of Environment and Forests. *The Times of India*, 5 August, 2009.

An Overview of Our Changing Environment, 2008, UNEP. *UNEP Year Book*, 2009.



A child's perception of Earth in the year 2050

ACHIEVING LOW CARBON ECONOMY BY CHANGING LIFESTYLE

Mudita Bhatnagar

*Principal, P.K.R. Jain Graduate College of Education
Village : Nasirpur, Hisar Road, Amala City, Haryana*

World environment day is celebrated every year on 5th June and this commemoration acts as a principal vehicle through which the environmental protection agencies create awareness about environment to enhance public attention and action. The climatic changes are becoming the major issue of our times. One major factor affecting climatic changes is perhaps accumulation of greenhouse gases in the atmosphere. Scientist, world over are trying to find out ways and means as to how to reduce them. One of the effective ways to tackle this problem may be active involvement of every individual by making a conscious effort to change our life styles, such as adopting energy efficient technologies, conservation and judicious utilisation of forests and other resources besides resorting to eco-friendly consumption of natural resources. These steps would ultimately lead to promotion of low carbon economy.

A low carbon economy is a term that in general refers to an economy which has a minimal output

of Greenhouse Gas (GHG) emissions into the biosphere but specifically refers to the greenhouse gas carbon dioxide (CO₂). Most of the scientific and public opinion in recent past has led to the conclusion that there is an unreasonable accumulation of GHGs (especially CO₂) in our atmosphere and human beings are to be blamed for this. The higher concentrations of these gases will change the climate dangerously in the foreseeable future. Global acceptance for a transition to Low Carbon Economy by all stake holders is, therefore, proposed as a means to avoid catastrophic climate change and as a precursor to an ideal zero carbon economy.

Buying locally produced fruits and vegetables, riding bikes or taking the trains and using the public transport systems instead of personal vehicles, buying carbon offsets and staging carbon neutral activities are all but part of some of the initiatives taking root to create awareness about consequences of climate change in many countries.

Individuals interested in reducing their “carbon footprints” through their activities need to take effective steps or else compensate for it. A majority of our daily habits due to our present lifestyle are responsible for up to 50 per cent of greenhouse gas emissions.

Automobiles running on fossil fuels alone cause a quarter of global greenhouse gas emission. Although automakers are making efforts to reduce this in new designs of vehicles, yet as of now the so called ‘clean car’ does not exist outside the research laboratory.

Our journey of around 1,000 km by an express train emits roughly a quarter less (CO_2) than an aircraft per passenger. A bus emits between 10-20 times less CO_2 than a car per passenger. All these are of course many folds higher than for walking and cycling, if distances permit. If you have to use a car, keeping your speed down can also help to reduce emissions. Driving at high speeds can increase a car’s CO_2 emissions up to 45 per cent. Another energy saving step could be to climb stairs rather than use lifts or escalators, a practice actively encouraged in many countries like Japan and Belgium.

Climate Action Network (CAN), an international collective effort of environmental groups, including Greenpeace and friends of the earth, lists “50 Top Tips” by which an individual can make a dent in global warming, simply by changing the personal habits.

The individuals can play a major role in reducing carbon dioxide emission simply by changing their lifestyles in such a manner that it facilitates conservation of conserving. For example, use of Compact Fluorescent Light (CFL) in place of

incandescent bulbs or tube lights, replacing electric or fuel bases geysers with solar geysers, using fuel efficient vehicles and ensuring their proper maintenance to enhance their fuel efficiency, encouraging walking/cycling, growing more and more trees, recycling and reuse of waste material after suitable treatment and adopt proper methods for waste disposal.

The following steps could facilitate achievement of low carbon economy:

Make a commitment

Reducing your carbon footprint is no different from any other task. Telling people you will reduce carbon emissions may seem simplistic, but even simple actions like announcing your commitment to go carbon neutral can be effective, while the simple act of asking for ideas can lead to creative and innovative solutions. Being carbon neutral implies that one makes a conscious effort to reduce carbon emissions due to her/his personal activities and adopts measures to reduce them. However, it must be borne in mind that reducing carbon emissions to zero is not possible. Several countries have indicated that they will go for carbon neutral. UNEP is facilitating carbon neutrality in all sector and all regions through its climate neutral network.

Assess where you stand

It is likely that carbon will eventually be judged as an atmospheric pollutant and regulated accordingly with consequent costs and opportunities for all sectors of the society. Knowing where and how you generate greenhouse gases is the first step towards reducing them. For individuals and small

businesses online calculators and internal assessments can help start the process. Larger organisations may need specialised advice and tools for greenhouse gas accounting and verification or the greenhouse gas protocol, provided by the World Resources Institute and World Business Council for sustainable development, which is an accounting tool for government and business managers to understand, quantify, manage and report greenhouse gas emissions.

Decide and plan where you want to go

Based on your assessment of climate related risks and opportunities, a strategy and action plan can be developed. Targets help focus efforts and also provide a benchmark for measuring success. Most homes or businesses can reduce energy use by 10 per cent which almost always result in a 10 per cent reduction in greenhouse gas emissions-with a one year payback or less. A plan to reduce carbon emissions will first focus on the type of energy and the way it is used; for example electricity for buildings and fuel for transport. Reducing this energy can create instant savings. An effective tool is an energy audit. Many electric utilities and government energy offices now offer an audit as part of their efforts to reduce carbon emissions.

De-carbon your life

There is a broader way to think about carbon and climate. Everything an individual, organisation, or government does or uses embodies some form of carbon either in products themselves or in the energy and business materials it takes to make them. Buildings, fittings and equipment are all proxies for carbon; carbon copies can be chosen

based on the least amount of impact they will have on the climate. Integrating climate friendly criteria into decision making can trigger a ripple effect.

Get energy efficient

Improving the efficiency of your buildings, computers, cars and products is the fastest and most lucrative way to save energy, money and carbon emissions. Energy efficiency is about increasing productivity but doing more with less. More efficient buildings, cars and products will be a direct and lasting contribution to limiting the carbon emissions. High performance, environmentally accountable, energy efficient and productive facilities are now economically possible.

The Ministry of Power, Government of India has established the Bureau of Energy Efficiency (BEE) to promote awareness amongst masses about adopting energy efficient electric devices and equipment on the one hand and to develop, in collaboration with industries, energy efficient devices on the other. BEE has devised a unique star system for a variety of electric devices like tube lights, refrigerators, air conditioners. These products by various manufacturers are given a rating on the basis of their energy efficiency. A five star rating implies maximum energy efficiency for a given electric device of a particular specification. Using electric devices with higher star rating could be a right step toward becoming energy efficient. BEE has also initiated a number of other programmes to evolve standards desirable for enhancing energy efficiency in industries, work places and buildings besides launching awareness campaigns for students as well as common masses.

Invest in offsets and cleaner alternatives

There is a limit to how much efficiency you can squeeze from your lifestyle or your organisation's operations, or how much renewable energy you can employ. The choice for those who wish to compensate for their remaining emissions is to fund an activity by another party that reduces emissions. This is commonly called a "carbon offset" or "carbon credit". The term carbon neutral includes the idea of neutralising emissions through supporting carbon savings elsewhere. Climate change is a global problem so carbon reduction will have the same impact no matter where they are implemented. Carbon credits can be generated by emission free energy generation, reduced demand, including energy efficiency or sequestration in the form of underground and forestry storage.

Get efficient

Looking at your life or business through a carbon neutral lens can help you in other ways by increasing the efficiency of resource use, avoiding and reducing waste and ultimately improving your overall performance and reputation. Economists are fond of saying that there are no banknotes lying around because someone will have already picked them up. After all, carbon is generally the waste product of producing energy and reducing waste and becoming more efficient is always a good idea. Integrate the 3R approach- reduce, reuse and recycle- into your thinking.

Let us take a pledge for maintaining cleanliness of air in natural form by undertaking sustainable development which will not only save our environment but also ensure healthy living on this planet.

Suggestions to strive for low carbon economy

- ⇒ Reduce waste generation at source.
- ⇒ Recycle and reuse the waste in the process.
- ⇒ Exploit and use non- renewable sources of energy.
- ⇒ Nuclear power is better option to reduce carbon emissions.
- ⇒ Eco friendly consumption of natural resources.
- ⇒ Use innovative technologies that produce little green house Gases.
- ⇒ Earn carbon credits and plan emission trading.
- ⇒ Use high efficiency electric motors.
- ⇒ Use high efficiency burners in furnaces.
- ⇒ Use heat recovery systems.
- ⇒ Use high efficiency boilers.
- ⇒ Use solar water heaters.
- ⇒ Use bio fuel such as bio diesel instead of coal, oil, etc.
- ⇒ Use fuel efficient vehicles and further enhance fuel efficiency by proper maintenance and use of genuine spare parts.
- ⇒ Grow more trees and maintain at least 25 per cent area as green cover.
- ⇒ Plan strategies of carbon capture and storage.
- ⇒ Promote of use of non- conventional sources of energy.
- ⇒ Install facilities for water harvesting to arrest fast depleting ground water table.

LEARNERS' ENGAGEMENT IN SECONDARY SCHOOL BIOSCIENCE ACTIVITIES : AN ANALYSIS

Gitanjali Mohanty

Subhash Chandra Panda

Department of Education, RIE (NCERT), Bhubaneswar

Various activities play a significant role in order to learn Bioscience concepts which lead to development of pupils' personality, character and academic career and inspire them to be adorned with scientific temper. Basing on data collected from one hundred forty three students of secondary schools of Orissa, the study analyses the activities undertaken by secondary school students in learning bioscience concepts. It is found that 73 per cent of the sample students developed interest to know more about bioscience. They liked to complete home tasks, write essays, articles, reports and stories in the process of learning bioscience. But their participation in seminar, debate, group discussion, etc, were unsatisfactory, might be due to lack of opportunities. High percentages of sample students learn bioscience through reading text books, newspapers and teacher-notes. Moreover, they enrich their concepts by watching TV, pictures, discussing with classmates, drawing diagrams, doing charts and models, observing nature, etc. The students expressed that they would be benefited from learning the subject in various ways. The teachers need to encourage and engage the students in different activities to attain higher level of cognitive, affective and psychomotor objectives.

Introduction

For a learner, Biology plays a catalytic role to acquire a great deal of scientific knowledge from the surroundings. In present day school curriculum, Bioscience has gained prominence. The National Curriculum Frame work (NCF) for School Education: 2000 recommended both Science and Technology as one curricular subject because of the strong organic linkage between the two. So the students, at the secondary stage, must be made to understand and appreciate how

the basic principles are applied to finding solutions to the problems of agriculture, health, nutrition, genetic engineering, communication and environment. The NCF-2005 also recommended the science curriculum up to class X to be oriented more towards developing awareness among the learners about the interface of science, technology and society, sensitising them especially to the issues of environment and health and enabling them to acquire practical knowledge and skills to enter the world of work.

Hafstein (1982) of Weitzman Institute of Science and Lunetta (1982) of University of Iowa in their study *The Role of Laboratory In Science Teaching: Neglected Aspects of Research* expressed that the laboratory has been given a central and distinctive role in science education and have suggested that there are rich benefits in learning from using laboratory activities.

The development of adequate students' conceptions on nature of science has been a perennial objective of science instruction regardless of the currently advocated pedagogical or curricular emphases as expressed by Lenderman (1992). Batra and Batra (1996) had given importance that a beginner in the learning of science is taught by using easily available low cost materials. Ediger (1996) had given importance on individualised reading, listening in the science curriculum and speaking and writing activities in science.

Mohapatra (1989) concluded through his study that:

- The children made a great deal of conceptualisation on the basis of their observation of day-to-day happenings in the environment and in home situations. In this process they formulated alternative concepts about things, objects and events.
- The science teacher had an important role in helping the child to develop proper concepts about objects and events by utilising children's personal experiences with the rational thinking process.

Phalachandra's (1989) analysis showed that:

- Boys were achieving better than girls through activity approach in all four concepts, achievement tests, viz physical and chemical

change, composition of substances, plants growth and its process, animal parts and their functions.

- The relationship between intelligence and concept achievement was significant.
- There was significant and positive relationship between school environment and concept achievement.
- Higher the socio-economic status level, the higher would be the concept analysis.

