

EVERYMAN'S SCIENCE

Vol. XLIII No. 5 (Dec. '08 – Jan.'09)

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Printed and published by Prof. S. P. Mukherjee on behalf of Indian Science Congress Association and printed at Seva Mudran, 43, Kailash Bose Street, Kolkata-700 006 and published at Indian Science Congress Association, 14, Dr. Biresh Guha Street, Kolkata-700 017, with Prof. S. P. Mukherjee as Editor.

Annual Subscription : (6 issues)

Institutional Rs. 200/- ; Individual Rs. 50/-

Price : Rs. 10/- per issue

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EDITORIAL

If one stands at a street corner in any city, one sees hundreds of vehicles and people passing by with enormous amounts of kinetic energy much of which is wasted. Energy is also wasted in the vibrations of machinery, railway tracks or even the dance floors—specially those accommodating disco dancing. Much of the wasted energy is dissipated into heat. For example, when vehicles brake to stop, say at intersections, the kinetic energy of the moving vehicle is dissipated into heat, due to friction, at the brake pads, the tyres and the ground. Can some of the waste be eliminated? Again, can one harvest some useful energy from the movements of the limbs as people walk about? After all the automatic watches that use these movements, specially that of the hand wearing the watch, was invented as early as 1770! Is it possible to find technologies for extracting, or rather harvesting, some energy from the vibrations of machinery, railway tracks and dance floors for useful applications? The answers to all the preceding questions is 'Yes'. How to harvest some useful energy from movements and vibrations is the subject matter of this write-up. The subject has been briefly discussed in a recent article published in Newsweek (Sophie Grove, *Tectonic Shifts*, p. 10, December 1, 2008). Some information given here is taken from this write-up.

Let us try to understand the issue better. Kinetic energy propels machinery that generate power. Thus water-falls, natural or artificial (from dams) run generators to produce hydroelectricity while wind is used to run mills to generate wind energy.

Kinetic energy derived from human and animal muscle power is used to move things. For example, bullocks go round and round to raise water or grind oil seeds. All these are planned uses of kinetic energy of moving bodies. Now consider an unconventional method of harvesting some extra energy for strategic application. One can attach the bicycle type dynamo against the wheels of a bullock cart to generate light at night for the dark village roads. In theory such a device does need an extra input of energy and the bicycle rider needs to put a bit of extra power to run the dynamo. However, this extra bit is miniscule but the light made available by the 'parasitic' device is of great value. Devices of such parasitic nature are often, but not always, meant to generate only small wattages for critical useful applications.

Let us go back to the example of the vehicle braking to stop. It is possible to transfer the kinetic energy of the moving vehicle to a flywheel as the vehicle slows down to stop when the flywheel is decoupled. When the vehicle is at rest the flywheel keeps rotating thanks to the kinetic energy transferred to it. When the vehicle restarts and needs energy to accelerate the flywheel is decoupled to the transmission to provide energy. The Metallurgical Consultants (MECON), Ranchi had demonstrated this device more than twenty years ago and ran a bus in Kolkata streets to demonstrate how the arrangement could substantially increase fuel efficiency. Unfortunately, the promising technology did not receive the necessary follow-up work.

Consider the hybrid car that is capturing the world auto market in a big way in the back drop of the fuel crisis. This Japanese concept makes use of a powerful rechargeable Nickel battery that, on its own, can run a medium size car for about 500km. The battery comes as a sealed unit guaranteed for 7 years – the normal life time of a first hand model in the west. This battery does not need plugging to power supply sockets for recharging like the normal batteries. It gets charged by the kinetic energy of the car when it cruises and only takes over when the car has to start, accelerate or climb uphill — situations when the fuel efficiency of a car's engine is lowest and when auto — emission for causing pollution is the highest. The hybrid car, by avoiding using the IC engine for these inefficient operations, reduces auto pollution by about 90 percent and nearly doubles fuel efficiency.

Research teams such as that in Engineering and Science Research Council in the United Kingdom are working on tapping kinetic energy—energy from moving objects to power electronic gadgets. They are also using surplus vibrations from industrial machinery to produce electrical power. As has been mentioned earlier, the principle of energy harvesting is not new but suitable technologies are available only now. For example, vibrations can be used to cause magnets to quiver, generating current in a copper coil, albeit with low efficiency (say 30 percent). Yet the small power harvested can run small devices such as environmental sensors or traffic tracking systems.

Such 'parasitic' devices have potential applications in many fields.

Researchers at Imperial College in London are working on a bionic powered pacemaker that harnesses energy from the beating of the heart itself and keeps a tiny battery charged which kicks in if the heart beat falters. The scheme is similar in principle to the hybrid car and the solar powered flashlight that uses the sunshine to power itself and then is ready to provide light in the dark when you need light. The new style pacemaker, however, is still in the prototype stage. Yet, it may be soon inserted in a human body. Once perfected, this new device will eliminate the need to replace the conventional pacemakers every 5 to 6 years.

As regards harvesting energy from dance floors, a trendy bar in London has put some kind of springs under the dance floor to capture the energy of the feet stamping around. The energy of the dancing feet is harvested by a piezoelectric material under the flooring that generates a small electric current each time a dancer steps where the device is located. Eventually, such energy harvesting devices may well reduce the electricity bills of dance clubs and may also encourage the dancers to continue longer by reducing fatigue. One day similar devices will generate electricity from under railway tracks when passing trains will vibrate them. Finally even the human strides have been targeted. A team in British Columbia has created a bionic harvester that extracts sufficient power from the human knee joint to extract 13 watts of electricity if one walks only for a minute. This energy can power a cell phone for half an hour talk time.

At the end consider an interesting device that has been commercialized by the Japanese to silence sounds by using the vibrations causing the sounds. In this feedback device the sounds of vibrations are recorded as electrical signals whose wave front is reversed by an electronic device. When superimposed the mirror image eliminates the primary sounds. Used inside cars, such a device maintains silence inside, eliminating sound from all vibrations emanating from inside or outside.

Used in offices, the device creates a silent atmosphere. Unfortunately, it will also make inaudible office gossip or angry outbursts of the boss.

Who knows, one day one may be able to silence the sound vibrations from an undesirable loudspeaker by simply pointing towards it another contraption equipped with this sound killer.

Prof. Hem Shanker Ray

"The only way of discovering the limits of the possible is to venture a little way past them into the impossible"

—Arthur C. Clarke.

PRESIDENTIAL ADDRESS

THE LIVING AND THE NON-LIVING

DR. D. M. BOSE*, M. A., PH. D., F.N.I.

INTRODUCTION

As the subject for my address for today I have selected the title "The living and the non-living". Fifty years ago in 1902, Acharya Jagadish Chandra Bose published a monograph on "*Responses in the Living and in the Non-living*". The book, because of the pantheistic nature of the conclusions arrived at aroused considerable interest amongst a large section of our educated public. Taking as the criterion of livingness, electric response to stimulation, Acharya Jagadish Chandra showed that under analogous conditions similar electric responses could be obtained by stimulation, both from living and non-living specimens. The starting point of these investigations was Bose's experiments with electric waves. The detector of electric waves in his apparatus was called coherer, whose resistance was reversibly reduced under the impact of electric radiation, and it could be detected by a deflection of the galvanometer connected with the coherer. Even in 1896, Bose was a biophysicist—he called the coherer the electric eye, the connecting wire the optic nerve and the galvanometer, the brain. This biological analogy struck him when he found that his coherer suffered from fatigue and recovered when given sufficient rest. He devised many other models of the eye, of which the following one approximated best to an actual eye, a hollowed silver cup whose inner side

was exposed to bromine vapour and filled with distilled water. This model eye also produced on illumination a galvanometer deflection. Two conclusions were drawn by him from these experiments.

1. That no demarcation line could be drawn which separated the physiological from the physical process—the physiological is an expression of the physico-chemical and
2. Responsive processes in life were preshadowed in non-life and there was no abrupt break but a continuity of law ^{5b}.

This was the first attempt ever made to subsume under common physiological laws, response to stimulation in living and non-living systems. I will not speak here of his later investigations on the unity of life processes in plants and animals ^{5c}, which I have discussed in a recent monograph ^{4a}.

Fifty years elapsed before a fresh synthesis was attempted, to describe the principles of communication and control in living and non-living organisms under common physiological laws. During the end of this period, coinciding with the last war, many complicated machines, using electron tube switching and amplifying devices, were constructed which could perform intricate tasks on receipt of instructions and messages from outside e.g.,

1. Computing machines to solve numerically intricate differential equations which had been supplied as data ;

* General President, fortieth Indian Science Congress held at Lucknow during January, 1953.

2. Detection of enemy airplane by means of radar and the training of guns of the planes. As a side result of the invention of many echo ranging devices used for war purpose, it was discovered that animals had been using such signalling devices. The time therefore seemed ripe to formulate a new discipline which described under common physiological laws, communication and control in animals and machines, for which the name Cybernetics was coined ²³.

Our knowledge of the evolution, both in the organic and in the inorganic worlds and the inter-relation between the two, has advanced considerably during the last fifty years. The relation between the living and the non-living has been made the subject of many important studies by competent investigations in many branches of Science. I have thought it worthwhile to present a review of some aspects of this subject which has interested me for some time.

The only form of life known to us is what has appeared on this earth. We do not know whether life has appeared in other parts of the universe, under conditions similar to or different from those prevailing on this earth. The fitness of the environment for the appearance of life here depended partly on the chemical properties of the elements, which in various combinations contribute the material structure of the living organisms, and partly on the physical conditions which favoured the formation of complex molecules out of which the life process began. This possibility along with many others were implicit at the period when the present phase of evolution of the universe commenced, coinciding with the creation of chemical elements in their relative abundance out of lighter atoms, possibly hydrogen. The history of evolution of living organisms, therefore, dates back right to the beginnings of the universe, and can be for our purpose roughly divided into three

periods ; the first one from the origin of the universe to the formation of the worlds, in particular of the earth, with its profusion of chemical species. The second period is concerned with the transition from the non-living to the living. The third period is concerned with the evolution of living organisms and stretches up to the present time. I shall deal principally with the characteristics of living organisms as autonomous energy systems, maintaining themselves by means of a continuous interchange of matter and energy with the environment. After presenting some related observational data, I shall discuss how far the activities of the living organism is interpretable in terms of known laws of Physics and Chemistry viz., as an autonomous energy system. In the opinion of many competent biologists, it becomes necessary at some phase in the development of the organism to take into consideration new factors, one of which became emergent when the transition from the non-living to the living took place, and the other with the emergence of the mind as a factor in partly controlling the activities of the organism ; along with it there arises the further question whether the process by which the organism gets adapted to changes in its environment is explicable as due only to natural selection operating on the results of chance variations in the hereditary mechanism of the organisms, or whether additional directive factors operate.

COSMOLOGY

If we look to the evolution of cosmological theories, we notice the appearance in succession of two alternative theories of finite and infinite universe. From the time of Ptolemy to the medieval ages, the universe was taken to be finite in dimension and according to Christian theology of finite duration. Since the time of Newton, the world was conceived as infinite both in space and in time.

Recently a great deal of evidence has accumulated which tends to show that the universe had a beginning in time, which is approximately taken to be about five billion (5×10^9) years, and that it has finite though rapidly expanding dimensions. Further the component parts including the earth and its heavy radioactive elements like uranium, were formed at about the same time. This epoch of creation of matter can be calculated from radioactive data, and agrees in order of magnitude with other estimates of the age of the universe. The conclusion that the universe is expanding is drawn from spectroscopic evidence, which shows that the constituent galaxies of the universe have velocities of recession which increases with their distances. The boundary of such a universe lies in the region where the receding galaxies have attained the velocity of light, and from where therefore no light signals can reach us.

In such a universe the average density of matter will diminish with time. All temperature differences will disappear, the entropy will reach a maximum and the universe will attain the state of heat death.

A recent alternative interpretation of an expanding universe, which is not running down, is associated with the names of Jordan, Bondi, and Gold. It is assumed that the universe is not finite, but infinite in extent and has existed from an infinite past and will continue indefinitely. Due to recessional velocities, some of the galaxies go out of the boundary of our observable universe. But at the same time continuous creation of matter, as hydrogen, is taking place from which new galaxies are being formed, so that the large-scale appearance of the universe does not change with time—it is in a stationary state. The running down of the universe, because of the increase of its entropy to a maximum is thus avoided. Although entropy increases in localised regions, the galaxies which pass out beyond the observational horizon carry entropy out

of the observable universe. Consequently the entropy does not increase with time—the mean density of matter in the universe also remains constant for all time. The theory assumes, in violation of conservation of matter and energy principles of Physics, a continuous creation of matter, which amounts on calculation to the creation of one hydrogen atom per cubic yard every 300,000 years¹⁹. Evasion of the conservation of energy principle in any finite portion of the universe is much too small to be detected. If this theory is found to be a better interpretation of the observable universe, it may also throw some light on the problem of interaction between mind and body, whether there is any transfer of energy involved in the interaction. How the truth or otherwise of the alternative cosmological theories can be verified from the continued existence of living organism on this earth for over half a billion years, has been discussed in Sir Edmund Whittaker's recent rather controversial Eddington Memorial Lecture²³.

Leaving aside such speculations, we shall take as a working model of the evolution of the universe that proposed by Weizsacker²¹ which has the usual attributes of a model that it correlates a large number of observations, at the same time it raises certain theoretical objections which are left unanswered. The basic assumptions of this model are

1. The laws of Physics have remained unaltered since the beginning of the present phase of the expanding universe ;
2. The universe is a closed system across whose boundary no flow of energy and matter can take place.

According to the second law of thermodynamics, it follows that the changes taking place in this closed system will be of an irreversible character, accompanied by increase of entropy. The latter is accompanied by equalisation of all differences of

temperature as well as of all electrical and chemical, and other potentials. The universe will ultimately reach a state of heat death, where, while the total energy remains unaltered, it is in unavailable form. Boltzmann first identified the entropy of a system as a function of its statistical probability, so that with increase of entropy a system will pass from a less to a more probable state. I will illustrate with some examples :

1. If one of two vessels is filled with a gas and the other is empty, then on connecting the two, gas will become equally distributed in the two vessels which is a more probable distribution of the gas molecules and has also the larger entropy.
2. A vacuum space enclosed within perfectly reflecting walls and filled with monochromatic radiation, will represent a state of labile equilibrium. If now a particle of matter is introduced, which can absorb radiations of all frequencies, it will lead to an interchange of energy between matter and radiation, until the radiation assumes what is known as black body character, where the spectral distribution of energy is a function of temperature only. The temperature is given by that of the piece of absorbing material particle. This represents a state of maximum entropy, for a given distribution of energy between matter and radiation.
3. If a saturated solution of sugar is taken, in temperature equilibrium with its surroundings and a minute sugar crystal is dropped into it—sugar will start crystallizing out of the solution. Taken by itself the separation of the solution in a crystalline solid and a liquid phase represents a state of greater differentiation and therefore of lower probability. At the same time heat has evolved during crystallization. This has led

to a transference of heat from the solution to the surrounding medium, resulting in an increase of total entropy of the system including the solution with its enclosure.

The hypothesis of the universe as formulated by Weizsacker is as follows : Some billions of years ago, all matter contained in the portion of the world we know was compressed in a narrow space. At that time the heavy nuclei came into being out of light nuclei, possibly out of hydrogen. Then matter flew apart and scattered through space in the form of more and more diffused gas. The fastest of the exploded particles will occupy the outermost portion of this expanding mass of gas.

Weizsacker has shown how from this diffuse expanding gas system formed the earliest stage of the universe, where most of the energy is concentrated in the kinetic energy of the materials particles, turbulent motion will arise. In such an infinite distribution of gas of uniform density the resultant gravitational attraction on any particle is zero. Chance concentration of matter occurring in any region will attract additional matter there, and an individual body comes into existence, resulting in the conversion of the gravitational potential energy of the condensing matter into radiation. Once formed the condensed units will not dissipate away again into a gaseous system, as energy will be required. Such partial systems formed in a cloud in turbulent motion will as a rule rotate from the beginning. Celestial bodies observed by means of powerful telescopes have been found to belong to the classes of clouds, rotatory forms and spheres. They represent the different stages in the evolution from the initially diffuse expanding mass of gas. The rotating celestial bodies are varied in degree of organisation from spiral nebulae to bodies like the globular sun with its planetary system ; most of them have a well-defined plane and vertical to it an axis of rotation. They show an increasing order of organisation and as such they represent a transition from a greater to a lower degree of probability. As

I have said before, in discussing the crystallization of sugar out of a saturated solution, such an increase in organization can occur, without violation of the second law of thermodynamics, in a part of an isolated system, if it is accompanied by the conversion of some kind of potential energy, chemical, or gravitational, into heat radiation, thereby increasing the total entropy of the isolated system. We find in Nature that there is always transitions from poor undifferentiated distribution of matter, rich in energy, kinetic, as well as potential, which create new forms always accompanied by a final transformation of the energy released in the process, to low temperature thermal radiation. We shall find when we turn to our earth, that new species of chemical molecules, crystals minerals, etc., were formed releasing chemical potential energy into heat radiation.

As inhabitant of the earth we are most interested in the origin of the sun with its planets. This represents the most differentiated form in the evolution of stars. Round the sun we have the planets moving in orbits of various degree of a ellipticity, all of them more or less coplanar, and rotating in the same direction. At one time it was thought that the planets were formed out of the rotating disc of gas, which was throw out of the rotating sun at some period of its evolution. But the chemical composition of the planet best known to us, the earth, is against this view. According to recent views, the earth is supposed to have grown out of accretion of dust particles, meteorities and planetoids. These bodies were cold, as they were as far as from the sun as the earth is today. The heat of the earth could feed on two sources of energy ; in the beginning on the kinetic energy of the fragments that combined to form the earth ; since then and until today on the nuclear energy of the radioactive elements contained in the rocks.

The age of the earth is taken to be about 3.35 billion years² and the age of the oldest sedimentary

rocks 2 billion years, since when the temperature on the earth's surface has remained within fairly stable limits. During the first period of its history, the earth was in a semi-liquid condition, convection of matter between the core and the surface took place, resulting in the formation of an inner core of high density, consisting most likely of iron and nickel, with a lighter outer crust. The great continents are of lighter substance than the floors of the ocean. Like floes of ice, the continents float on heavier materials underneath.

With the gradual cooling of the surface temperature, condensation of water took place forming the hydrosphere, together with an enveloping atmosphere of gases and vapours. The absorption of solar radiation by the surface layers of the earth, led to a circulation of matter and energy in the form of wind, rain, and ocean currents, and these have partially shaped the earth's surface to its present appearance. Utilisation of solar energy became possible with appearance of green plants, and of the circulation of matter and energy, when animals which could fly or swim appeared. The sun and the earth form a coupled system.

The sun is still a hot mass of gas, consisting mainly of hydrogen, in whose interior extremely high values of temperature and pressure exist. A hypothesis, originally proposed by Weiszacker and worked out in details by Bethe, accounts for the continuous generation of heat in the interior of hot stars including the sun, as due to a thermonuclear reaction, in which four hydrogen atoms are converted into a helium nucleus ; the resulting loss of mass is given out as thermal energy. The surface temperature of the sun, of the photosphere, is estimated to be about 6000° K. Annually about 1.3×10^{21} K calories of solar energy strikes the surface of the earth, and except for transformation of only a small fraction into organic matter, the rest is re-emitted as heat radiation at temperature of about 287° K. The wave length of maximum

energy in the solar spectrum is at about 0.48μ while that in the emitted radiation it is at 10μ — this gives an idea of the degradation of radiant energy which has taken place.

TRANSITION FROM THE NON-LIVING TO THE LIVING

When the temperature had sufficiently cooled complex chemical molecules were formed, water had condensed on the surface of the earth, and conditions were becoming favorable for life. The oldest sedimentary rocks are estimated to be 2 billions years old, and earliest fossil records of primitive algae and worms are estimated to be over 1.2 billion years old ; by this time organisms which these fossils represent had already become highly complex². We may therefore roughly estimate the time taken for the transition between the evolution of complex chemical species and the first definite evidence of life to be about half a billion year. Several “improbable” transitions must have taken place, possibly in succession, before even the most elementary forms of living organisms known to us could have evolved. Taking a green alga as the simplest type of an autotrophic organism, which can maintain itself by synthesizing its own food requirement from inorganic compounds plus solar energy, we find that the following component parts and functions are essential :

1. synthesis of complex molecules like protein, which form the essential constituent of cell structures and of the enzymes ;
2. mechanism for mobilisation of free energy, on which all the activities of the cell depends ;
3. origin of photosynthesis ;
4. origin of genes in the cell nucleus on which the self-replication of the cell depends ;
5. origin of the cell which is the smallest unit of living organism known to us.

It is generally assumed that the first step in the evolution of life was taken when protein-like molecules began to form out of less complex constituents. The first organism had severely limited synthetic ability, subsisting on a readily available menu of organic materials formed by non-vital processes.

This is known as the heterotroph hypothesis of the origin of life. We owe to Oparin the suggestion that the first living organism on this earth exhausted the supply of organic materials which were essential for the origin of first life. Thus spontaneous generation of life could not occur again because the requisite materials were no longer available. Horowitz extended the idea, assuming that there were present to begin with complex organic compounds—presumably formed in the process of chemical evolution—and the first organism utilized some of these compounds which they were unable to synthesize. When the initial supply of these materials was exhausted, the original organism perished. But in the meantime there had occurred mutation, resulting in living forms that could carry out the synthesis of the essential complex compounds from simpler ones remaining in the environment. Further mutations provided additional steps in the synthesis until finally there were organisms which could synthesize all of the necessary complex compounds. The intermediate mutant forms, unable to perform the complex synthesis, were eliminated by natural selection, as the intermediate substance were exhausted from the environment.

This brilliant hypothesis of Horowitz provides a model of how the earliest self-propagating organisms feeding on simpler compounds functioned. In present day organisms, mitochondria provide the nearest analogue to the functioning of such living units. They are macromolecules containing a large number of enzymes so arranged spatially that the substrate of one enzyme has been synthesized by its neighbour⁹. These mitochondria

are self-duplicating and mutable but cannot exist outside the cytoplasm. Similar to it are the viruses which in the simplest form occur as crystallizable nucleoprotein molecules similar to gene molecules. They are found endowed with the property of self-replication. But such organisms can only thrive inside living cells and represent degenerate parasitic forms, between whom and the primitive self-propagating units there can be no analogy.

These self-duplicating units can only flourish inside living cells. Whether the proto life molecules were provided with analogous nutrient medium is doubtful. In any case many hurdles had to be crossed, of nature not known to us, before the evolution of the present unit of life, the cell became possible. With these remarks I shall leave the topic of transition from the non-living to the living.

CHARACTERISTICS OF LIVING ORGANISMS

As Thermodynamic System

The evolution of the inorganic universe can be considered as a historical process in time, in which at every stage the past conditioned the present. Its irreversible nature follows from the second law of thermodynamics ; all changes taking place are from states of less to more probable distribution of matter and energy, accompanied by increase of entropy. On the earth similar increase in order has taken place, accompanied by evolution of chemical species, minerals and rocks, in which potentialities have been transformed to forms. With the origin of life on this earth, chemical evolution has been supplemented by organic evolution. But the same process of differentiation and creation of new forms continues. The thermodynamic characteristics of the living organism are similar to those of the non-living. There is a circulation of matter and energy through such organisms ; the source of energy is ultimately the radiation from the sun with which

the organism is thus coupled. Unlike non-living terrestrial bodies, in which solar energy is first transformed into heat energy, working between different temperatures, the living organism absorbs energy under almost isothermal conditions, the energy is received as free energy. The unit of living organism, the cell is a highly differentiated entity, enclosed by a semi-permeable cell wall, and divided into a nucleus and a cytoplasm. The latter contains inclusions like plastids, mitochondria etc., each with an envelope of semi-permeable walls. If the supply of free energy as nutrient is stopped, only tissue breakdown processes will continue, resulting in the death of the cell with breakdown of structure, semi-permeability of the enclosing membranes, and increase of entropy. The inflow of free energy thus maintains the state of differentiation in the cell. In this sense living organisms feed on negative entropy, but in no case is there a violation of the laws of thermodynamics. Whether the maintenance of organisation in the living cell involves besides known physical and chemical forces, some additional directive principle I shall discuss later.

The living organism is thus an autonomous energy system, which takes in energy of a suitable kind for the maintenance of its activities, for growth and reproduction. The supply of all this energy is based upon oxidation of carbohydrates molecules, either synthesized by the organism or supplied to it from outside. Organisms which manufacture their food requirements from inorganic materials are called autotrophic. I shall for the present consider only autotrophic unicellular organisms. The mechanism of carbohydrate synthesis depends upon the reduction of CO₂ molecules and can be represented symbolically as



here H₂A is the hydrogen donor and CO₂ the acceptor. The process being endoergic requires the supply of free energy.

Two different types of CO₂ reduction have been observed in autotrophic micro organisms :

1. photosynthesis, in which the hydrogen donor is water and the source of energy is light absorbed by chlorophyll molecules present in chloroplasts.
2. chemosynthesis which is found in certain types of bacteria, where the hydrogen donor is SH₂ and the energy is supplied by the reduction of SH₂ to sulphur.

There are other bacteria, which carry out the reduction of CO₂ by a variety of inorganic reactions, including the oxidation by O₂ of nitrites, sulphides, sulphur, and hydrogen. These examples of chemosynthesis are of great interest in elucidating the general mechanism of hydrogenation of CO₂. However by far the most important of these processes is photosynthesis.

All the other types of heterotrophic organisms are dependent ultimately on green chlorophyll containing plants for the supply of energy-rich carbohydrates.

The first sugar produced during photosynthesis is hexose (CH₂O)₆ from which by polymerisation more complex carbohydrates like starch and cellulose are formed.