Brahma Prakash's (1990) findings showed that the performance of students' learning by concretised instruction was better than those learning by traditional instruction.

The use of concrete materials such as charts, models, analogies, more lucid examples and other manipulable materials based on concrete thoughts and a specialised sequencing of instruction found to help the concrete level operators in understanding the formal level concepts more effectively.

All the studies discussed here show enhancement of learning facilities in science due to engagement of students in differential activities in different ways, thus creating better environment for higher learning achievement. It is with this background that a study on the process of teaching of Bioscience particularly in the context of the exposure of students to different activities in secondary schools in Orissa has been undertaken.

Objectives of the Study

- To study the activities undertaken by secondary school students to learn Bioscience concepts.

- To assess the impact of the activities in terms of students perception on Bioscience.

Delimitations of the Study

The study was conducted on students of Oriya medium secondary schools affiliated to Board of Secondary Education, Orissa in the high literate district of Khurda.

Plan and Procedure of the study

Sample

The sample for the study was drawn on the basis of stratified random sampling technique from secondary schools of Khurda, Orissa, based on the level of achievement of students in the Annual High School Certificate Examination, 2007 conducted by the Board of Secondary Education, Orissa. On the basis of scholastic achievement, sample of students were categorised under three levels for the purpose of the study:

- High Level schools with pass percentage of more than 80 per cent of students appeared.
- Average Level schools with pass percentage in between 40 per cent and 60 per cent of students appeared.
- Low Level schools with less than 30 per cent results.

Eleven high level schools, ten average level schools and ten low level schools were identified for the study.

Tool and its Administration

An interview schedule was developed for the students of sample schools to initiate a conversation with them. The schedule consisted

of 10 items comprising minute details of everyday life to elicit information regarding the scientific knowledge the students acquired from the school and the environment.

About 143 (60 boys and 83 girls) students of 31 schools were interviewed for elicitation of opinion on different activities undertaken and on possible benefit from studying Bioscience.

Analysis

Popularity of Bioscience Among Secondary School Students

Among the various scholastic subjects taught in high schools, it was revealed that Mathematics was the most liked subject of the sample students (50 per cent) followed by Bioscience (45 per cent) and Physical science (33 per cent).

Activities of Students to Learn Biological Science

The information elicited from the sample students regarding activities undertaken to learn Biological Science are consolidated in Table 1.

The table reveals that 77 to 90 per cent of sample students had undertaken activities like writing, reading, speaking, listening, observing and drawing diagrams in order to grasp concepts of Bioscience. Considering the locale of the schools, it was found that the students' participation was more in rural areas in writing and reading than in urban areas. About 75 per cent students got engaged in learning biology by watching TV, conducting experiments (45 per cent), collecting specimens (48 per cent), making charts and models (54 per cent), studying nature

Table 1: Students Learn Biological Science through Activities

Activity	High Level Schools	Average Level Schools	Low Level Schools	Urban Schools	Rural Schools	Total
	N=51	N=45	N=47	N=76	N=67	N=143
Write	37(73)	42(93)	39(83)	60(79)	58(87)	118(83)
Read	45(88)	41(91)	43(91)	66(87)	63(94)	129(90)
Speak	41(80)	40(89)	33(70)	64(84)	50(75)	114(80)
Listen	39(76)	42(93)	33(70)	61(80)	53(79)	114(80)
Observe	42(82)	35(78)	41(87)	64(84)	54(81)	118(83)
Drawing diagrams	35(69)	43(96)	32(68)	59(78)	51(76)	110(77)
Conduct experiment	21(41)	16(36)	27(57)	36(47)	28(42)	64(45)
Go for excursion	24(47)	25(56)	38(81)	45(59)	42(63)	87(61)
Discussion with friends	32(63)	29(64)	34(72)	50(66)	45(67)	95(66)
Make improvised apparatus	16(31)	22(49)	18(38)	29(38)	27(40)	56(39)
Discuss with elders	35(69)	25(56)	27(57)	50(66)	37(55)	87(61)
Watch TV	39(76)	36(80)	32(68)	62(82)	45(67)	107(75)
Collect specimen	20(39)	24(53)	25(53)	35(46)	34(51)	69(48)
Make chart and models	28(55)	24(53)	25(53)	43(57)	34(51)	77(54)
Preserve leaves, flowers and seed	21(41)	31(69)	30(64)	39(51)	43(64)	82(58)
Study nature	28(55)	27(60)	25(53)	44(58)	36(54)	80(56)

(Figures in parentheses indicate percentage of students)

(56 per cent), preserving leaves, flowers and seeds (58 per cent), discussing with elders (61 per cent) and friends (66 per cent) and participating in excursions (61 per cent) This indicates that sizeable percentage of students learn the subject being engaged in different types of activities.

Reading

Reading is one of the vital factors contributing a lot to master and succeed in a subject. There are numerous kinds of subject matters for learners to

read, factual as well as fictional in ongoing bioscience units of study. Reading of additional materials besides textbook adds advantage to have clear concepts in Biological science. The information regarding learning bioscience by reading as elicited from the sample students are furnished in Table 2.

The table displays that large numbers of sample students learnt bioscience by reading text books (83 per cent), news papers (79 per cent) and teacher notes (69 per cent). A larger section from

Table 2: Students Learn Biological Science by Reading

Items	High Level Schools	Average Level Schools	Low Level Schools	Urban Schools	Rural Schools	Total
	N=51	N=45	N=47	N=76	N=67	N=143
Stories	23(45)	16(36)	24(51)	40(53)	23(34)	63(44)
Poems	11(22)	16(36)	19(40)	25(33)	21(31)	46(32)
Textbook	39(76)	41(91)	39(83)	61(80)	58(87)	119(83)
Newspaper	43(84)	35(78)	35(74)	63(83)	50(75)	113(79)
Magazine	25(49)	21(47)	16(34)	35(46)	27(40)	62(43)
Teacher notes	36(71)	32(71)	31(66)	52(68)	47(70)	99(69)
Essay	22(43)	21(47)	25(53)	42(55)	26(39)	68(47)
One act play	17(33)	14(31)	8(17)	24(32)	15(22)	39(27)
Biographies	18(35)	9(20)	4(9)	23(30)	8(12)	31(21)

(Figures in parentheses indicate percentage of students)

high level schools were engaged in reading newspapers, magazines and biographies of biologists than those from average and low level schools. When locale is considered, the urban students were ahead of the rural students in reading stories, news papers, magazines, essays, one act plays and biographies; might be due to easy availability of facilities and conducive environment.

Listening

Listening also plays a vital role for conceptual clarity of learners. The students augmented learning in bioscience by listening to different sources. The sources have been indicated in Table 3.

The table shows that vast majority of the sample students, in general, learnt bioscience by listening to teachers (86 per cent), class mates (73 per cent) and listening to tape recorder was resorted to moderately (47 per cent).

Writing

Writing is one of the generalised skills and key factors affecting success in a subject. Different activities related to writing undertaken by students are presented in Table 4.

The table indicates that majority of students (74 per cent) of all categories of schools chose home task as the most dependable activity for learning bioscience and they liked to participate more or less on activities like writing essays, articles, small poems, stories and preparing reports on current issues in areas related to Bioscience.

Speaking

A variety of richly spoken experiences were available to pupils in schools to achieve quality communication through bioscience. The participation of students in different speaking activities are consolidated in Table 5.

Table 3: Students Learn Biological Science by Listening

Sources	High Level Schools	Average Level Schools	Low Level Schools	Urban Schools	Rural Schools	Total
	N=51	N=45	N=47	N=76	N=67	N=143
Teachers	43(84)	38(84)	42(89)	64(84)	59(88)	123(86)
Classmates	35(69)	34(75)	36(77)	57(75)	48(72)	105(73)
Tape recorder	25(49)	24(53)	19(40)	44(58)	24(36)	68(47)
Radios	8(16)	12(27)	9(19)	16(21)	13(19)	29(20)

(Figures in parentheses indicate percentage of students)

Table 4: Students' Writing Activity for Better Learning of Biological Science

Writing Activities	High Level Schools	Average Level Schools	Low Level Schools	Urban Schools	Rural Schools	Total
	N=51	N=45	N=47	N=76	N=67	N=143
Essay	12(24)	15(33)	21(45)	30(39)	18(27)	48(34)
Article	13(25)	25(56)	20(43)	24(32)	34(51)	58(41)
Poem	6(12)	10(22)	12(26)	14(18)	14(21)	28(20)
Report	16(31)	5(11)	3(6)	19(25)	5(7)	24(17)
Home task	34(67)	37(82)	35(74)	55(72)	51(76)	106(74)
Story	12(24)	18(40)	18(38)	30(40)	18(27)	48(34)

(Figures in parentheses indicate percentage of students)

Table 5: Students' Participation in Speaking Activities in Bioscience

Activities	High Level Schools	Average Level Schools	Low Level Schools	Urban Schools	Rural Schools	Total
	N=51	N=45	N=47	N=76	N=67	N=143
Seminars	14(27)	Nil	3(9)	16(21)	1(2)	17(12)
Debate	23(45)	25(56)	14(30)	38(50)	24(36)	62(43)
Group discussion	17(33)	29(64)	18(38)	30(39)	34(51)	64(45)
Exhibition/Fair	25(49)	26(58)	15(32)	37(49)	29(43)	66(46)

(Figures in parentheses indicate percentage of students)

The table shows that participation of students of average level schools was better in group discussions and science exhibitions/fairs and in urban schools it was more in debates, seminars and exhibitions/fairs than rural schools apparently for availability of more activity related facilities.

Observing

Observation is the foundational process skill to learn and systematic observation facilitates easier learning of bioscience concepts. Various media of observation resorted by the students are reflected in Table 6.

Table 6 indicates that 61 to 72 per cent students, in general, learnt by seeing pictures, charts, diagrams, nature, models and films. More students of low level schools learnt by observing films (74 per cent), diagrams (70 per cent) and

nature (87 per cent). Observation technique was least followed by students of high level schools except through internet, slides, models and specimen as compared to other types of schools, might be due to undergoing comparatively more stress for reading to secure higher score in the examination from parents and teachers, as a result they preferred not to utilise more time in observing the related phenomena. The students of low level schools could not afford to observe through internet, slides, models and specimen as these were not easily available in the school system.

Students' Perception on Possible Benefits from Bioscience

Examples are ample how science and technology has improved the quality of life. High quality

Table 6: Students Learn Bioscience by Observing

Medium of Observation	High Level Schools	Average Level Schools	Low Level Schools	Urban Schools	Rural Schools	Total
	N=51	N=45	N=47	N=76	N=67	N=143
Essay	12(24)	15(33)	21(45)	30(39)	18(27)	48(34)
Internet	11(22)	11(24)	4(9)	16(21)	10(15)	26(18)
Pictures	30(59)	38(84)	35(74)	52(68)	51(76)	103(72)
Films	27(53)	25(56)	35(74)	49(64)	38(57)	87(61)
Slides	20(39)	12(27)	11(23)	25(33)	18(27)	43(30)
Photographs	28(55)	29(64)	28(60)	50(66)	35(52)	85(59)
Charts	33(65)	33(73)	31(66)	47(62)	50(75)	97(68)
Models	38(75)	36(80)	21(45)	49(64)	46(69)	95(66)
Specimens	27(53)	10(22)	18(38)	43(57)	12(18)	55(38)
Diagrams	34(67)	30(67)	33(70)	51(67)	46(69)	97(68)
Nature	28(55)	27(60)	41(87)	47(62)	49(73)	96(67)
Map	25(49)	30(67)	16(34)	40(53)	31(46)	71(50)

(Figures in parentheses indicate percentage of students)

Biological Science Education is the need of the day for a healthy society. The sample students perceived benefits from studying bioscience in different ways and their perceptions about various benefits that can be derived from learning bioscience are furnished in Tables 7, 8 and 9.