The energy involved in synthesis, respectively by oxidation of hexose can be represented as follows :

$6\text{CO}_2 + 6\text{H}_2\text{O} \rightleftharpoons (\text{C}_6\text{H}_{12}\text{O}_6) + 6\text{O}_2 + 686 \text{ K cal/mol.}$

When the reaction proceeds to the right it is endoergonic requiring a supply of 686 K cal/mol of energy. It may be mentioned that the processes can be commenced or ended at any intermediate stage in the living organism. The catalytic mechanism which facilitates the reaction will be discussed later. The carbohydrates not only provide the source of energy for all cellular processes, but some of their products like cellulose, hemicellulose lignin, pectin form the building materials for plant structures.

ENERGY UTILIZATION IN LIVING ORGANISMS

Two of the main functions of the energy released by oxidation of glucose, are the synthesis of other molecules of biological importance, and performance of work by muscular contraction. The biochemical reactions underlying them proceed by isothermal coupling of an energy spending (exoergonic) with an energy receiving (endoergonic) process. In the corresponding non-living counterparts, energy is supplied by heat flowing down temperature gradients. I cite two illustrative examples :

1. In a chemical plant, like the one installed at Sindri, fixation of nitrogen is brought about by processes which require supply of energy, both for compression of atmospheric nitrogen as well as heat for synthesis of energy-rich nitrogen compounds. For this purpose, in thermal stations fossil fuel coal is generally utilized, alternately electric power from hydroelectric generators.

Generation of mechanical power can be both by thermal plants or by hydroelectricity. In the former heat is generated by combustion of fossil fuel produced by photosynthetic activity in past ages, in the latter, the head of water for power generation is based upon evaporation of water by sun's rays.

In green plants glucose is synthesized by utilization of absorbed solar energy and in all living systems oxidation of glucose is utilized for supply of energy. Both the process take place at nearly constant temperatures. Several soil micro-organism like *Azotobacter*, *Rhizobium*, can fix nitrogen by isothermal processes, based upon oxidation of glucose. In the nodules of leguminous plants a hemoprotein similar to blood hemoglobin, occur, which can be reversably oxygenated and deoxygenated, and serves to supply oxygen to *Rhizohium*.

The energy liberated in oxidative processes may be transported to other units of the cell by at least two well-investigated methods, of which the most important is by means of energy-rich phosphate intermediates like adenoxine triphosphate (ATP), phosphates of creatine and arginine. When one mole of ATP is decomposed to ADP + a phosphate ion, 10 K cal. of energy is set free. The free phosphate can combine with glucose to form glucose 1-phosphate with an energy of oxidation of 3 K calories. This compound is the starting point for polymerisation of hexose into cellulose and other polysaccharides. Other known instances of the use of ATP are in the formation of peptide bonds in the synthesis of proteins from amino acids, the synthesis of fatty acids etc.

From each mole of completely oxidised glucose which release 864 K cal., 36–50 energy-rich phosphate bonds are set free, which can be utilized in the cell for many purposes. The completion of the cycle of operation includes the resynthesis of ATP from ADP + PO_3^{2-} ; the energy of reformation comes ultimately from oxidation of glucose. In animal tissues ATP, creatine phosphate, and arginine phosphates are found; in plant tissues other energy-rich phosphate compounds have been found, but the modes of their action are not known.

PATHWAYS OF GLUCOSE BREAKDOWN

The following three processes are known, all of which follow a common path ($\text{C}_6\text{H}_{12}\text{O}_6 \rightarrow 2\text{C}_3\text{H}_4\text{O}_3$ (pyruvic acid) + 2H_2); their final transformations are as follows:

1. $\text{C}_6\text{H}_{12}\text{O}_6 + 6\text{O}_2 \rightarrow 6\text{CO}_2 + 6\text{H}_2\text{O} + 686 \text{ K cal.}$:
aerobic oxidation

2. $\text{C}_6\text{H}_{12}\text{O}_6 \rightarrow 2\text{C}_2\text{H}_5\text{OH} + 2\text{CO}_2 + 50 \text{ K cal.}$:
fermentation (alcohol)

3. $\text{C}_6\text{H}_{12}\text{O}_6 \rightarrow 2\text{CH}_3\text{CH}(\text{OH}),\text{COOH} + 36 \text{ K cal.}$:
glycolysis (lactic acid)

With a sufficient supply of O_2 , (1) is carried out in all organisms. Under restricted supply of oxygen (2) and (3) occur, (2) in yeast and (3) in muscles.

MUSCULAR WORK

Having considered the chemical transformations accompanying breakdown of glucose coupled with synthesis of other compounds of biological importance inside the cell, I shall next consider the case of how glucose breakdown supplies energy for muscular contraction. The muscles I shall consider are vertebrate striated muscles. Contraction of such muscle is brought about by stimulation of the attached effector nerve. The propagation of nervous electric excitation is ultimately based upon chemical metabolism in the nerve cell with its thread-like processes the axons, and is accompanied by increased nerve tissue respiration. Acetylcholine (ACh) is associated with nerve transmission in many not clearly understood ways. When the nervous excitation passes across the nerve and plate junctions with muscle fibre, an appreciable quantity of ACh is liberated, followed by muscular contraction and the disappearance of ACh after sometime. ACh directly introduced in a nerve-free muscle causes muscular twitches¹⁸.

How the release of ACh starts the contraction of a skeletal muscle is not clearly understood. The muscle contains a reserve of glycogen, ATP and phosphocreatine. The first step in the chemical changes accompanying the contractile process is the release of phosphate ion from phosphocreatine. This starts the breakdown of glycogen; after a number of intermediate steps it results in the formation of lactic acid. A part of the acid is completely oxidised and the rest reformed into glycogen in the liver. Phosphocreatine is reformed by the transfer of a phosphate ion from ATP.

While the contraction of skeletal muscle is neurogenic i.e., due to nerve stimulation, the rhythmic contractions of a vertebrate heart muscle is not dependent on any extraneous nerve stimulation,

and is called myogenic. It has been recently shown by Burns³ that the contraction of vertebrate heart muscles is dependent on ACh. While in neurogenic muscle, ACh is released by a nerve impulse at end plate junction, a chemical process is responsible for the formation of ACh in the heart muscle which is destroyed at each contraction. As in skeletal muscles the contractile pulsations of the heart are maintained by glycogen breakdown, and the ATP is the activating agent. In both cases the releasing agent is ACh, in one case by the action of a nerve current and the other by a chemical process.

ELECTRIC ORGANS

When an excitation from a nerve passes from the nerve end plate junction of the connected muscle, it elicits along with muscle contraction an electric disturbance which travels along the muscle from end to end. It is believed that electric organs found in certain fishes in Africa and South America arise from a degeneration of the muscle end plate. The development of electric organs has been followed in very young specimens of the *Torpedo* or electric ray, where the various states in the transformation of a muscle to an electroplax has been observed. A similar origin of electroplaxes is assumed in fishes possessing electric organs like the *Electrophorus* (*Gymnotus*), the electric ray (*Torpedo*) and in others. These electroplaxes are arranged in columns which may contain up to 400 plates, several columns together form the electric organ. Each electroplax is connected individually to the brain centre which controls their discharge. When stimulated they discharge in series and can generate potentials up to 500 volts¹¹. In fact each column is equivalent to a Galvani pile. As at the ends with the motor nerves, the electroplaxes release a considerable amount of ACh when stimulated. They are also rich in phosphocreatine, which diminish in quantity with activity.

The point which I have tried to illustrate here is, that not only the metabolism of the organisms

but also their motor and electrical activities are brought about by a correlated series of chemical changes in the related tissues, and in every instance almost identical chemical reactions are involved¹⁸.

BIOLOGICAL BUILDING BLOCKS

The structure and functions of organisms are as we shall see built up from a limited number of chemical elements, which are combined into a limited group of simple compounds. The latter in turn serve as construction units of large molecules which again are the building blocks of organisms as varied as unicellular cells like alga to the highly differentiated mammals. While natural selection has played a dominant role in the evolution of living organisms, its influence on the evolution of chemical units is probably negligible. One consequence of the existence of a limited number of biological building units and their limited variability is, that chance variation of organisms on which natural selection acts can only take place within limited ranges.

The principal chemical elements which enter in the organisms in diminishing quantities are H, O, C, N, Ca, P, Cl, S, Mg., with some traces of other elements. I shall next list some of the intermediate molecules which enter as units in large molecules.

1. Hexose, pentose and other carbohydrate building units composed entirely of C, H, and O.
2. Molecules which in addition contain N, like the ring-structured purine and pyridine. The amino acids of which about 20 have been isolated and their structure determined, form the structured units out of which the proteins are built up, contain in addition sulphur.
3. The pyrrole ring structure which occur in units of four in many molecules concerned with the absorption of light in photosynthesis, in the transport of oxygen, like hemo, cytochrome.

I shall next pass on to the consideration of some of the large molecules which serve as building units or have special functional properties in the metabolic processes. The most important of them are

Protein : Molecular weight of protein ranges at least as high as 676000, which correspond to about 50,000 amino acids ; these are joined together by what are known as peptide bonds. If the twenty amino acids were combined at random along polypeptide chains, millions of different kinds of proteins would be possible ; but actually these are a relatively few types, indicating that certain restrictions are imposed. The proportion of amino acid groups varies widely among the different kind of proteins, but there is evidence that a given amino acid is always distributed at regular intervals throughout a polypeptide chain, so there appears to be some recurring pattern. There is also evidence that proteins are made up of units, each containing about 288 amino acid groups, in which the individual types follow such a recurring arrangement.

Proteins are of two general types, fibrous and conjugated. Fibrous proteins are made up of units of long chain molecules which possess the property of shortening their length parallel to the longitudinal axis. The contractile skeletal muscles are made up of such fibrous proteins. They also enter into the structures of horn, hair, nail, skin and exoskeleton of insects.

Many of the most important proteins, including nucleoproteins, the respiratory pigments and various enzymes are conjugated proteins, having an attached or prosthetic group, which may confer many important properties to the protein molecule. These will be discussed later.

Nucleic acids are nitrogen and phosphorous containing compounds, which can be broken down into a variety of nucleotides including adenylic acid, so, important in energy transformations. The latter contains a nitrogen base purine, a pentose sugar and phosphoric acid.

Two types of nucleic acid are found, the ribose and 2-desoxyribose forms. The desoxyribose form is associated with the cell nucleus and heredity. There is considerable evidence that the nucleoproteins are in general concerned with the synthesis of protein. Both plants and animals contain nucleoproteins, and this is taken as evidence of their common origin.

Enzymes : As is well-known enzymes are biological catalysts, which alter the rate of chemical reaction without any rise of temperature, and without altering the direction or the extent of the reaction. Enzymes can be of many kinds :

1. it can be made up wholly of protein molecule ;
2. it can have a prosthetic group which may be a simple metallic ion or a non-protein molecule. In certain enzymes the prosthetic group may be a complicated group like the nucleotide of coenzyme I.

Investigations of Tatum and Beadle make it probable that in simple organisms like *Neurospora* and some bacteria, each enzyme is controlled by a gene. I have mentioned before of the macromolecule mitochondria, common to all animals and yeast, is a multienzyme unit containing the full complement of about 100 enzymes necessary for the carrying out of the citric acid cycle and allied processes, discovered by Krebs. In non-mitochondrial systems e.g., in the higher plants all the activities of mitochondria have been duplicated. In such systems the activated substrate is transferred from one enzyme to another and undergo reactions without at any time coming into contact with non-activated molecules. Such a reaction sequence calls for an intimate collaboration of a group of enzymes. The capacity unit for the overall reaction is no longer the individual enzyme but a team of enzymes.

The last compounds I shall consider in this section are coloured compounds, containing a tetrapyrrole structure, which are active as light

absorber as in chlorophyll or in the transfer of oxygen in the body fluid as heme, the prosthetic group in hemoglobin. In chlorophyll a Mg atom is at the center of the tetrapyrrole ring, while in heme, Mg is replaced by iron. The same structure is met with in a number of enzymes connected with the transport of oxygenic respiration in the cytochrome system. In organisms belonging to different genera and species either the structure of the pyrrole compound or its ratio to the globin is altered².

ADAPTATION AND NATURAL SELECTION

The discovery that the chemical compounds found in living organisms were confined to a limited number of types, was preceded more than a century ago by a similar morphological discovery based upon comparative anatomical studies by Owen and others. It was noticed that groups of animals were organized in one or more architectural plan such as that of the Vertebrata, the Arthropoda, the Mollusca and so on. Owen held that in each of the main phyla, there is an underlying plan or archetype build up of a number of similar parts, such as the vertebra of vertebrates, the segments of centipides and worms, the ossicles of Echinoderms¹⁶. These parts are modified in different species in adaptation to their special conditions of existence. Similarities found to exist in the forms and functions of animals could be classified according to Owen under two different concepts. He defined homologous organs as the same organs in different animals under variety of form and function, e.g., in two such vertebrates as a mole and a bat, the prelimbs have entirely different functions, yet the skeletal plan of the limbs is in both cases the same. On the other hand it is frequently found in the animal kingdom, organs which show remarkable similarity of structure and function but whose bodies are otherwise built upon totally different plans. The wing of a bird and the wing of an insect perform analogous functions. The ability to fly has been developed in them on

different lines, the appendage pattern in the insect being totally different from that of the vertebrate. Another example is that the eye of a cuttle fish imitate the eye of a vertebrate, in both case we have the same arrangement of lens, iris, retina, and so on. Though there is some differences in the innervation of the retina, the resemblance is striking. One of the most striking examples of such so-called parallel evolution is the development of the brain in insects and vertebrates ; the highest developments have been found in bees and ants on the one side, and in mammals on the other. Bergson pointed out that instinct and intelligent behaviours are on two different lines of evolution, each with its advantages and drawbacks. Instinctive behaviour is characteristics of the little brained type of animals, reaching its climax in ants and bees with a rich repertory of instincts and very little of educability, while the big brained type reached its climax in the higher vertebrates. Speaking of such instances Bergson said whether we will or not we must appeal to some inner directing principle in order to account for this convergence of effect¹⁶.

The harmonious development of the component organs related to the organism as a whole and their adaptation to the performance of specific functions have attracted the attention of natural philosophers since the ancient times. According to Aristotle, an entelechy or final cause guides the development of an organism from birth onwards. To Owen it appeared that in every species, ends were obtained and the interests of the animals promoted in a way which indicated superior design, intelligence and foresight, in which the judgement and reflection of the animal were never concerned, and which we must ascribe to the "Sovereign of the Universe". To Lamarck adaptation of the organism to its environment was due to the inheritance of aptitudes acquired during an animal's lifetime. All these different hypothesis were swept aside by the publication of Darwin's *Origin of Species* in 1859. The adaptiveness of the organism to its environment was attributed to the weeding out by natural

selection of all chance variations which occurred in successive generations, but which were not suited for survival. "With the knowledge that has been amassed from Darwin's time, it is no longer possible to believe that evolution is brought about through the so-called inheritance of acquired character—the direct effect of use or disuse of organs or of change in environment or by the conscious or unconscious will of the organism ; or through the operation of some mysterious vital force ; or by some inherent tendency i.e., all theories lumped together under the heads of orthogenesis and Lamarckism—are invalidated". Regarding the nature of the variations on which natural selection operates, J. Huxley remarks "In all cases they (the variations) are random in relation to evolution. Their effects are not related to the needs of the organism or to the condition in which it is placed. They occur without reference to their possible consequences or biological uses—the capacity of the living organism for reproduction is the expansive driving force of evolution ; mutation provides its raw materials ; but the natural selection provides the direction"^{10b}. In fact "Natural selection" is creative in the sense that it can and does operate to produce evolutionary novelty. It will only be creative in certain conditions of evolutionary environment ; in others it will operate to discourage novelty and to produce and maintain stability".

The view held by many competent biologist of the difficulty of imagining that "chance" could create a hand or eye or other adaptive organ, no longer, according to Huxley carry weight "In fact the 'argument from improbability' has recoiled on the heads of its users, and the apparently incredible complications of an organ must now be taken as additional evidence for the power of natural selection". "It is due to the capacity of natural selection—to combine over a series of generations, a number of mutational steps, each of which by itself is an improbable or rare event ; the separate improbabilities are not merely added up but

multiplied by each other at each new step. What is involved may be clearly pictured when we recall that the number of generations available for the evolution of the human eye for instance is of the order^{10a} of 10^8 "

One critic (Roger Pilkington)¹⁷ has remarked "It is difficult to see how natural selection could possibly have selected independently a number of separate anatomical imperfections and gradually build up into a single evolutionary strain when each aberration by itself was useless and perhaps disadvantageous, until accompanied by all others. This is the difficulty in the case of the eye ; to tell us that the sheer improbability of natural selection being the responsible agent, is the very proof of its efficacy is just absurd... To suggest that natural selection is the only "effective agency of evolution" is to make an assertion for which there is no evidence whatsoever. Perhaps the insertion of the word "discovered to date" at the end of the sentence would give us a more realistic picture of the state of our knowledge of the magnificent and baffling evolutionary process.

BIOMETRICAL GENETICS

Huxley bases his conclusion on some probability calculations by biometrical geneticists like R. A. Fisher and Muller. It may be doubted whether statistical analysis of genetical data can always provide a reliable check on the basic assumptions on which the analysis is based. The following illustration will elucidate my point. The application of Statistics to hereditary data was started by Galton and was based upon his cousin Charles Darwin's observations. Darwin while recognizing the occurrence of "sports" of unitary genetic changes having major effects, nevertheless laid emphasis on small differences whose accumulation and mutual supplementation the greater difference between species would come about. To him important variations were continuous. Galton in his biometrical genetics endeavoured to give quantitative precision to notions of variations and

heredity. By this method some amount of success was obtained in expressing variation and likeness between relatives. On the other hand the method could not cope with the evaluation of the simple arithmetical relations found by Mendel to represent discontinuous variations. Mendel's investigations as Mather remarks "must have held a great appeal to the less mathematically minded biologists who as students of heredity and variation before 1900 had doubtless suffered under a biometrical tyranny". The question remained unsolved for sometime whether it could be possible to reconcile Darwinism, biometry and continuous variation with Mendel's simple arithmetic, and discontinuous variation. In 1918 R. A. Fisher demonstrated that the "biometrician's own results must follow from Mendelian inheritance, and that their own methods could be used to partition continuous variation in such way that Mendel's own phenomenon of dominance could be recognized at work"¹³. It is likely that at the present moment some of the less mathematically minded biologists are also suffering from the newer "biometrical tyranny".

HOMOLOGY AND ANALOGY

As a physicist not competent to evaluate the statistical methods employed in current genetical studies, I shall confine myself to citing a few examples of homology and analogy, morphological, functional, and biochemical and discuss how far they are explicable in terms of Neo-Darwinism. Morphological homology has been studied in relation to comparative anatomy which made striking advances during sixty years following the publication of the *Origin of Species*. It was interested particularly with the search for archetypes in the guise of hypothetical ancestors¹⁶. One of the problems thrown up was regarding the significance of orthogenesis, a term used to describe the persistence of evolution along certain pathways. Increase in size of horns in successive species of titanothera or the progressive increase in size of canine teeth of sabre tooth tigers are examples frequently cited². These are taken as examples of

persistence of a non-adaptive series not explicable in terms of natural selection.

Examples of homology occur amongst each species of chemical compound found in living organisms. Homology in comparable enzymes form an interesting study. The enzymatic breakdown of hexose molecules follow a common pathway in many of higher plants animals and micro-organisms. The cyclophorase enzyme system which control the Krebs citric acid cycle is common to many animals, micro-organisms, and higher plants. In the former two, these enzymes groups are found in the mitochondria, while in higher plants the occurrence of such macromolecules has not been reported. It has been shown in many instances, that comparable enzymes found in different species have not identical structures. Thus leaf phosphates of many plants although generally similar in nature, do differ in their characteristic electrophoretic mobilities. Amylases as well as proteases, differ amongst themselves as to pH optima, inactivation characteristics and other qualities, indicating also a measure of species specificity. This is probably due to the specificity of the conjugate protein groups of the similar enzymes. The hemoglobin of vertebrates consist of a protoheme a tetrapyrrole structure, attached to a globulin molecule whose specificity varies with the species.

The limited variability of the molecular species which are found throughout the whole kingdom of living organisms, also imply a limited degree of variability of the gene molecules which controls the development of the organisms. This is not surprising, since the gene molecules are nucleoproteins. The chance mutation of genes is thus possible within a very restricted range, and that may account for the occurrence of orthogenesis.

Another enzyme system responsible for transport of oxygen in respiratory systems, the cytochromes is present both in plants and animals. These compounds are evidently of more primitive origin than the heme series of pigments, which are associated with circulation of fluids in higher

organisms. The continuation of the same basic pattern of the tetrapyrrole structure in chlorophyll, in the heme series of pigments, and in the cytochromes, while evolutionary changes of great magnitude have been taking place should give the appearance of direction in evolution. It might be described as orthogenic trends. The morphological orthogenetic trend may in some way be related to the biochemical one viz., to the limited freedom of large molecules to modify their structure².

ANALOGY

There are again instances where these same function is being performed in different groups of unrelated organisms by analogous structures. Erythrocrurin (invertebrate hemoglobin) appear in widely separated species, between which there is no evidence of genetic relationship. There is a haphazard distribution of these respiratory pigments, many of which have modified tetrapyrrole structure or which may contain iron but no heme, or which has neither iron nor tetrapyrrole ring, as in hemocyanin. Here there is no evidence of orthogenic trend, but rather is evidence of a few patterns which have been used quite unsystematically for analogous functions. Again while the tetrapyrrole chlorophyll is most widely distributed in plants as light absorber in photosynthesis, there are other chromoproteins which can act in this capacity, like phycocyanin and phycoerythrin in which the prosthetic groups are open tetrapyrrole compounds².

Another group of instances relate to the appearance of the same substances or function or organ in quite unrelated organisms. A hemoprotein which performs identical function of oxygen transport has been found in the root nodules of leguminous plants. Astbury and Weibull¹ have studied the X-ray diagrams of bacterial flagella in *Proteus* and *B.subtilis*, which show patterns very similar to that of fibrous protein of skeletal vertebral muscle. On the other hand the X-ray pattern of algal flagella has not so far revealed any discernable

similarity. I shall refer to the very interesting review by Dr. Pantin¹⁶ for similar examples of repeated appearance of complicated structures in unrelated zoological groups, and content myself by giving some examples of appearance of analogous structures in plants.

ANALOGOUS FUNCTIONS IN PLANTS

Growing regions of plants show tropistic response to light, gravity, and mechanical stimulations. The plants possess receptor organs developed for the perception of specific stimuli. The photoreceptor in plants contain some carotenoid compound ; in animals the photoreceptor organs from the lowest to the highest are conjugate proteins to which carotenoid containing prosthetic groups like rhodopsin, phorphyropsin are attached. The geo-perceptor organs in animals consists of fluid filled chamber, the bottom or top of which contains a sensory epithelium. A solid or semi-solid body the statolith, rest or hangs from this epithelium. Any change in the alignment of the organism displaces the statolith and release self-aligning reflex activities. The geo-perceptive layers in the growing regions of plants, stems and roots, contain layers of starch granules which according to Haberlandt are the geo-perceptive statoliths in plants. By their displacements in a horizontally placed young plant, the stem is caused to point upwards, and the root tip downwards. Similarly there is a great deal of similarity in the behaviour of sensitive hair-like structures found in certain plant organs, like the tendrils and on certain parts of the skin of animals. These perform the part of mechano-receptors. The tropic curvature produced in plants is related to the direction of an electric field produced in the receptor layer, such that the concave side is always electronegative. In analogous receptor organs of animals, the effect of stimulation of the receptor is to produce a change in electric potential at the junction of the receptor to the attached effector nerve.

The leaf system of some of unrelated species of plants e.g., *Desmodium gyrans* (*Leguminosae*) and *Oxalis acetosella* (*Oxalidaceae*) perform rhythmic pulsations during the day ; the best example is found in the small lateral leaflets of *Desmodium gyrans*. Each mechanical pulsation is accompanied by an electric one. It has been found that the source of energy for mechanical pulsation is the oxidation of sugar formed in the leaflet by photosynthesis. The mechanical pulsations are accompanied by pulsations in the respiration of the leaflet^{4a, 6}.

The hair-like algae *Nitella*, *Chara* show all the characteristics of isolated nerves. Mechanical, chemical stimulation of one end, can give rise to single or repetitive propagated excitations of an electrical nature. In the sensitive plant *Mimosa pudica* (*Leguminosae*) the stimulation of one part of the stem is conducted as an electric excitation, which elicits mechanical closure of the pulvinus and attached leaf system. Such excitations are subject to the same kind of amplification or depression by means of cold block, flow of electric current or chemical agents, as are found effective in an animal nerve muscle unit. The mechanical response to stimulation may be either single or repetitive. Further a chemical substance which can be isolated by hot water extraction of macerated Mimosa stems when introduced within the cut end of a revived stem pulvinus unit of mimosa, can produce single or repetitive discharges of the pulvinus leaf system—its role is analogous to that of acetyl choline^{4a}. *Biophytum sensitivum* (*Oxalidaceae*) also exhibit similar characteristics of mechanical response to transmitted stimulation.

EXAMPLES FROM EMBRYOLOGY

Other instances of appearance of similar functional processes in unrelated animal organism, is to be met within the methods adopted for embryonic development.

Egg laying has been abandoned and giving birth has been independently resorted to by many

groups of invertebrates (Molluscs, Insects, Arachnida and Crustaceans) and Vertebrates (Fish, Amphibia, Reptiles and Mammals). How these needs are satisfied is familiar to students of Embryology. Well-known too that these highly complex structures of the embryonic states have been developed many times in complete independence.