Perusal of the Table 7 and 8 shows that a large percentage of sample students perceived the possible benefits from studying biology, as to develop a comprehensive knowledge of bioscience (75 per cent), develop interest and appreciation of nature and environment

Table 7: Assumptions of Students for Possible Benefits from Studying Biological Science

Benefits	High Level Schools	Average Level Schools	Low Level Schools	Urban Schools	Rural Schools	Total
	N=51	N=45	N=47	N=76	N=67	N=143
A comprehensive knowledge of bioscience	39(76)	35(78)	33(70)	58(76)	49(73)	107(75)
Develop skill & abilities to understand and utilise the processes procedures in study of bioscience	35(69)	36(80)	32(68)	52(68)	51(76)	103(72)
Develop interest and appreciation of nature and environment	36(71)	37(82)	33(70)	56(74)	50(75)	106(74)
Training in scientific attitude	38(75)	32(71)	28(60)	56(74)	42(63)	98(69)
Training in scientific method	24(47)	25(56)	25(53)	34(45)	40(60)	74(52)
Helping in career development	28(55)	30(67)	30(64)	46(61)	42(63)	88(62)

(Figures in parentheses indicate percentage of students)

Table 8: Assumptions of Students for Possible Scholastic Benefits from Studying Biological Science

Scholastic benefit	High Level Schools	Average Level Schools	Low Level Schools	Urban Schools	Rural Schools	Total
	N=51	N=45	N=47	N=76	N=67	N=143
Enhance creativity	28(55)	29(64)	22(47)	37(49)	42(63)	79(55)
Problem solving	29(57)	33(73)	30(64)	43(57)	49(73)	92(65)
Make decision	23(45)	33(73)	28(60)	31(41)	53(79)	84(59)
Utilise the leisure properly	23(45)	35(78)	19(40)	30(39)	47(70)	77(54)
Understand nature	36(71)	29(64)	32(68)	53(70)	44(66)	97(68)

(Figures in parentheses indicate percentage of students)

Table 9: Students' Assumptions of Possible Affective Benefit from Studying Biological Science

Affective benefit	High Level Schools	Average Level Schools	Low Level Schools	Urban Schools	Rural Schools	Total
	N=51	N=45	N=47	N=76	N=67	N=143
Appreciation of boon of bioscience	49(96)	40(89)	38(81)	69(91)	58(87)	127(89)
Liking plants and animals	51(100)	44(98)	43(91)	74(97)	64(96)	138(97)
Liking truth	51(100)	44(98)	43(91)	74(97)	64(96)	138(97)
Willingness to doexperiment	44(86)	42(93)	33(70)	60(79)	59(88)	119(83)
Believing any thing with rectification	45(88)	44(98)	35(74)	64(84)	60(90)	124(87)
Appreciation of the work of Biologists	45(88)	43(96)	38(81)	65(86)	61(91)	126(88)
Adopting the conditions essential for maintaining good health	46(90)	44(98)	42(89)	68(89)	64(96)	132(92)
Developing beliefs of food deficiency Diseases of human beings	48(94)	43(96)	43(91)	71(93)	63(94)	134(94)
Adoptingthe methods to check the Pollutions	45(88)	43(96)	33(70)	59(78)	62(93)	121(85)
Participation in Group activity	45(88)	42(93)	27(57)	59(78)	55(82)	114(80)

(Figures in parentheses indicate percentage of students)

(74 per cent) and to develop skills and abilities to understand and utilise the process and procedures in studying bioscience (72 per cent). Assumptions in respect of other benefits were equally remarkable (52 to 69 per cent).

Perusal of Table 9 reveals that the sample students (80 to 97 per cent) of all types of schools had affective assumptions of higher level benefit from studying bioscience against all the aspects.

Conclusion

To the tune of 73 per cent of the sample students were desirous to know more about bioscience.

They liked to complete home task, write essays, articles, small poems, stories and preparing reports in the process of learning bioscience. But their participation in seminar, debate, group discussion, etc. was unsatisfactory, might be due to lack of opportunities. High percentage of sample students learnt bioscience by reading text books, news papers, teacher- notes, watching TV, pictures, listening to teachers and classmates, drawing diagrams, doing charts and models, observing nature, etc.

Various co-scholastic activities undertaken for effective bioscience learning facilitated easier and comprehensive learning of intricate concepts and

generated likingness and interest for the subject among the students. A good majority of the students appreciated the advantages of learning bioscience for maintaining good health, checking pollution and training in scientific attitude, method and temper. Above all they felt like enhancing higher mental process such as creativity, problem solving and shaping life and career etc. A strong impact of activity based

learning bioscience is visible from the perceptions of 52 to 97 per cent students on benefits from studying bioscience in different aspects necessary for good life and developing career, Thus, in the process of learning bioscience content, learners must be encouraged in different activities so as to develop scientific attitude and in long run the scientific temper.

References

- BATRA, B., and K. BATRA. 1996. *Teaching Science through Low-cost Apparatus at Primary Level*, *School Science*, 34(2) 47-56.
- BRAHMA, PRAKASH. 1990. *Effectiveness of Concrete Materials to Enhance Learning in Physical Science*. Independent Study. National Institute of Educational Planning and Administration, New Delhi.
- EDIGER, M. 1996. Reading in Science, *School Science*, 34(3), 50-56.
- HOFSTEIN, A., and V. N. LUNETTA. 1982. The Role of Laboratory in Science Teaching: Neglected Aspects of Research. *Review of Educational Research*, 52(2), 201-217.
- LENDERMAN, NORMAN. G. 1992. Students' and Teachers' Conceptions of Nature of Science: A Review of the Research. *Journal of Research in Science Teaching*, 29(4), 331-359.
- MOHAPATRA, J. K. 1989. Four Dimensions of the Teaching-Learning of Science: Characteristics and Implications. *Indian Educational Review*, Vol 24(3), 1-17.
- National Curriculum Framework for School Education- 2000*, NCERT, New Delhi.
- National Curriculum Framework-2005*, NCERT, New Delhi.
- PHALACHANDRA, B. 1989. An Analytical Study of Some Correlates in the Acquisition of Science Concepts in School Children. *Fifth Survey of Educational Research-1988-92*, Vol. II, p.1255, NCERT, New Delhi.

PROJECTILE MOTION OF CRICKET BALL : CAUGHT OUT OF A BATSMAN IN CRICKET GAME

S. N. Maitra

303, Elite Galaxy, Ramnagar Colony, NDA-Pashan Road, Bhavdhan, Pune

In a cricket game let the ball hit by a batsman be in flight. A fielder runs to catch the ball to render him caught out. In this article we depict a model involving projectile motion of the ball to effect caught out and as such an example is cited.



Introduction

Author (S. N. Maitra) in his earlier paper demonstrated projectile motion and elastic collision of the ball, thrown by a bowler, with the pitch before its striking the wicket escaping the batsman's stroke. Here the batsman in an attempt to strike boundary or over boundary lifts the ball in the air. Unfortunately for the batsman, a fielder runs and catches the ball to make him caught out. The projectile motion of the ball vis-a-vis the fielder's running speed to reach the spot for catching the ball are dealt with neglecting the air resistance to the motion of the ball.

Formation of Model 1

Let us consider a system of axes XOY with the origin O at the position of the batsman. The batsman hits the ball thrown by the bowler. The x-axis is taken as the line of intersection of the field and the vertical plane of flight of the ball, obviously passing through the position of the

batsman at the time of hitting the ball; the y-axis is perpendicular to the x-axis and lies on the ground with reference to an observer behind the wicket and wicket keeper. A fielder runs and catches the ball in air. This is illustrated in Figures 1 and 2.

Solution to projectile motion of the ball for caughtout

Let the batsman hit the ball with a velocity x at an angle α to the horizontal, while the position of the concerned fielder is (a, b) with reference to the foregoing co-ordinate axes XOY. After time t_1 of the ball leaving the bat the fielder starts running with a speed v in a straight path and catches the ball in flight at height h from a horizontal line passing through the point of contact between the ball and the bat, which is obviously vertically above O approximately.

If t be the time taken by the ball to reach that height h then the fielder reaches the spot to catch

the ball in time $(t - t_1)$. If the man runs with uniform speed v and is able to catch the ball then considering the vertical and horizontal motion of the ball, one gets

$$h = (u \sin \alpha) t - \frac{1}{2} g t^2 \quad (1)$$

$$s = (u \cos \alpha) t \quad (2)$$

where s is the horizontal distance described by the ball. Since the distance travelled by the fielder is that between the position $(s, 0)$ and (a, b) , we have

$$v(t - t_1) = \sqrt{(a - s)^2 + b^2} \quad \{\text{By use of (2)}\}$$

$$t_1 = t - \sqrt{(a - u \cos \alpha)^2 + b^2} / v \quad (3)$$

Solving the quadratic equation (1) we find the time taken to reach height.

$$t = \frac{u \sin \alpha}{g} + \sqrt{\left(\frac{u \sin \alpha}{g}\right)^2 - \frac{2h}{g}} \quad (4)$$

which is in fact the time taken by the ball to reach the fielder's hand (after attaining the maximum height) while moving downwards. The fielder should start running to catch the ball making an angle λ (obtainable by use of cosine formula) with the line of sight of the batsman :

$$\cos \lambda = \frac{(a^2 + b^2) + \{b^2 + (a - ut \cos \alpha)^2\} - (ut \cos \alpha)^2}{2\sqrt{a^2 + b^2} \cdot \sqrt{b^2 + (a - ut \cos \alpha)^2}}$$

$$\text{or } \cos \lambda = \frac{a^2 + b^2 - aut \cos \alpha}{\sqrt{(a^2 + b^2)(a^2 + b^2 + u^2 t^2 \cos^2 \alpha - 2aut \cos \alpha)}}$$

where t is given by (4). However equation (3) reveals that the fielder should reach the spot in time $t_2 \leq (t - t_1)$ to catch the ball, whereas $u \sin \alpha$ or $u \cos \alpha$ increases as t increases, which suggests that the ball can travel greater horizontal distance beyond the reach of a fielder leading to boundary/over boundary. Further there exists a minimum velocity of projection of the ball to the point (s, h) with an optimum angle of projection, which is studied in chapter 'projectile motion' of almost all textbooks' of dynamics.

Now, it is upto the readers comprising students and teachers and others to seek for any other model on this subject.

Numerical example

Let us suppose :

Fielding position of the fielder with reference to the foregoing coordinate system of axes is $(67.6, 15.6)$ in metres, i.e. $a = 67.6$ metre, $b = 15.6$ metre $g =$ acceleration due to gravity $= 10$ metre/second².

The fielder is observed to start running one second after the ball, being hit by the batsman, leaves the bat and he runs for two seconds through a straight time path with a uniform speed before he catches the ball at height 2.5 metre above the ground at spot B $(62.4, 0)$, i.e. $s = 62.4$ metre whereas the batsman strikes the ball when it is at a height 0.7 m from the pitch such that $h = 2.5 = 0.7 = 1.8$ m. Radius of the cricket play ground is about 75 m (vide website on the subject).