If after a consideration of all these marvellous, temporary organs and structures we turn to post-natal life, we are almost forced to admit that what is developed before birth is almost more perfect in its adaptation than anything that is developed after the embryonic period is passed. That the embryonic developments are directly developed towards the satisfaction of the specialized needs of the embryo seems impossible to deny—at least we might say that it is difficult to extend Charles Darwin—Alfred Wallace theory of evolution, by means of chance variation acted only by natural selection, to what happens before the individual rubs shoulder with the world²⁴.

SOME THEORETICAL CONCLUSIONS

Before proceeding further it will be useful to review some of the theoretical conclusions which can be drawn from the materials I have placed before you, on the nature of the living organism.

1. The organism can be considered as an autonomous unit through which there is a continuous flow of matter and energy. On the one side there is increase of entropy due to breakup of the energy-rich compounds accompanied by respiration and elimination of waste products, which on the other hand is compensated by the organism absorbing negative entropy from some system coupled with the organism, one of which is the donor and the other the acceptor ; these changes take place according to thermodynamic laws. Does it imply that the living organism is a machine ? It is possible to construct automation which can perform cycles of operations, in which energy is

taken in from either a heat or water reservoir, and the whole or part of it is discharged into a sink and at the same time perform work. To keep such machines going, certain amount of human supervision is required, to mitigate the effect of frictional waste of materials and to prevent breakdown. Such machines cannot replicate themselves, they also require human ingenuity and direction for their planning and construction. Does this indicate that an additional directive principle, other than the known laws of Physics and Chemistry, becomes active ? Philosophers have coined the word "emergence" for any new property emerging in an assembly of material units, which is not a sum of the properties of the individual components. We have to assume that potentialities for life and mind, are inherent in material units and it requires certain state of accretion for their emergence. The principle characteristic of a living organism is its capacity for self-maintenance in a changing environment. Additional property is that of self-replication, with which is associated a limited degree of variation. The last character provides the basis for evolution.

2. How does this increase in organisation conform with the postulates of the law of entropy, which requires that in an isolated system, like the universe, there is an irreversible tendency to pass from a lower to a greater randomness in the distribution of matter and energy? As mentioned earlier, according to Weizsacker, the second law of thermodynamics allows us to conclude from the existence of forms, that some thing still more improbable had existed in the past, an energy namely capable of producing form. The local increase in organization is associated with increased randomness of distribution of matter and radiation elsewhere. Cosmological examples are the creation of galaxies, stars, the solar system with its planets. Here the gravitational potential became effective in producing forms and the energy released during the condensation of matter is converted into thermal radiation. Similarly on the earth, lowering of

temperature made possible the appearance of molecular species, crystals, and rocks, for which a corresponding amount of chemical affinity potential was set free and transformed into heat radiation. Finally, with increase in complexity of chemical molecules, a new state of accretion of matter became possible, viz. the thermolabile self-replicating protein molecules which became the fabric of the living organism. In the beginning the earth was rich in potentialities and poor in actual forms, rich in creative possibilities poor in created structures. With the coming of life one of the creative potentiality became an actuality, thereby diminishing the total available potentiality of the earth.

ORGANIC DESIGN

The living organisms are built up of a limited number of molecular species, the carbohydrates, the proteins, the nucleoproteins, the enzymes and so on. These molecules are again built up of a limited number of atoms ; their structure and mode of interaction are based upon laws of Physics and Chemistry. Their continued production for millions of years in organisms which passed through different stages on the evolutionary scale, from protozoa to man, show that their existence is not dependent on natural selection. The organism has a number of functional requirements connected with metabolism. It has to be provided with mechanism for reception of stimuli from the environment, by means of receptor organs, a central nervous agency for the reception of messages, and for the sending out of orders to motor organs. By such means the purposive self-preservative activities of the organism are carried out. For such multifarious activities, a limited number of constructional units are available, out of which the organism can be built up. It is also noticed that for the satisfaction of the same functional requirement, alternative plans of construction are available.

Dr. Pantin¹⁶ has drawn an interesting analogy between the assembly of a living organism out of

the limited number of available biochemical building blocks, to that of a model made out of a child's engineering constructional set, consisting of standard parts with unique properties, of strips plates and wheels. These can be utilised for various functional objectives, such as cranes and locomotives. Generalising, on this, he says "in this universe of ours any functional problem must be met by one or other of a few possible kinds of solution. If we want a bridge, it must be a suspension bridge or cantilever bridge, and so on. And the engineer who constructs the bridge, must choose whichever of the solutions he can best employ with the standard parts at his disposal. In the design of a bridge there are in fact three elements ; the classes possible in this universe, the unique properties of the materials available for its construction ; and the engineer takes the third place by selecting the class of solution, and by utilizing the properties of the materials to achieve the job in hand. He is in a sense executing one of a set of blue prints already in abstract existence ; though it requires insight to see that the blue print is there".

I mentioned earlier, that in the conditions prevalent at the period of the formation of the universe, when the elements were created, were implicit all the possible future forms and events which could take shape during the subsequent history. These are the blueprints of Dr. Pantin or entelechies of Aristotle. Which of these did or did not materialize at any time in any particular region of the universe, depended upon the conditions prevailing there, and they may be considered as contingent or accidental. We become aware of the blueprints only when we see them actually realized. Assumptions of the existence of such blue prints raises embarrassing metaphysical problems, such as were discussed by Plato in his doctrine of forms or ideas.

Applying these ideas to the construction of living organisms, it follows according to Pantin,

that like all material structures they must conform to certain constructional principles. Blue prints of many of them, Pantin finds, in D'Arcy Thompson's book "*Growth and Form*", The standard parts available for the construction are the bio-chemical building blocks. Like the engineer, natural selection takes the third place by giving reality to one or other of the series of possible structural solutions with the materials available. There are two sets of designs involved. One of them refer to the design of the component parts, of the biochemical units ; these we have seen are not the results of natural selection in the Darwinian sense. The overall design on the other hand, is selected by natural selection. This equating of natural selection with the engineer by Pantin, is open to criticism. All engineering designs, before they come in general use have to pass the test of fitness. Innumerable aeroplane models were tried and failed, before successful flight was achieved by the Wright brothers.

Putting into existence in living organism alternate solutions of certain structural problems is to be attributed in my view, to the mechanism which controls the production of novelties in living organisms i.e., when gene mutation takes place. According to this view, mutations are not all entirely random events in the sense defined by Julian Huxley, but are partly of a directed or teleological nature, due to, it is to be presumed, some activity of the psyche, which even in the subconscious level we must associate with the living organism, from the initial stage of its evolution. Probably it is to this psychic element is to be attributed the autonomous activities which characterize the living organism. According to Lillie, the essential peculiarity of vital organization—as contrasted to the non-living part of nature—is that spontaneous factors, whose activities are internally determined and largely independent of present environmental condition and past history, are somehow enabled to assert themselves in a unified and effective manner. Physical research has shown that single microphysical events have a certain degree of

indeterminacy in the sense of not being completely predictable ; thus no one can predict to which of the possible atomic orbits in an excited atom, an electron will jump back. Predictability enters only when a large number of such events are considered ; it is a statistical predictability¹¹.

Of this nature are the decisions taken by human beings at critical situations, the average statistical behaviour of such a person may be predictable, like accidents, death rates, the number of suicides, and so on, each of which has its individual as well its external determination. However this indeterminate characteristic which exhibits itself in simple physical events, becomes in some manner an essential factor in the control of the whole complex system. Of this nature is the control exercised by individual gene on the development of the organism. Gene mutations are believed to be transitions between metastable states of the constituent nucleoprotein molecules. Generally such transitions are of a random character. It is part of my thesis, that under extreme situations such transitions may be directly controlled by the unconscious psyche of the organism. They do not violate any macrophysical laws, but only alter the statistical weight amongst the different permissible transitions. The extreme situation referred to above arise, when the organism has to cope with special environmental situations, and mutations are directed to provide one or other of the functional solutions compatible with the available biological materials. It is on such mutated organisms that natural selection acts.

I am very much aware that there are many unsurmountable difficulties, which I have no time to discuss here, in picturing how directed mutations acting over several generations can produce a structure adapted to the altered environment. I will end this section with a quotation from Lillie¹¹ in which an analogous situation has been discussed, how spontaneous activities can arise in organisms.

“According to the present view, some element of indeterminacy in the sense of present determination, or internal determination, or what may be called “spontaneity” is always present in a natural event, but to a degree which varies greatly in the different instances. Within the vital organization this internal determination is apparently able to express itself in a way which is not possible in non-living systems ; the latter are more directly dependent for their determination on factors external to themselves. Such a conclusion has the advantage of not dividing living systems sharply from non-living systems, and is consistent both with Physics and with the rythm of organic evolution. I may add that I do not underrate the difficulty of understanding how a present activity can have a property which is independent of past conditions. But equally I do not “understand” the natural characteristic of creativity, which nevertheless is an undeniable fact, as human experience and evolution both show. This characteristic is ultimate, as Whitehead insists ; and on the basis of immediate experience, as well as of our scientific knowledge, it seems justifiable to refer it to psychical rather than to purely physical factors, since psychical events are, in a sense peculiar to themselves, a manifestation of novelty or spontaneity as well as of the individuation which is a main characteristic of nature”.

COMMUNICATION AND CONTROL

I now return to the topic with which I started, the discovery that physiological principles of communication and control observed in living organisms has been employed by human beings for similar purpose in the machines constructed by them. J. C. Bose was a pioneer in this line of thought. I find it very suggestive that recent developments in communication technique, based upon electromagnetic theory, electronics, and ultrasonics, which were introduced during the last two wars, should have led to the discovery that analogous methods of communication were already

being employed by animal organisms ; a study of the electronic circuits employed in the construction of computing machines should have given us for the first time a satisfactory working model of the brain. It is difficult for a physicist to accept the view that the principles of communication based upon applications of electromagnetism and electronics, the result of several generations of intelligent human effort, could have been evolved in living organisms by chance variations acted upon by natural selection. Consideration of such problems has led me to believe in the possibility of psychic factor being responsible for giving directional gene mutations.

Animals unlike plants, have to seek for their food, which may be other animals. For this purpose they have developed mechanism for locomotion, and perception of external objects. The animal receives a message through one of its receptor organs, eye, ear etc., which is conveyed as excitation along an afferent nerve to a nerve centre, from where an order is sent out along effector nerves to muscles controlling the appropriate muscular organs. The most widely developed receptor organ in animals is the photoreceptor. The object to be located must be either self-luminous or made visible by diffuse reflection of sunlight or artificial light. The normal eye fails in its function in the absence of light, during the night, in dark caves, in muddy waters, or in the depths of the sea. Some animals have developed alternative modes of perception for location of objects.

The sense organs in the facial pit of blindfolded crotalids—rattle snakes, copper heads, and moccasins—mediate the ability to strike correctly at moving objects such as dead rats, cloth-covered light bulbs, and to distinguish between warm and cold objects. Radiant energy appears to be the effector stimulus. The electric activity of the receptor organ has been studied and it is found to be specially sensitive to radiant heat in the region 1 to 10–15 μ with maximum between 2–3 μ . As

with many other receptor organs, the connecting afferent nerve is traversed by a barrage of rhythmic pulses, whose form is modified when infrared radiation is incident on the receptor⁷. Some fishes employ detector of pressure waves and ripples in water, to locate other swimming fishes. The lateral lines of a cat fish is traversed by barrage of rhythmic pulses which is modified by impact of pressure waves received from the surrounding. Such detector mechanism enable the fishes to keep oriented when they move in schools¹⁶.

In the above instances the organism is a passive receptor of message sent out from some other sources. There are groups of animals who use the principle of echo ranging, first employed during the first war to detect the position of submerged enemy sub-marines. For this purpose pulses of ultrasonic radiations were sent out at regular intervals. In between the pulses, the beam reflected from an object is received by a pair of detectors from which the position of the reflecting object could be located. This echo sounding technique has been used subsequently to measure the heights of the reflecting layers in the ionosphere. For this purpose pulses of e.m. waves of different wavelengths are employed.

In the more recent technique of communication, frequency modulated pulses are used in which the frequency instead of being kept constant is varied between certain limits. The echo sounding technique employing very short e.m. waves has been used to locate enemy airplanes. Originally anti-aircraft guns were directed towards the enemy planes by manual operation, after the radar had located it. Later the reflected beam was used as message to automatically direct the fire of the guns. Here the principle of feedback is employed about which I shall speak later.

Insect devouring small bats *Myotis*, *Pipistrellus* are known to be able to fly in complete darkness. Blind or blindfolded bats can fly normally and capture their preys and they are known to be able

to avoid obstacles formed by a network of wires, with great skill. It was found that on closing the ears these animals lost their faculty of avoiding obstacles. Later it was proved that the animals emit through their open mouth pulses of ultrasonic radiations of continuously varying frequency from 30–120 kilocycle per second ; the pulse duration varies between 1 and 3 m. s., and the number of impulses emitted per second varied from 20–30 for normally flying bats to 50 to 150 per s., when the animal is flying fast or approaching an obstacle. The pulses sent out are what is known as frequency modulated, and has a maximum intensity at 50 kc/s. During flight these bats turn their heads in all directions, like a search light, and thus employ the echo ranging technique to locate hard obstacles. All the details of the method of location are not well understood, specially when the animal is so very near an obstacle, that it receives the reflected echo at the same time it is emitting sound pulses. One of the explanation offered is that the animal adjudges distance by perception of the different tone between the emitted and reflected beam, a kind of heterodyne reception.

Mohres¹⁴ describes another family of echo ranging bats, widely separated from the *Mikrochiroptidae* (var. *Verspertilionidae*) named *Rhinolophidae*. Round the nose of this animals, there is a cone-like attachment made of skin, whose opening can be varied by muscular adjustment. In this type of bats the ultrasonic waves are emitted through the pair of nasal holes with the mouth shut. The sound pulses are undamped and monochromatic, of frequency which varies between 80–100 kc/s according to the different types of animals, and are emitted for 90–100 m/s. The variable cone-like opening as well as the interference between the sound waves emitted through the pair of nasal openings, separated by half a wavelength distance, help to focus the monochromatic sound beam along the median direction perpendicular to the nasal opening. The head is rotated through a cone of 120° opening and obstacle

location is evidently not based on the echo ranging principle.

*Some recent observations of W. N. Kellong and Robert Kohler made on captive porpoises kept in the Oceanographic Institute, Florida, show that these animals can hear sound of frequencies up to 50 kcs. The authors infer that porpoises like bats not only hear but also emit ultrasonic radiations and use an echo location technique to locate objects, including preys during night or when submerged in muddy waters (*Science*, 5–9–52 p. 250).

ELECTRIC ORGAN AND RADAR MECHANISM

I have in a previous section described how in electric fishes the electric organs consisting of columns of electroplaxes, each containing up to 400, have developed from degeneration of muscles. In the electric eel with lengths up to seven feet, the guts are crowded into the first fifth of its length, leaving the remaining four-fifths filled almost entirely by a jelly-like electroplaxes. When stimulated by nerve impulses from the brains, all the plaxes are discharged in series simultaneously. To compensate for the time lag which the nerve impulses from the brain may take to reach the top and bottom layers of the electroplaxes, the short nerve lengths are provided with delay devices, probably in the spinal chord, which compensates almost exactly the differences in nervous conduction times. In the electric eel, only the tail muscle have been converted into electric organ. In the *Torpedo*, one of the muscles which normally move the gills, has been adapted for this purpose. Another electric fish, popularly known as the Stargazer, has its electric organ developed from the eye muscle, while in the electric cat fish of the Nile, the electric organ did not start from a muscle at all, but developed from glands on the skin¹¹. A better example of analogous evolution of the same functional organ in unrelated speies of fishes, in response to a particular environmental situation

could hardly be found. That some of these electric fishes could send out continuous beam of electric pulses was described by H. N. Lissmann¹³. The hind end of the fish *Gymnarchus niloticus*, and particularly the finger-like tail are known to contain tissues corresponding to an electric organ. Probably the electric organs in other fishes like the electric eel (*Gymnotus*), the *Torpedo* or the electric ray may have developed from similar electric pulse emitting organs as in *Gymnarchus*. The pulse frequency vary between 215 to 318 pulses per second, at temperatures between 21°–31.5°C, probably they are of the nature of relaxation oscillations. The fish can detect the pulses emitted by it and reflected from metallic obstacles, as well as pulses emitted by other sources of similar range of frequency. The fishes could steer extraordinarily well when going backwards, evidently without seeing where it was going. Lissmann has found that other fishes like *Mormyrops boulengers* and *Gymnotus carapo*, agree well in all essential features with *Gymnarchus niloticus* though there is a marked difference in pulse shapes and frequencies.

FEEDBACK PRINCIPLE

The mechanism by which these animals locate objects, is one of the innumerable applications of the principle of feedback control of the activities of animals and of machines, either for the purpose of maintaining the *status quo* or for guiding the performance of such organisms towards some defined objectives. Any deviation of the present activity of the organism either from a *status quo* or from approach towards a defined objective, is fed back as information by a receptor mechanism to the controlling agency, calling forth appropriate reaction which opposes such deviation—hence the name negative feedback. I cite some examples.

A thermostatic relay is employed to keep the temperature of a bath constant within certain prescribed limits ; this is done by controlling the supply of heat to the bath, such that with rising temperature the heat supply is reduced and vice

versa. The rotating governors in a steam engine control the supply of steam from the boiler to the moving parts, by cutting off steam when the machine is going too fast. The speed of the engine is thus kept constant under varying loads. In a radio circuit variations in the output due to fluctuations in the input signals, is stabilized by automatic volume controls. Regulators based upon feedback principle are being increasingly used in many industrial processes.

Complex biological organisms can maintain a nearly constant internal environment in face of an external environment which change all the time, often suddenly and unpredictably. Human beings would die quickly if it were not for such characteristics as the intricate thermostat that keeps the body within one or two degrees of its normal temperature. Blood pressure, acid-alkaline ratios, sugar levels in muscle and liver—these and many other factors are regulated within definite limits to maintain health. Distributed all over the body, both on the surface and inside, are receptor organs which are continuously sending messages to the controlling centres in the brain, and when any deviation from the normal state occurs appropriate remedial reactions are set in operation.

Other set of feedbacks refer to our postural and voluntary efforts. As I am sitting on a chair and writing, my sitting posture is maintained by a series of reflexes, based upon messages from what are called stretch receptors attached to muscles controlling posture. Voluntary action is often based upon messages received from outside. A thirsty person sees a glass of water placed on a table, It releases in him a set of muscular activities whose aim is to lift the glass of water from the table and place it to the lips. The eyes continually gauges the distance between the hand and the table. The information is telegraphed to the brain, which passes orders to the arm, hand, and wrist muscles. The first part of the process is completed when the hand has touched the glass. Raising the glass to the

lips calls forth a similar cycle of muscular activities, based on information supplied by the eye. The controlling factor in such cases is the degree in which the act is not completed. Sometimes it happens that the effector mechanism which the negative feedback activates, has a lagging characteristic ; a compensating arrangement is then provided which is of the nature of an anticipator or predictor. When a sportsman goes out duckshooting, the error he tries to minimize is not the position of the gun and the actual position of the target, but with the anticipated position of the latter. Every system of anti-aircraft fire control, has a predictor mechanism to compensate for similar lag effect in the aiming of the guns.

MECHANICAL BRAIN

Computer machines based upon electron relay circuits are employed for fast computation and they perform their operations in an analogous way to the human brain. All the data (information) are inserted at the beginning of the operation. The electron tubes employed have a remarkable similarity to the human brain nerve cells. The machine remembers, chooses between alternatives, checks their own results, and perform so many human operations that in describing them, free use is made of human terms like memory, judgement. The fundamental characterisation shared by brain and computers are, that they are both devices for receiving information and using them to achieve results and solve problems.

Compared to the brain with its 10 billion nerve cells, the calculating machine is bulky, using in the Eniac about 18000 tubes which dissipate several kilowatts of power. Such machines can do arithmetic faster and more accurately than people, they can make elementary judgments, learn in a fashion, remember thousands of numbers and instructions, and forget by simple opening of a switch. They solve the problems men invent, but cannot frame new theories or tell people how to build apparatus to check them.

BODY AND MIND

The living organism has in the higher evolutionary stage evolved an integrating nervous mechanism which it uses to maintain its internal environment at some desired level, as well as to react purposively to some changes in the external environment. These activities have been imitated in a large measure in servomachines, in radars, and in electronic computers. Thus both the metabolic activities as well as these responsible for control and communication in the organism can be described in terms of laws of Physics and Chemistry. On this plane of activity, the organism is an energy system whose activities take place in space and time.

Side by side with the growth in complexity in the nervous organisation which integrates the motor activity of the organism, mind, recognizable mind, appears to have arisen. What was this mind at the beginning, germinating in the primitive animals as appurtenance to motricity ? Natural selection had brought it ; it had some survival value. From it as common germ, has sprung several types of mental experiences, affect (feeling), conation (will), cognition (intellect). What is the relation between the physical and the mental aspects of human behaviour ? In the same cerebral process, on the one side electrical brain potentials with thermal and chemical action, compose the physiological entity held together by energy relations, on the other side, suite of mental experience, activity no doubt but what if any in relation to energy ? There are suggestions for redefining energy so as to bring mind into to. But this according to Sherrington is not possible²⁰. The puzzle appears to be not unlike that in the interpretation of the dual aspect of the behaviour of photon, as well as of matter generally, viz., the necessity of describing them both as particles as well as waves. To overcome this difficulty Bohr formulated his principle of complementarity viz., the complete description of a "photon" or of a material particle, is not possible

either from the wave aspect or from the particle aspect ; but they complement each other. Similarly the description of the activity of a human being, of which only we have a first hand experience, will not, be complete if considered only as an energy system whose activities can be described in space and time, or simply in terms of insensible, i.e., not directly perceptible to the senses, unextended mind. The mind-aspect as well as the energy aspect of the organism can interact with one another, so that its motor behaviour can be due either to an extrinsic cause i.e., dependent of messages received through the sense organ or to an intrinsic one i.e., the activity is initiated by some mental state of the organism.

MIND AS A FACTOR IN EVOLUTION

What has been the role of mental processes in biological evolution ? According to Huxley “Gene mechanism cannot by its nature directly transmit experience or knowledge acquired by the individual organism or the effect of the environment on the organism. It can indeed transmit no mental experience, but only the capacity for having a certain kind of experience, including in certain animals the capacity for learning by experience. It is a purely material mechanism and cannot be operated or transformed except by the difficult and often wasteful material process of selection, natural or artificial”^{10a}. With the gradual evolution of the higher vertebrates, mind instead of being a mere “appurtenance to motricity” began to exert a directive influence on the behaviour of organisms. We speak of intelligent behaviour, when there is evidence of the organism understanding a new situation, and has as well the capacity to vary known methods to apprehend a new desirable objective. In higher vertebrates also, there is some sort of training or education of the offsprings by the parents. But it only bridges the gap between one generation and the next, so that its effect is not cumulative, and there is nothing we can call an

organ of experience, common to the entire species. The mental functions of life were brought into being by natural selection and transmitted indirectly by the vehicles of gene complex. “Before the human level, mental functions and activities have not succeeded in invading the evolutionary process itself”.

In man, development of the techniques of communication by means of speech and writing has made possible a new method of transmission of experience, not only between individuals of the same generation, but between succeeding generations. Thus according to J. Huxley^{10a} was brought into being a new genetics—the genetics of the human society—resting upon a mental or psychological basis of socially transmissible ideas, emotions, or attitudes. One field of human activity where deliberate attention has been given to the technical problem of how to acquire, transmit and accumulate experience—the field of Natural Science—the advancement has been most extraordinary. In the sphere of social genetics, the creative factor, the agency for production of novelty, has been solely the contribution by the mental faculties of man.

The recognizable mind we know of is a product of evolution, and appears at a certain stage when the organism had achieved nervous integration. To explain this appearance, we have to assume with Huxley, that the world stuff possesses not only material properties, but also rudimentary potentialities of mental properties. The question then arises, whether we have to restrict the activity of the mind stuff in the creation of novelty in social genetics only, after the organism has attained a certain technique of communication. To many biologists it appears unreasonable to rule out the possibility, of the psyche exercising some influence in the sphere of biological genetics viz., by influencing gene mutation, the biological mechanism for introducing novelty in organisms. This stand point has been advocated specially by

Lillie, with which I myself with my limited knowledge of Biology, am inclined to concur.

How does J. C. Bose's conclusions quoted in the beginning fit in with the picture of the relation between the non-living and the living I have sketched, and which is based upon investigations extending over the last fifty years. So long as the living organism is considered only as an energy system, his conclusions, though based on very limited data, still remain astonishingly valid. It was an intuition or inspired guess, and was possible in the pantheistic tradition of his country. On the other hand the mental activities of the higher organisms affect, conation, and cognition, escape his conclusions.

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PHOTOVOLTAIC—A HOPE IN THE ENERGY FRONT

S. N. Upadhyay* & N. K. Dutta**

Photoelectric effect is known to scientists for about 150 years, though it has earned recognition for practical utility as Photovoltaic (PV) during last 50 years.

Different aspects of photovoltaic, beginning with its base structure i.e. a solar cell, its working principle, structural arrangements and configurations, operational arrangements for different utility applications along with different factors which influence its optimal performance in actual set up, have been discussed.

Some important features incorporated lately in the fabrication process, which not only enhance the operational efficiency but also lowers the cost of production, have been highlighted.

The areas of application of solar cells have been suitably identified, their present status of usage in India and in other countries of the world have been compared. Some statistical data regarding photovoltaic power generation by different countries along with their research efforts have also been compiled.

The present level of development in photovoltaic is way below the desired level which can really replace the other modes of energy production, specially by conventional energy sources. A long stride is required by mankind to improve on the technology of photovoltaic sooner than later as energy production by conventional methods (specially by burning fossil fuel) is going to diminish very quickly in foreseeable future.