Now an attempt has been made to find the speed and the direction with which the ball leaves the bat due to stroke by the batsman as well as the speed

and direction of the fielder's running with a view to catch the ball. In the light of the above delineation, the time of flight of ball leading to caught out of the batsman is

$t = 3\text{ s}$, $t_1 = 1\text{ s}$, $h = 2.5 - 0.7 = 1.8\text{ m}$. Then by use of (1) and (2), one gets

$$1.8 = (u \sin \alpha) \times 3 - \frac{1}{2} \times 10 (3)^2$$

$$\text{or, } \sin \alpha = 15.6 \quad (6)$$

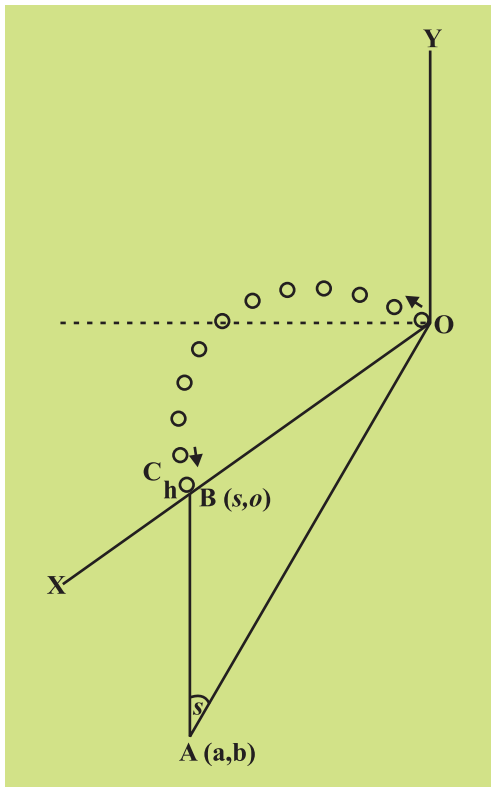


Fig. 1: The fielder runs from position A to B to catch the ball hit by the batsman at position O, the ball thus lifted in the air reaches the point C at height h and is caught by the fielder.

$$\text{and } 62.4 = 3 (u \cos \alpha)$$

$$\text{or, } u \cos \alpha = 20.8 \quad (7)$$

$$\text{or, } u \cos \alpha = 20.8$$

Squaring and adding (6) and (7)

$$u^2 = (15.6)^2 + (20.8)^2 = 262$$

$$u = 26\text{ m/s i.e. } u = 93.6\text{ km/h} \quad (8)$$

Dividing (6) by (7) one gets

$$\tan \alpha = \frac{3}{4} \text{ i.e. } \sin \alpha = \frac{3}{5}, \cos \alpha = \frac{4}{5} \quad (9)$$

Hence after being hit by the batsman, the ball

leaves the bat at an angle $\tan^{-1} \frac{3}{4}$ i.e. $36^\circ 54'$ to the

horizontal. In consequence of (3) we get the running speed of the fielder,

$$v(3-1) = \sqrt{(67.6-62.4)^2 + (15.6)^2} = \frac{26}{3} \sqrt{3} = 16.44$$

$$\text{or, } v = 8.22\text{ m/s i.e. } 29.6\text{ km/h.} \quad (10)$$

Finally the angle between the straight line path of the fielder (to catch the ball) and his line of sight of the batsman at the origin O is obtained because of (5), (8) and (9);

$$\cos \lambda = \frac{(67.6)^2 + (15.6)^2 - (67.6)(26) \times 3 \times 0.8}{\sqrt{\{(67.6)^2 + (15.6)^2\}\{(15.6)^2 + (67.6-26 \times 3 \times 0.8)^2\}}}$$

$$= \frac{178-156}{\sqrt{178 \times 10}} = \frac{22}{42.2} = 0.5213$$

$$\text{or, } \lambda = 31^\circ 24' \quad (11)$$

If the fielder fails to reach the spot in time to catch the ball, it would fall on the ground after time t_2 at distance x_2 from the batsman :

$$x_2 = (u \cos \alpha)t_2 - \frac{1}{2}gt_2^2 = -0.7$$

which gives $t_2 = 1.56 + \sqrt{(1.56)^2 + .1400} = 3.2$;

and $x_2 = 66.58$ m

The stationary position of the fielder is

$$\sqrt{(67.6)^2 + (15.6)^2} = 69.38\text{m}$$

Hence this example shows that the fielder skillfully catches the ball (when it is about to strike the ground) by jumping or stretching/raising his hands to a height 2.5 m. This happens near the boundary line as is evident from the above data.

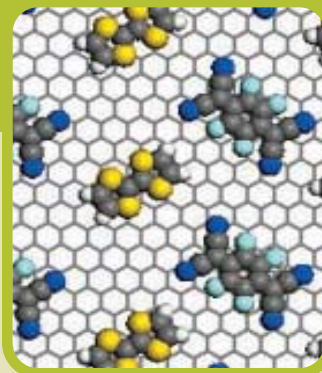


Fig. 2: The fielder catches the ball, hit and lifted in air by the batsman

GRAPHENE— A TWO-DIMENSIONAL MOLECULAR FORM OF CARBON

P.K. Mukherjee

*43, Deshbandhu society
15, Patparganj, Delhi*



Diamond and graphite have been known to be the only two allotropes of carbon till fullerenes or bucky balls, molecules of carbon in the shape of soccer balls, were discovered in 1985 by Robert Curl, Harold Kroto and Richard Smalley. In 1991, carbon nanotubes, which are hollow cylindrical structures made of carbon atoms, were discovered by Sumio Iijima of Japan. While diamond and graphite are three-dimensional molecular forms of carbon, fullerenes and nanotubes are respectively its zero-dimensional and one-dimensional forms.

However, two-dimensional molecular forms of carbon were unknown till 2004 when a group of physicists from Manchester University, UK led by Andre Geim and Kostya Novoselov of Institute for Micro electronics Technology, Chernogolovka, Russia reported discovery of graphene in the journal Science. Starting with three-dimensional graphite, the team of scientists at Manchester University extracted a single sheet (a monolayer of atoms) by using a technique called

'micromechanical cleavage.' Generally, two-dimensional atomic crystals are not stable but the two-dimensional form of carbon made by the Manchester team was found to be quite stable.

In fact, graphene is a one-atom-thick sheet of carbon that looks like a molecular chicken wire. It is the thinnest of all possible materials in the universe. It shows many of the properties that excited physicists about nanotubes (which may be considered to be rolled-up graphene) a decade ago. But, it is easier to make and manipulate giving greater hope that graphene will make the move from laboratory to practical application.

Physicists at the University of California, Riverside, USA have demonstrated that when the electrons flowing in graphene interact with the honeycomb chicken-wire structure, they behave like quasi-particles that have lost their rest mass or as neutrinos that acquired the electronic charge. Thus, in graphene electrons behave as if they have no mass, always travelling at the same speed

regardless of their energy, like photons or particles of light.

It was also found that in graphene, electrons travel much faster than electrons in other semiconductors. The finding makes graphene an excellent electronic material that could be used in place of silicon for making ultrafast and stable transistors.

Electrons in graphene can roam about freely across the sheet of carbon as they encounter no obstacles. Therefore, they can conduct electric charge with extremely low resistance. Physicists have already proposed taking advantage of such novel properties of graphene in a new type of electronics which they call valleytronics.

Graphene exhibits another astonishing behaviour, namely, quantum Hall effect at room temperature. Usually, this effect is observed at extremely low temperatures, typically below -243°C . The phenomenon of quantum hall effect at room temperature exhibited by graphene opens up new vistas for graphene-based resistance standards and quantum devices.

Graphene also exhibits far better thermal conductivity than carbon nanotubes. Thermal conductivity defines how well a given material conducts heat. It has been found that, at room

temperature, graphene has thermal conductivity which, as compared to carbon nanotubes, is greater by a factor of about 35. The high thermal conductivity of graphene makes it a suitable material for making high speed computer processors as electrons move through graphene with almost no resistance, generating little heat. This can indeed be a great advantage over conventional silicon-based processors that are known to suffer from the problem of overheating thereby putting a limit on their processing speed.

Physicists have been able to make transistors out of graphene. In 2006, researchers at the Georgia Institute of Technology, USA in collaboration with the Centre National de la Recherche Scientifique (CNRS) in France announced the production of experimental transistors using graphene. In a recent development, IBM researchers found that by placing two layers of graphene on top of each other, they could reduce the electrical noise by a factor of 10.

However, many obstacles still remain that need to be overcome before graphene's full potential can be utilised. According to researchers, if better lithograph methods are developed to pattern graphene sheets into narrow ribbons and circuits, this could provide a reliable way of making complex graphene-based electronics.

SCIENCE NEWS



Breakdown in Planck's Law!

A well-established physical law describes the transfer of heat between two objects, but some physicists have long predicted that the law should break down when the objects are very close together. Scientists had never been able to confirm, or measure, this breakdown in practice. For the first time, however, Gang Chen, MIT's Carl Richard Soderberg, Professor of Power Engineering and Director of the Pappalardo Micro and Nano Engineering Laboratories with a team of researchers have achieved this feat, and determined that the heat transfer can be 1,000 times greater than the law predicts.

The new findings could lead to significant new applications, including better design of the recording heads of the hard disks used for computer data storage, and new kinds of devices for harvesting energy from heat that would otherwise be wasted.

Planck's blackbody radiation law, formulated in 1900 by German physicist Max Planck, describes how energy is dissipated, in the form of different wavelengths of radiation, from an idealised non-reflective black object, called a black body. The law says that the relative thermal emission of radiation at different wavelengths follows a precise pattern that varies according to the temperature of the object. The emission from a black body is usually considered as the maximum that an object can radiate.

The law works reliably in most cases, but Planck himself had suggested that when objects are very close together, the predictions of his law would break down. But actually controlling objects to maintain the tiny separations required to demonstrating this phenomenon has proved incredibly difficult. Planck was very careful, when he said that his theory was only valid for large systems. Part of the problem in measuring the way energy is radiated when objects are very close

is the mechanical difficulty of maintaining two objects in very close proximity, without letting them actually touch.

Chen and his team, graduate student Sheng Shen and Columbia University Professor Arvind Narayanswamy, solved this problem in two ways, first, instead of using two flat surfaces and trying to maintain a tiny gap between them, they used a flat surface next to a small round glass bead, whose position is easier to control. According to researchers if they had used two parallel surfaces, it would have been very hard to maintain nanometre separation without some parts touching each other, but by using a bead it was much easier to maintain distance as there is just a single point of near-contact. To measure the temperature changes with great precision, they used the technology of the bi-metallic cantilever from an atomic-force microscope.

They have been trying for many years with parallel plates, but without success as they were unable to sustain separations of closer than about a micron (one millionth of a metre). By using the glass (silica) beads, they were able to get separations as small as 10 nanometres and are now working on getting even closer spacings. These experiments provide a beautiful solution to this difficulty and confirm the dominant contribution of near field effects to heat transfer.

In present day magnetic data recording systems such as the hard disks used in computers, the spacing between the recording head and the disk surface is typically in the 5 to 6 nanometre range. The head tends to heat up affecting the quality and researchers, therefore, have been looking for ways to manage the heat or even exploit the heating to

control the gap. Such applications could be developed quite rapidly and some companies have already shown a strong interest in this work.

According to Chen, the new findings could also help in the development of new photovoltaic energy conversion devices to harness photons emitted by a heat source, called thermophotovoltaic. The high photon flux can potentially enable higher efficiency and energy density thermophotovoltaic energy converters, and new energy conversion devices. In addition to practical applications such experiments might provide a useful tool to understand some basic physics.

(Source: *Science Daily Online*)

Brain Surgery with Sound

Neurosurgeons might soon be able to say goodbye to the scalpel. A new technique has been developed by a team of researchers led by Neal Kassell, a neurosurgeon at University of Virginia that uses ultrasound waves to remove parts of the brain. The high intensity ultrasound waves to be used for brain surgery are of different type than those that are used in ultrasound imaging, say for prenatal screening. In the new technique the high intensity ultrasound waves heats up parts of the brain, thereby killing sections of tissue that are damaged. According to a preliminary study done in Switzerland, focussed ultrasound surgery has now been performed successfully on nine human patients. According to Kassell the groundbreaking finding of the new technique is that one can make lesions deep in the brain through the intact skull and skin with extreme precision, accuracy and safety.

The Swiss study tested the technique on nine patients with chronic debilitating pain. The traditional treatment involves destroying a small part of the thalamus, a structure that relays messages between different areas of brain. In the past, this has been accomplished with radio frequency ablation, in which a probe is inserted into the skull, or with radio surgery which focuses radiation on the area. Surgeons believe that the new technique will be faster acting and more precise than the current methods.

In the procedure, ultrasound beams are focused on a specific point in the brain; the exact location depends on the condition being treated. The small portion of brain tissue at the focus (about the size of a rice grain) absorbs the energy and converts it to heat; the temperature in this area rises to about 54 °C (130° Fahrenheit), killing the cells. The entire system is integrated with a magnetic resonance scanner, which allows neurosurgeons to make sure they target the correct piece of brain tissue.

The patients get relieve from pain soon after the procedure, and could begin their normal work soon afterward. Ultrasound could also potentially be used to treat other brain disorders, such as Parkinson's disease. Thirty years ago, this kind of technique was science fiction; today, it is science fact.