With ever increasing energy demand all over the world, coupled with fast depleting fossil fuel reserves, it is absolutely essential that photovoltaic is harnessed with much more vigour so that ultimately it can take over from conventional sources in due course and save humanity from energy crisis—“a real hope in the energy front”.

INTRODUCTION

A French physicist, Edmund Becquerel, first noted the photoelectric effect in 1839, who found that certain materials would produce small amounts of electric current when exposed to light. In 1905, Albert Einstein described the nature of light and the photoelectric effect on which

photovoltaic technology is based, for which he later won a Nobel Prize in physics. Bell Laboratories built the first photovoltaic module in 1954. It was billed as a solar battery and was mostly just a curiosity as it was too expensive to gain widespread use. In the 1960s, the space industry began to make the first serious use of the technology to provide power aboard spacecraft. The technology advanced through the space programmes, its reliability was established, and subsequently the cost began to decline. During the energy crisis in

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the 1970s, photovoltaic technology gained recognition as a source of power for non-space applications also.

PRINCIPLE

Photovoltaic is the direct conversion of light into electricity at the atomic level. Some materials exhibit a property known as the photoelectric effect that causes them to absorb photons of light and release electrons. When photons of sunlight are absorbed in semiconductor, they create free electrons with higher energies than the electrons which provide the bonding in the base crystal. An electric field is necessary to induce these higher energy electrons and holes to flow out of the semiconductor to do useful work. When these free electrons are captured, an electric current results that can be used as electricity.

Solar cells are made of the same kind of semiconductor materials such as silicon as are used in micro-electronic industry. For solar cells thin semiconductor wafer is specially treated to form an electric field, positive on one side and negative on the other. When light energy strikes the solar cells, electrons are knocked loose from the atoms in the semiconductor material. If electrical conductors are attached to the positive and negative sides, forming an electrical circuit, the electrons can be captured in the form of an electric current—that is, electricity. This electricity can then be used to power a load, such as a light or a tool. So, solar cell is a transducer which converts sun's radiant energy directly into electricity. It is capable of developing a voltage of 0.5 to 1 volt and a current density of 20–40 mA per cm² depending on materials used and sunlight conditions. The schematic diagram of a typical solar cell is shown in **Figure 1**. The working principle of a solar cell is shown in **Figure 2**. The active area of a solar cell is less than the full front surface area because of the need to position opaque conductors on top of the cell to collect the generated

current. Practical top contact structures are generally in the form of comb like grids, so designed as to

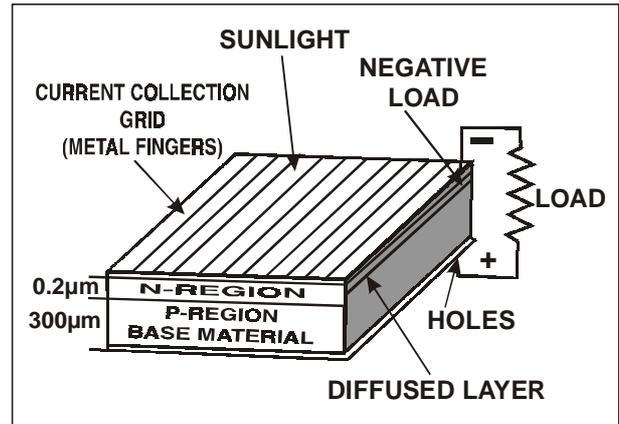


Fig. 1. Schematic View of a Typical Solar Cell

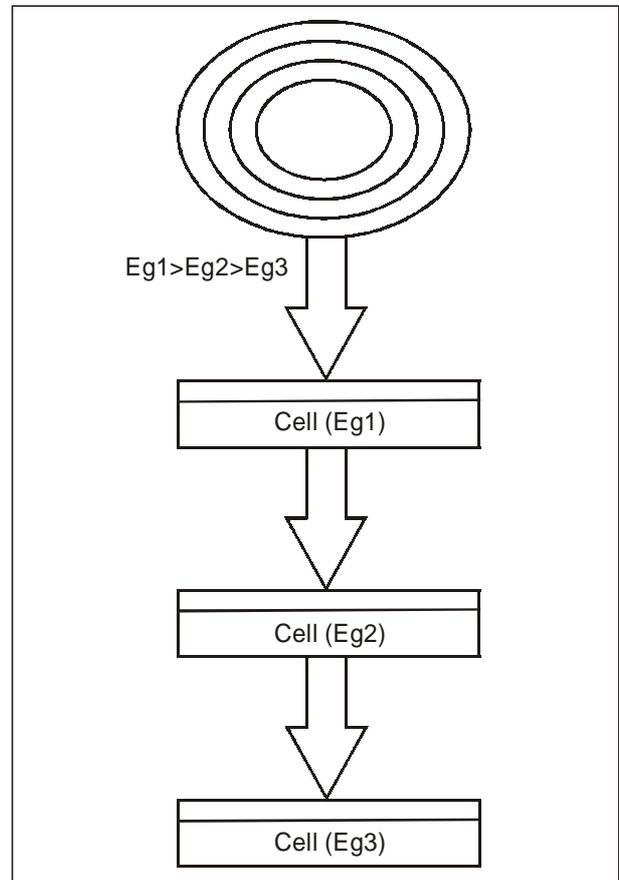


Fig. 2. Working Principle of a Solar Cell

The band gaps have been shown as Eg (1), Eg (2), and Eg (3). The top cell captures the high energy photons and passes the rest of the photons to be absorbed by lower cells.

strike a balance between reduced active area and reduced series resistance brought about by increasing the contact coverage. An anti-reflection coating is often employed to improve the coupling of light into the semi-conductor. The solar cell has to be encapsulated to protect it from atmospheric degradation.¹

TYPES & CONSTRUCTION OF SOLAR CELLS

Two types of solar cells commercially available are single crystal Silicon cells and cadmium sulphide cells. Silicon cells have 10–14% efficiency. Cadmium sulphide/Cuprous sulphide solar cells are not p-n junction type. It provides a charge separation field by the junction of two dissimilar materials that have different band structures. It can be made very thin ($\approx 20 \mu\text{m}$). But its efficiency is poor.

Single Junction PV cell : Today's most common PV devices use a single junction, or interface, to create an electric field within a semiconductor. In a single-junction PV cell, only photons whose energy is equal to or greater than the band gap of the cell material can free an electron for an electric circuit. In other words, the photovoltaic response of single junction cells is limited to the portion of the sun's spectrum whose energy is above the band gap of the absorbing material, and lower energy photons are not used.

Multi Junction Cells : One way to get around this limitation is to use two (or more) different cells, with more than one band gap and more than one junction, to generate a voltage. These are referred to as "multi-junction" cells (also called "cascade" or "tandem" cells). Multi-junction devices can achieve a higher total conversion efficiency because they can convert more of the energy spectrum of light to electricity. A multi-junction device is a stack of individual single junction cells in descending order of band gap (E_g). The top cell

captures the high energy photons and passes the rest of the photons to be absorbed by lower band gap cells.

Much of to-day's research in multi-junction cells focuses on Gallium arsenide as one of the component cells. *Such cells have reached efficiencies of around 35% under concentrated sunlight.* Other materials studied for multi-junction devices have been amorphous silicon and copper—indium di-selenide. As an example, the multi-junction device uses a top cell of gallium–indium phosphide, "a tunnel junction" to aid the flow of electrons between the cells, and a bottom cell of gallium arsenide. The schematic diagram of multi-junction PV cell is shown in Figure 3.

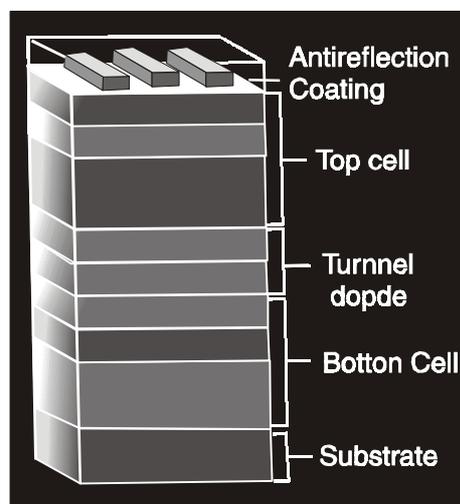


Fig. 3. Multi-Junction Photovoltaic Cell

It is a stack of individual single junction cells in descending order of band gap (E_g). The top cell captures the high energy photons and passes the rest of the photons on to be absorbed by lower band gap cells. *Such cells have reached efficiencies of around 35% under concentrated sunlight⁶.*

PHOTOVOLTAIC MODULE

A number of photovoltaic cells electrically connected to each other and mounted in a support structure or frame is called a photovoltaic module.

Modules are designed to supply electricity at a certain voltage, such as a common 12 volts system. Multiple modules can be wired together to form an array. In general, the larger the area of a module or array, the more of electricity that will be produced. Photovoltaic modules and arrays produce direct current (dc) electricity. They can be connected in both series and parallel arrangements to produce any required voltage and current combination.

SOLAR PANELS

PV modules are normally arranged in “solar arrays” which are sometimes referred to as solar panels. Such solar arrays have been used to power orbiting satellites and other spacecraft and in remote areas as a source of power for applications in roadside emergency telephones, remote sensing, etc. The continual decline of manufacturing costs (dropping at 3 to 5% annually in recent years) is expanding the range of cost-effective uses including road signs, home power generation and even grid-connected electricity generation.

PHOTOVOLTAIC TECHNOLOGIES

Thin film technologies promise further reduction in cost. Standard silicon wafers are 200–500 μm thick. However, in recently improved optical designs only 10 μm thickness of silicon is sufficient to capture all the available light. Some other materials such as amorphous silicon or copper-indium-diselenide (CIS) have higher absorption co-efficient so that thickness of 1 μm is sufficient. A multi junction device has two or more cells stacked on top of each other. The top cell absorbs higher energy portion of the spectrum and the longer wavelength light would pass on to the second cell. Such a cell reduces the energy converted in to heat and thus improves the efficiency to about 30%. **Table 1** shows a comparison of different PV technologies.

Table-1
Photovoltaic Technologies

Technology	Efficiency %	
	cell	module
Crystalline silicon	22	10–15
Multi-crystalline silicon	18	10–12
Thin layer silicon	17	6–8
Thin film amorphous silicon	13	8–11
Thin film copper-indium diselenide	19	12
Thin film cadmium telluride	16	9

PHOTOVOLTAIC POWER GENERATION²

The maximum possible output of a solar array is about 250 W/m². Thus a 250 MW plant needs an array of 1 Sq Km size. The cost is very high. This scheme is suitable for feeding a local load as also for feeding a grid. The concentration and tracking units and storage unit are optional but are invariably present in any set up. The photovoltaic array produces *dc* power and this must be converted into *ac* power for local use and feeding into the grid. An important component of the generation system is the power conditioner which consists of an inverter, a power charging device and control circuitry. The output of the power conditioner can be fed to the local load or to the grid depending on the requirement. In case of low power availability from photovoltaic generation, the local load can be fed from the grid. Some form of energy storage is invariably used so that at times of excess generation, the energy may be stored so that it may be used at times of low generation. The regulation and dispatch unit regulates the flow of power from the photovoltaic power system into the grid and *vice versa*.

Small size photovoltaic power units (of sizes varying from a few watts to a few kW) for local use are being increasingly used. A solar powered battery charger has recently been developed in India. This charger can charge 12, 18 and 24 V nickelcadmium and lead acid batteries for operating mobile radio sets.

Efficiency : An area of major importance is the efficiency of the PV device. When a spectrum of light falls on PV cell, most of the light energy is wasted. About half of the light has so little energy that it can not be absorbed. Moreover, about half of energy absorbed from sunlight is lost as heat to the crystal lattice. The maximum efficiency achievable is only 25%. Practical devices have additional losses. Some electron hole pairs recombine before being collected by the p-n junction. Some resistance loss and loss in shunt path across the junction also occurs. When the cells are combined to form module, some more losses occur. Mismatching of characteristics of cells and loss of active area due to cell shape and contact requirements cause the additional losses when modules are formed. It has been found that production of wafers sliced from castings of polycrystalline silicon reduces the cost³.

STAND ALONE PV POWER GENERATION SYSTEM

A stand alone PV power generation system is ideal for remote areas. To feed such areas from grid requires long transmission system which can not be justified from economic considerations. Operation of a diesel generator at low loads is very costly because its efficiency at part loads is very poor. The rating of such systems is about 10kWp to 100kWp. These are used for battery charging and solar water pumping systems. It consists of a PV array, battery, inverter and charge regulator. The PV array converts solar insolation into electricity. The *dc* output of PV array charges the battery. The inverter converts *dc* into *ac*. The charge regulator consists of blocking diodes in series with PV modules. It prevents the battery from being discharged (through PV array) at night when there is no sunshine. The blocking diode also protects the battery from short circuits. In addition to the above, the charge regulator also prevents overcharging and deep discharging of battery. Another application of stand alone PV power

generation system is for water pumping in remote areas. Either *dc* motor or *ac* motor can be used. These are environment friendly and help in conservation of fossil fuels.