(Source: *Science Daily Online*)

DNA 'barcodes' for Cataloguing Plants

An international team of scientists, including botanists from the University of Toronto, has identified a pair of genes which can be used to

catalogue the world's plants using a method known as DNA barcoding. According to Spencer Barrett, a Professor of Ecology and Evolutionary Biology at University of Toronto and the head of the Canadian plant barcoding working group, barcoding provide an efficient means by which we can discover many undescribed species that exist on earth. DNA barcoding is a rapid and automated classification method that uses a short genetic marker in an organism's DNA to identify it as belonging to a particular species. This discovery is important because understanding biodiversity is crucial to long-term human existence on the planet.

DNA barcoding has been widely used to identify animal species since its invention five years ago. But, its use for plants was delayed because of the complex nature of plant genetics and disagreements over the appropriate DNA regions to use. Scientists in order to evolve a unique system for DNA barcoding of plants compared the performance of the seven leading candidate gene regions against three criteria: ease of obtaining DNA sequences; quality of the DNA sequences; and ability to tell species apart based on a sample of 550 species of land plants. Based on this global analysis, they recommended the two chloroplast genes **matK** and **rbcl** which are adopted as the DNA barcode for land plants.

The primary application of the methodology will be the identification of the many species in the world's biodiversity hotspots where a shortage of specialists hinders conservation efforts. Other applications include to identify illegal trade in endangered species, identify invasive organisms, poisonous species and also in fragmentary material in forensic investigations.

The technique will work on minute amounts of tissue and can be used on fragments of plant material, small seedlings, and in some cases digested or processed samples. The methodology will also be used immediately in global projects such as Tree BOL, which aims to build the DNA barcode database for all the species of trees of the world many of which are of economic and conservation importance.

(Source: *Science Daily Online*)

Genetic Diversity of Rice Unlocked

By looking at what different types of rice have in common, a team of international scientists have succeeded in unlocking genetic diversity in rice to help conserve it and find valuable rice genes to help improve rice production.

Rice is the world's most important food crop. Understanding its valuable genetic diversity and using it to breed new rice varieties will provide the foundation for improving rice production into the future and to ensure global food security. An international research team scrutinized the genomes of twenty different types of genetically diverse rice that are used in international breeding with a wide range of different characteristics. Dr. Ken McNally at International Rice Research Institute (IRRI), Philippines, searched for snippets of DNA that distinguish each type of rice. If the rice types share a favourable trait, like drought tolerance, high yield, or even desirable cooking quality characteristics, they are likely to also share the same DNA variation responsible for that trait.

Rice contains tens of thousands of genes, so finding a successful way to hunt through them all

is a major breakthrough. International Rice Gene Bank contained over 109,000 types of rice, yet relatively few have been used in breeding programs. According to Dr Robert Zeigler, Director General of IRRI, if breeders know more about the genetic makeup of rice, they can use it more effectively. As they face more erratic changes in climate, they will increasingly rely on using the untapped diversity of rice to develop new and improved rice varieties.

The comprehensive SNP information is enabling the exploration of rice diversity not only for understanding how genes function in a growing and developing plant, but also for improving important rice traits related to disease resistance, drought tolerance, increased productivity, and human health benefits. This work sets the stage for the next phase of unlocking the treasure trove of genetic diversity available at IRRI and other centres for rice breeding.

(Source: *Science Daily Online*)

How to Manage Dental Erosion Caused by Everyday Beverages

Researchers have warned people to be aware of the damage that acidic beverages have on their teeth. Yet, for some, the damage and problems associated with drinking sodas, citric juices or certain tea may have already begun to take effect.

A recent study conducted by Mohamed A. Bassiouny, DMD, M. Sc., PhD, provides details about the acidic content of a variety of beverages, such as soda; lemon, grape fruit and orange juice; green and black tea; besides recommending three steps to rehabilitate teeth that suffer from dental

erosion as a result of the excessive consumption of these products.

According to Dr Bassiouny, Dental erosion is a demineralisation process that affects hard dental tissues (such as enamel and dentin). This process causes tooth structure to wear away due to the effects that acid has on teeth, which eventually leads to their breakdown. It can be triggered by consumption of carbonated beverages or citric juices with a low potential of hydrogen (pH), which measures the acidity of a substance. Excessive consumption of the acidic beverages over a prolonged period of time may pose a risk factor for dental health. He suggests that those who are experiencing tooth erosion to first identify the culprit source of erosion, possibly with the help of a dental professional. Then, the individual should determine and understand how this source affects the teeth in order to implement measures to control and prevent further damage. Lastly, the person should stop or reduce the intake of damage causing beverage(s).

(Source: *Science Daily Online*)

Some Innovative Ideas for Sustainable Agriculture

Advances in ecology increasingly reveal that conventional agricultural practices have detrimental effects on the landscape ecology, creating problems for long-term sustainability of crops. Some of the recent studies that support this view are being presented, in brief, to bring home the idea.

Perennial plants produce more; require less input than annual croplands

The major crops used globally to feed people and livestock are wheat, rice, maize and soy which are based on an annual system, in which crop plants live for one year, are harvested, and are replanted the following year. These systems, however, draw heavily from organic nutrients of soil over a period of time.

Perennial systems, on the other hand, contain plants that live longer than one year despite being harvested annually. An agricultural scientist, Jerry Glover of The Land Institute, Kansas, USA, firmly believes that perennial crops are the key to creating more sustainable agricultural systems.

To compare the long-term sustainability of these two cropping systems, Glover and his colleagues conducted a study on the physical, biological and chemical differences between annual wheat fields and perennial grass fields in Kansas. Both types of fields had been harvested annually for the past 75 years.

In each test, the researchers found perennial fields to be healthier and having more sustainable ecosystems. In the perennial fields, the plants' total root mass was more than seven times that of the annuals, and the roots infiltrated about a foot deeper into the ground. The perennial fields also had higher soil microbe biodiversity and higher levels of dissolved carbon and nitrogen in the soil. All these findings, according to researchers, suggested that the perennial field soil is healthy enough to maintain high levels of organic nutrients.

Create habitat for natural pest enemies

Farmers spend a lot of money on pesticides to kill crop-eating insects. But in nature there are organisms who feed on these insects, that is, they

are natural pest enemies. Researchers are now investigating what farmers can do to encourage the proliferation of these pest-eaters. One study showed that increasing the natural habitat in and around agricultural farms can boost populations of pests' natural enemies.

Rebecca Chaplin-Kramer at University of California, Berkeley surveyed the abundance of flies, ladybugs, wasps and other predators of a common agricultural pest, the cabbage aphid, in croplands ranging from 2 per cent to about 80 per cent natural vegetation. She found that as the proportion of natural area or complexity increased, so did the numbers of natural enemies in the croplands.

She also showed that increase in number of predators did not always result in fewer aphids in the croplands. However, according to her the agents of control, i.e. natural pest enemies, constitute only half of the equation and sources of the pests themselves must also be considered. In the absence of predators, pest levels would likely rise even more dramatically.

Pesticides are a short term solution, because pests can build up resistance, and new pesticides are constantly being developed. Building up predator communities takes time, but the systems are more stable and will provide more ecosystem services in the long term.

Reduced tilling improves soil microbe biodiversity

The idea of using biological instead of chemical methods to create healthy croplands does not include just above-ground approaches. Soil bacteria can affect the growth and success of crop plants by fixing nitrogen, aiding in the uptake

of nutrients and decomposing dead organic matter. Some current farming practices, however, may disrupt the soil ecosystem and decrease the effectiveness of the microbe community.

Shashi Kumar from Texas Tech University while exploring the relationship between conventional tilling and low-tilling practices on farms in semi-arid areas of west Texas has found a higher diversity of soil bacteria in the areas where soil tilling was kept at a minimum while conventional tilling produces lower bacterial diversity. According to Kumar conventional tillage systems disrupt soil particles and decrease soil pore size, which can lead to decreased water and soil access for microbes. Although he recognizes that tillage is necessary, he thinks that farmers can reduce their tillage, even in semi-arid regions, to promote soil bacterial biodiversity.

(Source: *Science Daily Online*)

Harnessing Wave Power with New 'Oyster' Machine

A giant new machine called 'Oyster' designed to harness the power of ocean waves and turn it into 'green' electricity is being installed on the seabed off the Atlantic shores of the Orkney Islands. It will undergo demonstration trials to in the last quarter of 2009 to find out whether its innovative technology could lead to a commercial source of renewable energy to harness energy near seashores around the world.

In contrast to many other wave power devices, Oyster uses hydraulic technology to transfer wave power to shore, where it is then converted into electricity. A key design feature of the first 'Oyster'

developed by an Edinburgh based Power Company, is a 18 m wide oscillator based on fundamental research at Queen's University Belfast led by Professor Trevor Whittaker. The oscillator is fitted with pistons and, when activated by wave action, pumps high-pressure water through a sub sea pipeline to the shore. Onshore, conventional hydroelectric generators convert this high-pressure water into electrical energy.

The whole field of generating electricity from wave power is ground breaking, but Oyster's technology is highly innovative because it relies on simplicity. Its offshore component, a highly reliable flap with minimal submerged moving parts, is the key to its success when operating in seas vulnerable to bad weather where maintenance can be very difficult. The new design of the wave powered machine has no underwater generator, power electronics or gearbox under water which can malfunction. All the complex power generation equipment remains easily accessible onshore.

Oyster is designed to be deployed at near shore water depths of 12 to 16 metres, benefiting from the more consistent seas and narrower directional spread of the waves in a given location. The reduced wave height and load enhance survivability with consistent power delivery thereby assuring a high percentage of annual average power availability. Any excess energy is spilled over the top of the flap, its rotational capacity allowing it to literally duck under the waves.

The environmental risks associated with the device are minimised by using only water as its hydraulic fluid, rather than oil, and there are no toxic substances involved. It is also silent in

operation. Based on figures from the Carbon Trust, each Oyster's annual carbon saving could be as much as 500 tonnes.

(Source: *Science Daily Online*)

Freshly Crushed Versus Processed Garlic

A scientific study has provided evidence that freshly crushed garlic has more potent healthy effects on heart than dried garlic. It also challenges the widespread belief that most of the benefits of garlic are due to its rich array of antioxidants.

Dipak K. Das and his colleagues, based on their study point out that raw, crushed garlic generate hydrogen sulphide through a chemical reaction. Hydrogen sulphide, a gas commonly known as the one that gives rotten eggs their distinctive odour, also acts as a chemical messenger in the body. It helps in relaxing blood vessels and allowing more blood to pass through them. Processed and cooked garlic, however, loses its ability to generate hydrogen sulphide.

In their study the scientists gave freshly crushed garlic and processed garlic to two groups of laboratory rats, and then studied how well the animals' hearts recovered from simulated heart attacks. Both crushed and processed garlic reduced damage from lack of oxygen, but the fresh garlic group had a significantly greater effect on restoring good blood flow in the aorta and increased pressure in the left ventricle of the heart.

(Source: *Science Daily Online*)

Next-Generation Microchips

Researchers are looking to the building blocks of our bodies DNA to be the structure of next-generation microchips. As chipmakers compete to develop ever smaller chips at lower prices, designers are struggling to cut costs. Artificial DNA nanostructure or "DNA origami" may provide a cheap framework on to build tiny microchips. Microchips are widely used in computers, cell phones and other electronics devices. The research is being pursued jointly by scientists at IBM's Almaden Research Center and the California Institute of Technology.

According to research manager Narayan at IBM, this is the first demonstration of using biological molecules to help with processing in the semiconductor industry. Basically, biological structures like DNA actually offer some very reproducible, repetitive kinds of patterns that can actually leverage in semiconductor processes.

Right now, the tinier the chip, the more expensive is the equipment to fabricate it. However, if the DNA origami process scales to production-level, manufacturers could trade hundreds of millions of dollars in complex tools less than a million dollars of polymers, DNA solution, and heating implements, asserts Narayan. The saving across many fronts could add up significantly. According to Narayan though the DNA origami could allow chipmakers to build frameworks that are far smaller than possible with conventional tools, the technique still needs years of experimentation and testing. Lithography is a common method of making computer chips that have shrunk to contain technology measuring a mere 22 nanometres. The "DNA origami" method can

allow for chip feature as slight as 6 nanometres. DNA origami chips would have vastly increased data storage capacity and lead to power smaller, faster, smaller devices, according to those pursuing their development.

(Source: *Science Daily Online*)

Green Roofs to Save Water

Having a garden on your roof is not just nice for a garden party; it can make your city more environmentally friendly. Many American cities are beginning to incorporate green roofs into their planning ordinances because they recognise that, planting a rooftop garden can offset heat, increase city biodiversity and decrease storm water runoff. This runoff can be problematic in cities where rainwater is funnelled by streets and parking lots directly into streams, carrying with it chemicals and debris and increasing the risk of flash floods.

According to Olyssa Starry, a graduate student at the University of Maryland at Baltimore County, green plants on the roofs can absorb some of this water like a sponge being saturated. Starry studied a green roof atop a Baltimore building in comparison to a similar building without a green roof to determine how well the roof would absorb water from frequent storms. By measuring water flowing out of building downspouts, she found that the green roof retained from 30 to 75 per cent of water from storms, compared to a negligible amount retained by the building with no green roof.

Although her results are preliminary, Starry thinks that cities can reap benefits from making green

roofs a part of their building requirements, as cities like Toronto and Berlin have recently done. Using GIS satellite imagery, she estimated the number and area of buildings that could hold green roofs within one watershed in the Baltimore area. If all these roofs were greened, the city could save the watershed 30 million litre of water per year, or about 10 per cent of its yearly water loss.

(Source: *Science Daily Online*)

Study Mathematics to Become a Biologist

Researchers at Sweet Briar College and the Virginia Bioinformatics Institute (VBI) at Virginia Tech, strongly advocate that mathematics should be compulsory for biology students at undergraduate level. This is because a more comprehensive understanding of the use of algebraic models would be needed by the next generation of biologists to facilitate new advances in the life sciences,

Professor Reinhard Laubenbacher at VBI and Professor Raina Robeva at Sweet Briar College Mathematical Sciences in an article published in the international journal *Science* have highlighted algebraic models as one of the diverse mathematical tools needed in the professional development of up-and-coming life scientists. Despite this critical need, according to the authors, algebraic models have played a less substantial role in undergraduate curricula than other methods.

Researchers contemplate that future generations of biologists will routinely use mathematical and computational approaches to develop and frame

hypotheses, design experiments, and analyse results. Sound mathematical models are essential for this purpose and are currently used in the field of systems biology to understand complex biological networks. Two types of mathematical models, in particular, have been successfully used in biology to reproduce network structure and dynamics: Continuous time models derived from differential equations (DE models) focus on the kinetics of biochemical reactions, while discrete-time algebraic models built from functions of finite-state variables focus on the logic of the connections of network variables. According to Laubenbacher and Robeva, while DE models have been included more often in undergraduate curricula integrating mathematics and biology, algebraic models should also be viewed as an important training component for students at all education levels.

Laubenbacher said that discrete time algebraic models created from finite state variables, such as Boolean networks, are increasingly being used to model a variety of biochemical networks, including metabolic, gene regulatory, and signal transduction networks. Often, researchers do not have enough of the information required to build detailed quantitative models. Algebraic models need less information about the system to be modelled, making them useful for instances where quantitative information may be missing. All the work that goes into building them can then be used to construct detailed kinetic models, when additional information becomes available. In addition, algebraic models are much more intuitive than differential equations models, which make them more easily accessible to life scientists.

Using algebraic models is a relatively quick, easy and reliable way for students to integrate mathematical modelling into their life sciences coursework. Creating algebraic models of biochemical networks requires only a modest mathematical background, which is usually provided in a college algebra course. Without the complexities involved in teaching students how to construct more complicated models, algebraic models make the introduction of mathematical modelling into life sciences courses more accessible for faculty members as well.

According to Robeva, the exciting thing about algebraic models from an educational perspective is that they highlight aspects of modern-day biology and can easily fit in both the biology and mathematics curricula. At the introductory level, they provide a quick path for introducing biology students in constructing and using mathematical models in the context of contemporary problems such as gene regulation. At the more advanced level, the general study and analysis of such models often require sophisticated mathematical theories. This makes them perfect for inclusion into mathematics courses, where the biology can provide a meaningful framework for many of the abstract structures. As educators, they should actively be looking for the best ways to seize this opportunity for advancing mathematical biology.

(Source: *Science Daily Online*)

Chemists Explain the Switchboards in Our Cells

Functions of our cells are controlled by billions of molecular "switches". Chemists at University of

Columbia Santa Barbara (UCSB) have developed a theory that explains how these molecules work. Their findings may significantly help efforts to build biologically based sensors for the detection of chemicals ranging from drugs to explosives to disease markers.

Biosensors are artificial molecular switches that mimic the natural ones, which direct chemical responses throughout the cell. These switching molecules control the behaviour of our cells. With the discovery of these switches, it is very easy to understand how living organisms are able to monitor their environment and use this knowledge to build better sensors to detect, for example, disease markers.

All creatures, from bacteria to humans, must monitor their environments in order to survive. They do so with biomolecular switches, made from RNA or proteins. For example, in our sinuses, there are receptor proteins that can detect different odours. Some of those scents warn us of danger; others tell us that food is nearby.

Like a light switch, biomolecular switches often exist in two states on or off states. When a biomolecule switches from on to off, or vice versa, its shape is changed. This change in structure is often triggered by the physical binding of a signalling molecule to the switch. However, unlike the single light switch that controls any one light in a house, cells use hundreds to millions of copies of each switch. Because there is more than one copy involved, the switching process is not a binary, all-or-none process. Instead, the output signal is determined by the fraction of switches that move from the off state to the on state.

(Source: *Science Daily Online*)

Plastics That Convert Light to Electricity

David Ginger, Associate Professor of Chemistry at University of Washington and other Researchers the world over are striving hard to develop organic solar cells that can be produced easily and inexpensively as thin films so that these could be widely used to generate electricity. But a major obstacle is coaxing these carbon based materials to reliably form the proper structure at the nanoscale to be highly efficient in converting light to electricity. The goal is to develop cells made from low-cost plastics that transform at least 10 per cent of the sunlight that they absorb into usable electricity.

Researchers found a way to make images of tiny bubbles and channels, roughly 10,000 times smaller than a human hair, inside plastic solar cells and use them to improve the materials' performance. These bubbles and channels are formed within the polymers as they are being created in a baking process, called annealing.

The nanostructured plastic solar cells at threshold efficiency could be put into use on a broad scale. To begin with, they could be incorporated into purses or backpacks to charge cell phones or mp3 players, but eventually they could make an important contribution to the electrical power supply.

The researchers succeeded in making direct measurement of the current each tiny bubble and channel carries, thus developing an understanding of exactly how a solar cell converts light into electricity. It is contemplated that it would help them to further refine their understanding of conditions which would result

in creation of materials that are most likely to meet the 10 per cent efficiency goal. Most researchers make plastic solar cells by blending two materials together in a thin film, then baking them to improve their performance. In the process, bubbles and channels form much as they would in a cake batter. The bubbles and channels affect how well the cell converts light into electricity and how much of the electric current actually gets to the wires leading out of the cell. The number of bubbles and channels and their configuration can be altered by the quantity of heat applied and its duration.

At present scientists have worked with a blend of polythiophene and fullerene, model materials considered basic to organic solar cell research because their response to forces such as heating can be readily extrapolated to other materials. The materials were baked together at different temperatures and for different lengths of time. According to Ginger the polymer tested, however, is not likely to reach the 10 per cent efficiency threshold. But the results will be a useful guide to show which new combinations of materials and at what baking time and temperature could form bubbles and channels in a way that the resulting polymer might meet the standard.

Such testing can be accomplished using a very small tool called an atomic force microscope, which uses a needle similar to the one that plays records on an old-style phonograph to make a nanoscale image of the solar cell. The microscope, developed in Ginger's lab to record photocurrent, comes to a point just 10 to 20 nanometres across (a human hair is about 60,000 nanometres wide). The tip is coated with platinum or gold to conduct electrical current, and it traces

back and forth across the solar cell to record the properties. As the microscope traces back and forth over a solar cell, it records the channels and bubbles that were created as the material was formed. Using the microscope in conjunction with the knowledge gained from the current research can help scientists to determine quickly whether polymers they are working with are ever likely to reach the 10 per cent efficiency threshold.

Making solar cells more efficient is crucial to making them cost effective. And if costs can be brought low enough, solar cells could offset the need for more coal-generated electricity in years to come.

(Source: *Science Daily Online*)

Beetroot Juice Boosts Stamina

Drinking beetroot juice boosts your stamina and could help you exercise for up to 16 per cent longer. Andy Jones, Professor of School of Sport and Health Sciences at University of Exeter, UK, has shown for the first time that how the nitrate contained in beetroot juice leads to a reduction in oxygen uptake, making exercise less tiring. The study reveals that drinking beetroot juice reduces oxygen uptake to an extent that cannot be achieved by any other known means, including training. Their research team believes that the findings could be of great interest to endurance athletes. They could also be relevant to elderly people or those with cardiovascular, respiratory or metabolic diseases.

The nitrate present in the beetroot juice cause to boost stamina. It could be a result of the nitrate

turning into nitric oxide in the body, reducing the oxygen cost of exercise.

(Source: *Science Daily Online*)

Waste Water Treatment Plant Mud Used As 'Green' Fuel

Scientists have shown that cement factories can reduce their CO₂ emissions by using mud from waste water treatment plants as a partial alternative fuel. This would enable factories to comply with the Kyoto Protocol, besides posing no risk to human health and being profitable.

Dependency on oil and coal could be coming to an end. José Luis Domingo, director of the Toxicology and Environmental Health Laboratory and other researchers at Rovira i Virgili University (URV) have studied and analysed the environmental and human health impacts of an alternative fuel that solves various problems simultaneously. This is the solid waste from the water treatment plants of large cities.

As this mud is already waste, burning it does not enter into the atmospheric CO₂ emissions assigned to each country under the Kyoto Protocol. This would enable plants producing cement, one of the most contaminating industries in terms of CO₂ as well as emissions of dioxins, furans and heavy metals, to consume energy in a more environment friendly way. Up to 20 per cent of the fossil fuel energy used at the Catalan plant has now been substituted for the fuel from waste water treatment plant mud.

From an economic point of view, the scientists will not say that cement plants could increase

their profits by using this method, but “they will not have to pay anything to exceed their agreed emissions”, the researcher points out. The economic benefits of this system also depend on the price of fuel.

One of the most important issues for the URV scientists is the reduction in environmental impact, and consequently the health risks for people living near the plants. The experiment with the mud has led to a 140,000 tonne reduction in CO₂ emissions between 2003 and 2006, and will have limited the potential deaths from exposure to chemical pollutants. In addition, the study shows that using this green fuel would reduce the cancer rate by 4.56 per million inhabitants.

The researchers say it is essential to carry out separate studies for each plant because however, if the conditions are right, using mud from waste water treatment plants in cement factories are a very good solution.

[Source: *Science Daily Online*]

Energy-Efficient Sewage Plants

High rate digestion with microfiltration is state of the art in large sewage plants. It effectively removes accumulated sludge and produces biogas to generate energy. A study now reveals that even small plants can benefit from this process.

Sewage plants remove organic matter from waste water. If the accumulating sludge decays, biogas is generated as a by product. However, only 1156 of the 10,200 sewage plants in Germany have a digestion tank. Smaller operations, especially, balk at the costs of a new digestion tank.

Instead, they enrich the sludge with oxygen in the existing activation basin, and stabilise it.

According to Dr Brigitte Kempter Regel of the Fraunhofer Institute for Interfacial Engineering and Biotechnology IGB in Stuttgart, Germany, activation basins require a lot of electricity. At the same time, enormous energy potential is lost, since no biogas is produced. A sewage plant eats up more electricity in the municipalities than their hospitals do.

In a cost benefit study, he showed that it also pays small sewage plants to transfer to more energy efficient processes even if they have to invest in a sludge digestion unit. Based on a sewage plant for 28,000 inhabitants, the plant can reduce its annual waste management costs from 225,000 euros by as much as 170,000 euros if sludge is decayed in a high-rate digestion unit with microfiltration, as opposed to treating it aerobically. This process was developed at IGB and is much more effective than conventional digestion.

Instead of the usual 30 to 50 days, sludge only remains in the tower for five to seven days. Around 60 per cent of the organic matter is converted into biogas the spoil is approximately a third more than in the traditional digestion process. The biogas obtained can be used to operate the plant, which, in the case study, would cut energy costs by at least 70,000 euros each year. High-rate digestion has the added advantage of producing less residual sludge needing disposal.

This saves the operator another 100,000 euros. In addition to high energy prices, budgets are also being hit hard by increasing waste management

costs. The use of residual sludge in agriculture is controversial, and slurry can no longer be disposed of on landfills; burning the sludge is a very expensive alternative. So an effective reduction of sludge through digestion pays off. Even small sewage plants have already followed the recommendation of the Stuttgart Institute and converted to the high-rate digestion process.

(Source: *Science Daily Online*)

Niche Differences in Biodiversity

Scientists at UC Santa Barbara, have found strong evidence that niche differences are critical to biodiversity.

Another scientist Janneke Hille RisLammers, assistant professor at the University of Washington, did field testing of small plants. These plants were found in northern Santa Barbara County on rocky outcrops, where diversity is very high. They used a combination of mathematical techniques, as well as experimental approaches, to remove niche differences from these experimental communities.

Ecological theory has posed two possible answers to the coexistence conundrum. The classic argument is that niche differences allow species to divide up the environment; much like different products caters to consumers of different tastes or incomes. The alternative is that competitors are so evenly matched that no single species can win as occurs when different airlines offer the same route for the same price.

Conflict between these hypotheses has formed the single greatest controversy in ecology over the last decade. The new study provides the first

strong evidence that species' differences are responsible for their coexistence.

Although the study's primary importance is in advancing pure ecological science, understanding how biodiversity works is critical. It is in those communities in which niche differences maintain diversity that species loss has the greatest impact on plant production, and other ecosystem services to mankind from economic to aesthetic. This work is great important because it resolves a century old biodiversity puzzle.

(Source: *Science Daily Online*)

Now Performs 1,000 Chemical Reactions At Once with the Microchip

Flasks, beakers and hot plates may soon be a thing of the past in chemistry laboratories. Instead of handling a few experiments on a bench top, scientists may simply pop a microchip into a computer and instantly run thousands of chemical reactions, with results literally shrinking the laboratory down to the size of a thumbnail.

Toward that end, UCLA researchers have developed technology to perform more than a thousand chemical reactions at once on a stamp size, PC-controlled microchip, which could accelerate the identification of potential drug candidates for treating diseases like cancer.

A team of UCLA chemists, biologists and engineers collaborated on the technology, which is based on microfluidics the utilisation of miniaturised devices to automatically handle and channel tiny amounts of liquids and chemicals invisible to the eye. The chemical reactions were

performed using in situ click chemistry; a technique often used to identify potential drug molecules that bind tightly to protein enzymes to either activate or inhibit an effect in a cell, and was analysed by using mass spectrometry. The study team relied on work in the UCLA labs of Michael E. Phelps, Norton Simon Professor and Chair of Molecular and Medical Pharmacology, and Clifton K.F. Shen, Assistant Professor of Molecular and Medical Pharmacology.

While traditionally only a few chemical reactions could be produced on a chip, the research team pioneered a way to instigate multiple reactions, thus offering a new method to quickly screen which drug molecules may work most effectively with a targeted protein enzyme. By this study, scientists produced a chip capable of conducting 1,024 reactions simultaneously, which, in a test system, ably identified potent inhibitors to the enzyme bovine carbonic anhydrase.

A thousand cycles of complex processes, including controlled sampling and mixing of a library of reagents and sequential microchannel rinsing, all took place on the microchip device and were completed in just a few hours. At the moment, the UCLA team is restricted to analysing the reaction results off-line, but in the future, they intend to automate this aspect of the work as well.

According to study author Hsian-Rong Tseng, a researcher at UCLA's Crump Institute for Molecular Imaging, and Associate Professor Molecular and Medical Pharmacology at the David

Geffen School of Medicine at UCLA, and a member of the California Nano Systems Institute at UCLA, the precious enzyme molecules required for a single in situ click reaction in a traditional laboratory now can be split into hundreds of duplicates for performing hundreds of reactions in parallel, thus revolutionising the laboratory process, reducing reagent consumption and accelerating the process for identifying potential drug candidates. Another scientist Kym F. Faull, Director of the Pasarow Mass Spectrometry Lab at UCLA, helped the team to reduce the amount of chemicals needed for reactions on the chip, enhancing test sensitivity and speeding up reaction analysis. The system allows researchers to not only test compounds quicker but uses only tiny amounts of materials, which greatly reduces lab time and costs.

Next steps to exploring the use of this microchip technology for other screening reactions in which chemicals and material samples are in limited supply for example, with a class of protein enzymes called kinases, which play critical roles in the malignant transformation of cancer. The new technology may open up many areas for biological and medicinal study.

(Source: *Science Daily Online*)

Compiled and Edited by
R. Joshi

Archana Sharma

Junior Project Fellow, DESM, NCERT, New Delhi

WEB WATCH

In this Section, we present websites and a brief introduction about them. Inclusion of a site does not imply that School Science endorses the content of the site. Sites have been suggested on the basis of their possible utility to school systems.



- **Homi J. Bhabha**

http://en.wikipedia.org/wiki/homi_j_bhabha

This website provides readers a comprehensive view of his early life, higher education and research at Cambridge, research in theoretical physics, untimely and tragic death, awards and recognition and a number of references for further reading.

- **Bhabha and Bohr**

<http://www.ias.ac.in/cursci/aug252009/583.pdf>

The article entitled, Homi J. Bhabha and Niels Bohr by Prof. Rajinder Singh is based on correspondence between Bohr, Bhabha and Nehru. Bohr knew Bhabha as a young scholar in Copenhagen and later as one of the builders of independent India's nuclear energy programme. It is intended to show how the relation between the two started, and how in 1960 Bohr's visit to India led to close cooperation between the two countries. It also discusses Bohr's views about India's scientific and cultural achievements.

- **Global Warming**

<http://globalwarming.com>

This website talks about global warming, issues and concerns related to global warming and possible solutions. It also has a link for kids : global warming.com for kids. It provides statistics about global warming.

- **Wiki of Tissue Culture**

http://en.wikipedia.org/wiki/tissue_culture

This website introduces tissue culture and talks about its historical and modern uses. It also has links for more information on cell culture and organ culture.

- **International Atomic Energy Agency**

<http://www.iaea.org>

It is the official website of International Atomic Energy Agency (IAEA), Vienna, Austria. Information, articles etc. about various issues related to atomic energy are available on this website.

Compiled and Edited by

V.P. Srivastava

DESM, NCERT, New Delhi

YOU'VE ASKED

Students are welcome to ask questions on general topics related to science and mathematics. However, routine questions with answers available in textbooks, solutions to problems, derivations and quizzes will not be included. Selected questions would be considered for publication in this column. Questions can be sent to the Executive Editor, School Science, DESM, NCERT, New Delhi 110 016 or emailed to school.science@yahoo.co.in



1. Question: What type of material do the adhesives contain that it gives them the property to stick things instantly?

*Virender Rekwal
Class VIII B, Jawahar Navodaya Vidyalaya
Aarnyakal, (Kala Pipal), Sajapur (M.P)*

Answer: All substances are made up of tiny particles called molecules that may comprise one or more atoms of same or different elements. All particles, or the molecules, in a given piece of a substance are bound together by attractive force between them, called the force of cohesion. The force of cohesion between particles of a given substance is strongest in its solid state and the weakest in gaseous state while it is in between the two in its liquid state. It is due to the force of cohesion that a substance in its solid state has a definite shape and volume, in its liquid state has only definite

volume but no definite shape while in gaseous or vapour state it has neither definite shape nor definite volume. A force of attraction also exists between particles of two different substances. This is known as the force of adhesion. However, the effect of adhesive forces could be observed only if the particles of two substances are as close as their size. It is rather difficult to bring the particles of two different substances to such closer distances by merely pressing them together. However, affect of adhesive forces could be easily seen between a liquid surface and a solid surface. It is common experience that two glass plates stick together if they are wet. The adhesive forces between the particles of water and that of glass make them stick together. Many a

time two steel bowls or tumblers stick to each other if these were wet at the time they were stacked. This again is due to adhesive forces between particles of steel and water. However, the adhesive forces get weakened as the water evaporates and disappears completely when there is no water between two glass plates or steel tumblers. Adhesive substances like natural and synthetic glues behave differently. The adhesive force between the surface of an adhesive substance and the surface to be glued increases as the glue dries up and becomes substantially large when it dries up completely. As a result, both the surfaces of the material to be glued are held firmly by the adhesive force of the two surfaces of the adhesive between them. For example, when we fix a stamp on an envelope, we first wet its surface having a layer of glue. Once the glue dries up, it forms a layer between the surface of the stamp and that of the paper. The large adhesive forces between the surface of glue and the stamp on one side and that between the paper and the glue on the other fix the stamp firmly with the paper. These days a variety of synthetic adhesives are available for gluing together different types of surfaces.

2. Question: We know that silkworms lay eggs on mulberry leaves and these eggs come out as larva and they feed on mulberry leaves, so why do only silkworms lay eggs on mulberry leaves and why do larvae only feed on mulberry leaves.

Shreya

36, Dev Bhumi Banglows

Jhunda, Ahmedabad

Answer: The name mulberry refers to a class of plants just like palms and pines. The variety of silkworm that feeds on different types of mulberry plants also varies. There are many wild varieties of silkworm that lay their eggs and feed on leaves of plants other than mulberry, but the quality of silk fibre produced by them is usually not suitable for making fabric. Moreover, it is difficult to collect cocoons of wild varieties in large quantities. The silkworms that can be reared for commercial production of silk feed only on mulberry leaves though the variety of mulberry plant may vary. Other insects sometimes lay eggs on mulberry leaves and feed on them. Common emerald, lime hawk-moth and sycamore are some examples of such insects.

3. Question: What will happen if an astronaut travelling in a spaceship throws an object outside the spaceship applying all his effort?

Suman Prakash

C/o Sri Ram Dayal

*East of SP Kothi
SDO Road
Hajipur, Vaishali*

Answer: You might have observed that if you throw an object from a moving vehicle, it first moves in the same direction as the vehicle and then falls behind to ultimately falls on the ground. When you are moving in a bus, car, train or any other vehicle every object in including you move with the same speed as the vehicle. When one throws an object from a moving vehicle initially it too has the same speed as the vehicle that is why it too moves in the same direction for some distance. However, the force or resistance of air which acts in the direction opposite to moving object decrease its speed and the force of gravity pulls it downwards which is responsible for its fall towards the ground. In a spaceship if the astronaut throws an object out that will also have the same speed as that of spaceship and so it will continue to move in the same direction. The additional speed imparted to the object by the effort of the astronaut would get added to this speed depending on the direction in which the object is thrown with respect to the spaceship. If it is thrown in direction perpendicular to the direction of motion of the spaceship it will continue to move by its side with the same speed as

the spaceship separated by some distance. If it is thrown in the direction of motion of spaceship it will continue to move ahead of it, while throwing it in opposite direction would mean it would continue to follow the spaceship. This will be so because there is no air or any other material to exert a force on it to alter its motion. The force of gravity may also be too weak at such distances to affect the motion of the object.

4. Question: How the ozone layer is slowly damaging and how can it be made up?

*Wangtum Lowung
Class VI
C/o Principal
Ramakrishna Mission School
Narottam Nagar
Arunachal Pradesh*

Answer: The ozone layer is like a blanket that shields Earth (not just the living things) which absorbs Ultraviolet radiation emitted by sun and protect us by this radiation which harms our body by creating many diseases, like cataracts, skin cancer (melanoma), malnutrition/ starvation (since our food crops are similarly attacked). But now a day this layer is depleting slowly by many type of pollution mostly by air pollution, including motor cycle and many vehicles which

produce CO₂ gas in the air by burning petrol, diesel, etc. and CFCs (chlorofluorocarbon) gas by air condition, which degrade the Ozone layer. These gases are called Green House gases. Due to these gases more heat occur in the atmosphere. By the depletion of this layer it also affect on the ocean or marine life. Increasing amount of UV radiation reduces the food planktons created through photosynthesis. Zooplanktons, shrimps, small fishes are also damaged. The high increase of UV radiation may disturb the land ecosystem also, including irregularity of climate, like summer season is too hot, low rain etc; reduces the production of crops.

5. Question: Energy is neither created nor destroyed. In which form does the energy of a lighted bulb change?

Suman Prakash

C/o Sri Ram Dayal

East of SP Kothi

SDO Road

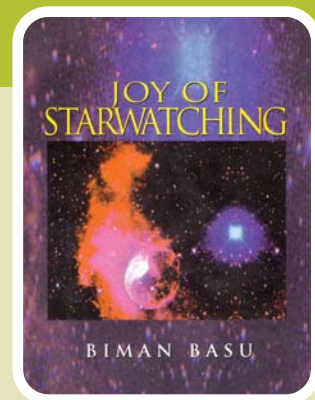
Hajipur, Vaishali

Answer: You have rightly said that energy can neither be created nor destroyed but can only be transformed from one form to other. When we switch on an electric bulb its filaments gets heated due to conversion of electric energy into heat. The filament attains a high temperature within a fraction of a

second and begins to glow, that is, gives off energy in the form of light. However, only a fraction of electric energy, usually between 5 to 10 per cent, gets converted in to light while the rest gets converted into heat which one can feel by touching the bulb after it has been switched off. Be careful bulb may be very hot even after it has been switched for a few minutes. The lighted bulb, therefore, radiates both light and heat. The light fall on all walls, roof, floor, furniture or any other object kept in the room. All the objects absorb most of the light that falls on them but reflect back a fraction of it. It is this reflected light that enables us to see the object in the room. The reflected light again falls on other objects in the room when again apart of it gets completely absorbed by the object in the room. Since light travels with a speed of 300000 km/s, this whole process is completely in a very small fraction of second. The heat and the energy of light absorbed by the objects raises their temperature, which is so small that we hardly notice it. However the lighted bulbs are used as a heating device in incubators, in aquariums and in poultry farms (to facilitate hatching of eggs). Thus, the law of conservation of energy is also valid when electric energy gets transformed into light and heat in bulb.

BOOK REVIEWS

Title	Joy of Starwatching
Author	Biman Basu
Publisher	National Book Trust, India Nehru Bhawan, 5 Institutional Area Vasant Kunj, Phase-II New Delhi
Year of Publication	
Pages	122
Price	₹ 55



The star-studded night sky not only enthralled ancient skywatchers but continue to fascinate the common man of modern times too. Although binoculars and telescopes are now available for viewing the night sky, even to the naked eye the night sky remains endlessly fascinating as the Moon, constellations and planets move against the dark backdrop of space.

Early astronomers recognised that many of the bright stars formed definite patterns which they called constellations. The ancients thought that the stars were fixed on the inside of a great dark globe, called celestial sphere, that surrounded and circled around the Earth. The simple concept of a celestial sphere provides a useful model even today, because we do appear to be at the centre of a hollow starstudded sphere that spins around the Earth once a day. And we can identify the positions of heavenly bodies in relation to that

sphere. Basic features of the celestial sphere are the celestial poles, which lie directly above the Earth's geographical poles; and the celestial equator which is the projection of the Earth's equator on to the celestial sphere. Because the Earth is spinning on its axis, the celestial sphere appears to rotate. It is this diurnal rotation that makes the stars, the Sun, and other heavenly bodies rise and set daily. Since the Earth spins from west to east, the heavenly bodies appear to travel in the opposite direction, rising in the east and setting in the west.

Although it is not difficult to locate some of the brightest stars in the sky when they form part of constellations whose shapes are easily recognisable, there are many other bright stars and all the faint ones that cannot be so conveniently located. Astronomers, therefore, require a kind of map reference, called sky map,



to pinpoint a star's exact location on the celestial sphere.

A simple strategy to watch the stars in the night sky is to locate a few prominent constellations which are easily recognisable and use them as signposts to locate others that are less distinctive. For example, two of the most prominent constellations in the night sky are Ursa Major-the Great Bear, and Orion. They are useful as pointers to many others stars and constellations.

The book under review provides some simple tips to help the amateur astronomers get familiar with the wonders of the night sky. Running through ten chapters, the book starts with a general description of the night sky making the readers familiar with some of the common characteristics of stars, e.g. their magnitude, and colour; and about variable stars who brightness varies over a period of time. These include Cepheid variables

and eclipsing binaries. The second Chapter 'Getting Around' talks about the features of the celestial sphere-the imaginary sky which offers a convenient framework for locating stars in the night sky. The third chapter 'The Constellations' introduces the readers to the various kinds of constellations. It is interesting to note by those who are not initiated that the largest constellation is Hydra, the Water Snake and the smallest is Crux, popularly called Southern Cross. Of the total 88 constellations, only about 20 are prominent and are easily recognisable. However, using prominent constellations as guideposts, the constellations that are difficult to identify can be located.

The sky appears different in different seasons. Winter is one of the best times for skywatching. As the sky usually remains clear during winter and it gets dark quite early, one can get plenty of time for observation. Also, some of the brightest

constellations can be easily viewed during winter. However, summer is the worst time for starwatching especially if one lives in the north of India. The night sky as seen during winter, spring, summer, and autumn is described in four separate chapters of the book.

One of the wonders of the night sky is the Milky Way or Akash Ganga, which can be seen as a faint whitish light stretching across the sky. The best time to see the Milky Way is on an autumn or winter evening. It is then highest in the sky and so its visibility is least affected by atmospheric haze. Indeed, the Milky Way can offer a skywatcher hours of exciting viewing if he has access to a telescope with a magnitude of 100x or more. Of course, he will have to go to a really dark place, far away from the city lights, to have the best view. Planets, called celestial wanderers, can also be viewed in the night sky. While Mercury, Venus, Mars, Jupiter, and Saturn are visible even to the unaided eye, Uranus and Neptune (Pluto has been demoted to the status of a dwarf planet and recently it has been put in a separate category called plutoid) can be seen only with the aid of powerful telescopes.

Tips on viewing the Milky Way and the planets in the night sky are provided in to separate chapters of the book under the titles 'The Milky Way' and 'Celestial Wanderers.'

The chapter 'For a Better View' describes the optical aids-binoculars and telescopes-which facilitate viewing of the night sky. The book also includes a brief description of nakshatras. In fact, the ancient Indian astronomers divided the ecliptic (it is the great circle around the celestial sphere round which the Sun appears to move during the year; the plane of the ecliptic is the plane of the Earth's orbit around the Sun) into 27 equal parts, each part being called a nakshatra or lunar hour. For those interested in more details, a list of references appears in the end of the book, which also includes an index.

Certainly, the book will be useful to amateur astronomers and those having interest in skywatching. The libraries, and clubs involved in skywatching, can be recommended to have a copy of the book.

Title **Enviornmental Education**
Author **Zeenat Kidwai**
Publisher **Institute of Advanced Studies in Education**
 Jamia Millia Islamia
 New Delhi
Year of
Publication **2001**
Pages **206**

The deteriorating condition of environment has now become a matter of great concern. The mad rat race among the nations over the globe for development jeopardised the health of man itself. Competition and technology has paved the way for scientific development accompanied with natural destruction. Man's understanding of environment in the recent years especially with reference to green house effect, deforestation and desertification has proved that environment, however vast it may appear to be cannot be, taken for granted. Ironically the hazards of pollution is being destroyed and human life is being shortened by the polluted air we breathe and unhealthy water we drink.

Environmental problem is a global problem and needs combined human effort from all sections of the society. We can cope up with the problems of environment by creating awareness among people at all levels. Education creates awareness which in turn is essential for action. Educationist realised their responsibility towards environment and took up the matter in early sixties. The term

environmental education for the first time was used in an environmental conference held at Keele University, Britain in 1965. Since then the educational front is being utilised to deal with the environmental problems.

The central theme of the book revolves around the nature, scope, purpose and approach of environmental education and the basic concepts of environment on which the pedagogy of enviornmental education is based. It seeks to integrate theory and practicum aspects of environmental education and presents a holistic view of environmental education. There seems to be a real dearth of books on environmental education in India. The editor has worked comprehensively to fill this void by editing the book.

The book is divided into two parts. The first part consist of six chapters which deals with pedagogical aspect of environmental education. The second part consist of eight chapters which explains conceptual framework of environment.

The editor has comprehensively worked on the holistic framework of environmental education in the beginning of the book. It traces the origin of environmental education in the world with special reference to India. It also discussed the aims, objectives and national policy on environmental education followed by curriculum development and teaching methodologies for the transaction of environmental education.

The editor beautifully explained the role of environmental education in sustainable development by taking into account the cognitive, affective and conative domains of education for sustainable future. The book reflects that there is a need to prepare future citizen to lead sustainable lifestyle and place ecosystem concepts as the intellectual centre of all disciplines. The article on environmental ethics explained that new awareness of planet earth which have developed since the first earth day have resulted in a need for environmental ethics and presents a new challenge for education system. Environmental ethics should be a part of one's education in order to understand what it means to be a person and how we relate ourselves to nature and planet earth. It also explained the need of awareness and attitude of societies towards environmental problems and shaping of the societal behavior for the achievement of conservation objective.

The second part of the book emphasized on the environment in totality. The editor touched various dimensions of environment. The concept of biosphere has been explained in simple and coherent sentences with illustrations. The history of population growth and related problems has been explained with special reference to India and supplemented with the data of related countries.

The article on environmental education explained the importance of education in bringing the compatibility between economy and ecology and especially at the juncture where the nature is fighting a lost battle against its degradation and experiencing a broken relationship with mankind.

The editor maintained a uniform chord through most of the articles incorporated in the book except few which were overlapping like there was no need to incorporate two separate papers on ecosystem and biosphere as the biosphere encompasses the ecosystem. A single paper could have served the purpose and avoided the duplication of the matter. It would have been more ethical to include bioethics and sustainable development in the second part of the book which is content specific rather than the first part as the topic is knowledge based whereas part first dealt with pedagogical aspect of environmental education.

The book culminates with an informative article on pollution, its source, types, its impact on environment and remedial solution to combat the environmental problems. This topic lacks upto date information and should be supplemented with statistical data wherever necessary. The topic should discuss in detail the natural and man-made environmental problems, its long and short term impact upon the climatology and biology of earth.

Epilogue

The book is neither a text book nor a condensed or expanded version of a Ph.D. thesis. As the editor rightly claims, it is a collection of papers on the content and pedagogy of environmental education.

The central theme of the book revolves around the disequilibrium between economy and ecology.

The book makes a good reference material for the reader in general and teacher educators, inservice and preservice teachers in particular. The book is well edited, readable and presented in a lucid manner. It must find respectable place in the shelves of teacher education institutions and school libraries.

After going through the whole book, a teacher will have an insight of the environmental problems

and the strategies to translate the message of environmental conservation in the curricula and its transaction to the target group. The book makes the teacher aware of his role as a green educator in today's scenario to spread green message to every body, be broadened in its scope to encompass issue that falls under the real of environment thus exposing the people to the holistic picture of environment and sensitising them with the slogan of conserve or perish.

To Our Contributors

School Science is a journal published quarterly by the National Council of Educational Research and Training, New Delhi. It aims at bringing within easy reach of teachers and students the recent developments in science and mathematics and their teaching, and serves as a useful forum for the exchange of readers' views and experiences in science and mathematics education and science projects.

Articles suitable to the objectives mentioned above are invited for publication. An article sent for publication should normally not exceed ten typed pages and it should be exclusive to this journal. A hard copy of the article including illustrations, if any, along with a soft copy should be submitted in CD. Photographs (if not digital) should be at least of postcard size on glossy paper and should be properly packed to avoid damage in transit. The publisher will not take any responsibility or liability for copy right infringement. The contributors therefore should provide copy right permission, wherever applicable, and submit the same along with the article.

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