HYBRID SYSTEM

A hybrid system is a photovoltaic diesel system. It has a photovoltaic array (with an inverter to convert *dc* to *ac*) operating alternately or in parallel with a conventional diesel engine driven alternator. The diesel engine alternator supplies the load when solar insolation is not available. Moreover, this system is necessary when the total load requirement is more than that which can be supplied by photovoltaic system alone. The hybrid system can have the following configurations :-

(i) Series configuration, (ii) Switched configuration and (iii) Parallel configuration.

(i) **Series Configuration :** Both the PV array and diesel generator along with the rectifier unit feed the *dc* bus. The inverter is fed from *dc* bus and converts *dc* to *ac* for supplying the load. The power output of diesel generator is fed to battery charger which feeds the *dc* bus. The conversion losses are high because two conversions (*ac* to *dc* and then *dc* to *ac*) are being done. The output of battery charger can be used to charge the battery bank to keep it fully charged. The solar controller prevents overcharging of battery.

(ii) **Switched configuration :** The load can be fed either from PV array or diesel engine depending on the requirement and availability of solar insolation. The system has DC and AC buses. The diesel engine output feeds the *ac* bus which feeds the load directly. Since the load is supplied directly by the diesel generator, the system efficiency is high. During off peak periods, the diesel engine is switched off and load is fed by PV array and the battery. There is a momentary interruption of power to the load when changeover switch is operated to transfer load from one source to the other.

(iii) **Parallel configuration** : This system can supply the off peak load by PV array or diesel engine. However, the peak load can be supplied from combined sources by synchronizing the output of diesel generator with inverter output. The bidirectional inverter can operate in rectifier mode as well as inverter mode. When in rectifier mode it charges the battery from diesel engine output. When in inverter mode, it feeds the load from PV array or battery. The solar controller prevents overcharging of battery. This system can meet the load demand in optimal way by maximizing the efficiency. However, automatic control is required to ensure reliable operation⁴.

SEMICONDUCTOR JUNCTIONS

Modern solar cells make use of semi-conductor materials usually based on single crystal silicon. When doped with phosphorus, arsenic or antimony, the silicon becomes an n-type semi-conductor and when doped with boron–aluminium, indium or gallium, it becomes p-type semiconductor. If a p-type semiconductor is brought into intimate contact with one of n-type semiconductor, they form a p-n junction. Recently Du Pont has introduced silver metallization with significantly lower material consumption and excellent initial and soldered edged adhesion employing leaded and lead free solders. This exhibits low contact resistance, high conductivity and excellent mechanical properties⁵. **Figure 4** elucidates the electric fields connected with a p-n junction.

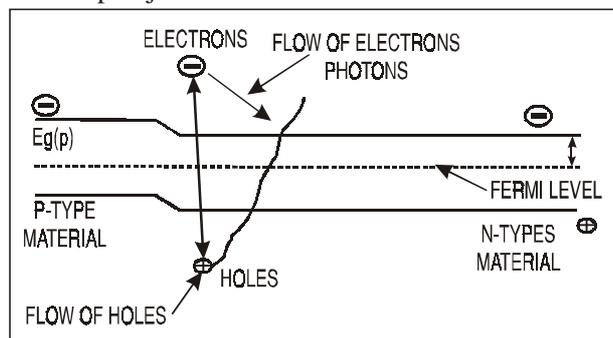


Fig. 4. P-N-Junction Electric Fields
Photons incident upon n-type material surface initiates their charge separation process.

It demonstrates how the p-n junction provides an electrical field that sweeps the electrons in one direction and the positive holes in the other. If the junction is in thermodynamic equilibrium, then the Fermi energy must be uniform throughout. Since the Fermi level is near the top of the gap of an n-doped material and near the bottom of the gap of p-doped side, an electric field must exist at the junction providing the charge separation function of cell⁴.

USE OF SOLAR ENERGY IN INDIA

India happens to be in a region which receives a good quantity of solar heat flux. **Table 2** gives mean daily solar radiations at some places in India.

Table—2
Mean Daily Solar Pradiations at Different Places in India

Place	Mean daily solar radiations (kWh/m ²)	Place	Mean daily solar radiations (kWh/m ²)
Port Blair	4.3	Western Rajasthan	7.4
Madras	5.6	Delhi	5.4
Poona	5.7	Shillong	4.4

At some places in western Rajasthan, the mean daily solar radiation has been found to be 7.4 kWh/m². If it were possible to utilize even a part of this solar heat, the energy problems would be solved for ever. However large scale conversion of solar energy into electricity is not economical as yet. Nevertheless work is in progress at many places to increase the share of solar energy in the total energy program.

WORLD'S LARGEST PV POWER PLANTS^{6,7}

The list below shows the largest photovoltaic plants in the world. For comparison, the largest solar plant, the solar trough–based SEGS in California produces 350MW and the largest nuclear

reactor generates more than 1,000MW. A plant in Australia, is expected to be 154MW when it is completed by 2013. The details regarding solar

power in practical fields. While private companies conduct much of the research on the development of solar energy, colleges and universities mainly

Table—3
World's Largest PV Power Plants

DC Peak Power	Location	Description	MW.h/year
12MW	Gut Erlasse, Germany	1408 SOLON mover	14,000 MW.h
5 MW	Espenhein, Germany	33,500 solar modules	5,000 MW.h
10 MW	Pocking, Germany	57,912 solar modules	11,5000 MW.h
6.3 MW	Mulhausen, Germany	57,600 solar modules	6,750 MW.h
3.3 MW	Hemau, Germany	32,740 solar modules	3,900 MW.h
4 MW	Gotelborn, Germany	50,000 solar modules	8,2000 MW.h
5 MW	Burstadt, Germany	30,000 B. P. solar	4,200 MW.h
4.59 MW	Springerville, AZ, U.S.A.	34,980BP solar modules	7,750 MW.h
4 MW	Geiseltalsee, Merseburg, Germany	25,000 BP solar modules	3,400 MW.h
3.3 MW	Dingolfing, Germany	Solara, Sharp and Kyocera solar modules	3,050 MW.h

Table—4
Worldwide Installed PV Power as at the end of 2005

Country	Cumulative			Installed in 2005	
	Off-Grid PV (kW)	Grid Connected (kW)	Total (kW)	Total (kW)	Grid-Tied (kW)
Japan	87,057	1,334,851	1,421,908	289,917	287,105
Germany	29,000	1,400,000	1,429,000	635,00	632,000
United states	233,000	246,000	479,000	103,000	70,000
Australia	41,841	8,740	60,581	8,280	1,980
Spain	15,800	41,600	57,400	20,400	18,600
Netherlands	4,919	45,857	50,776	1,697	1,547
Italy	12,300	15,200	37,500	6,800	6,500

power generation in Germany and U.S.A. are shown in **Table 3**. Worldwide installed photovoltaic power at the end of 2005 is shown in **Table 4**.

INVOLVEMENT OF SCIENTIFIC COMPANIES & RESEARCH INSTITUTION^{6,7}

Many corporations and institutions use solar

work on solar powered devices. Countries which are particularly active include Germany, Spain, Japan, Australia, China and the U.S.A. Some universities and institutes which have photovoltaic research departments are :-

1. Imperial College of London : Experimental Solid State Physics.

2. Institute de Energia Solar at Universidad Politecnica de Madrid.

3. Centre for Renewable Energy Systems Technology at Loughborough University.

4. School of Photovoltaic and Renewable Energy Engineering at the University of New South Wales.

5. Institut fur Solare Energies Systems ISE at the Fraunhofer Institute.

6. Centre for Sustainable Energy Systems at the Australian National University.

7. National Renewable Energy Laboratory (NREL), USA.

8. Advanced Energy Systems at Helsinki University of Technology.

9. The Centre for Electronic Devices and Materials at Sheffield Hallam University.

10. The Solar Calorimetry Laboratory at Queen's University.

11. Energy & Environment Technology Application Centre at the College of Nano-scale Science and Engineering, University at Albany-SUNY, USA.

ADVANTAGES & APPLICATIONS OF PHOTOVOLTAIC SYSTEMS

Advantages : 1. Long life. 2. Low maintenance cost. 3. Good degree of reliability. 4. Conservation of conventional resources. 5. Saving from pollution.

Applications : 1. Village street lighting. 2. Railway signalling. 3. Unmanned off shore oil platform lighting. 4. Battery charging. 5. Rural telephone exchange. 6. Domestic lighting particulars in villages. 7. Community center lighting. 8. TV and radio-systems. 9. Defence applications. 10. Water pumping. 12. Solar refrigerators. 13. Satellites, etc.

FUTURE PROSPECTS OF SOLAR ENERGY

At current level of prices, solar energy is not economical. But as fuel cost is rising everywhere, the situation could become different after a decade or so. From the experience of other countries, it can be concluded that solar energy should be harvested and research should continue. The low intensity of solar radiation means that collector surfaces have to be very large. A power station of 300 MW capacity may need a collector having an area of 6 square kms. The construction and maintenance of such a solar collector has many problems in addition to requirements of space. Such solar farms have to be situated in remote areas. This would necessitate huge transmission cost.

The above considerations have led to the view that the immediate future of solar energy lies in use of this energy on a small and local scale. Millions of solar water heaters and solar cookers exist in homes throughout the world and their number is likely to increase in every year. Considerable research and development activities are going on at many places to use solar energy economically for agricultural purposes. The US National Science Foundation's research program envisages the future use of solar energy for providing 35% of heating and cooling, 40% of fuel and 20% of electricity requirements. Governments in many countries have liberally funded the solar energy research programs.

CONCLUSION

The global generating capacity of solar power is 5,000 megawatts and the top efficiency of solar cells is 37 percent⁸. Solar cells are poised to become major energy source. New policies could dramatically accelerate that evolution.

Acknowledgement

Authors are thankful to Mr. Neeraj Dhaka, Faculty member-Chemistry Department and

Gagandeep (Student) for providing computer facility required for this work.

Authors express their sincere gratitude to Dr. V. P. Batra, Director, Punjab College of Engineering & Technology for his keen interest in this work.

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DO YOU KNOW ?

- Q1. What does the word Tibet Mean?
- Q2. What is known as dry ice?

AYURVEDA TO OSDD—INDIA'S UNBROKEN TRADITION OF AFFORDABLE HEALTHCARE

Sukanya Datta*

The Council of Scientific and Industrial Research (CSIR) has launched an innovative Internet-based 'Open Source Drug Discovery' (OSDD) programme to eliminate infectious diseases that afflict the developing world by providing affordable drugs especially for the weaker sections of global populations. OSDD relies on knowledge sharing and constructive collaboration. It is an open source platform for both computational and experimental technologies.

INTRODUCTION

Ayurveda, one of the first and finest holistic healthcare systems in the world comes from India. Yoga is a powerful adjunct to it. Ayurveda is amazingly affordable ; depending on medicinal herbs and natural minerals—produce of the earth ; readily available to all. And Yoga needs no paraphernalia at all. Affordable and inclusive healthcare has always been part of India's tradition. Today, when diseases and disorders seem to have eclipsed good health, and the cost of modern drugs has spiralled out of reach for many, India has risen to the challenge to re-usher an age of affordable and inclusive healthcare.

OPEN SOURCE DRUG DISCOVERY PROJECT (OSDD)

Open Source Drug Discovery project (OSDD) is an initiative led by the Council of Scientific and Industrial Research (CSIR) and the brainchild of Prof. Samir Brahmachari, Director General, CSIR.

It is a de-centralized, web-based, global, community-wide effort to deliver the power of genomics and computational technologies into the hands of the young, the capable and motivated, thus enabling students, scientists, technocrats, universities, institutes and corporations to work together. It orchestrates an international collaborative effort to create what is a virtual International Centre for Affordable Health by channelizing scientific ability, political will, industrial participation and philanthropic support that cuts across communities and nations.

OSDD aims to significantly bring down the cost of drug discovery by knowledge sharing and constructive collaboration ; to establish a novel open source platform for both computational and experimental technologies ; to make drug discovery for infectious/neglected diseases, cost effective and affordable, for the people of the developing world. It seeks to discover new chemical entities and to make them generic as soon as these are discovered , so as to expedite the process of drug discovery.

The Government of India has committed Rs. 150 crores (US \$38 million) and already

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released about 46 crores (US \$12 million) towards this project. Further sums will be raised from philanthropic funding, corporate houses and international bodies.

TARGETING TUBERCULOSIS

OSDD has chosen Tuberculosis (TB), an infectious, bacterial disease caused by *Mycobacterium tuberculosis* as its first target. TB is rampant in developing countries. The global statistics are frightening. WHO reports that one-third of the world's population is currently infected with the TB. At least one person in the world is newly infected with the TB every second. An estimated 450,000 new Multiple Drug Resistant-TB cases occur every year. About 5 percent of TB patients are co-infected with HIV. The picture from India is equally stark. The estimated incidence of TB here is 1.8 million new cases, annually. There are two TB deaths every three minutes.

One may argue that there are effective TB specific drugs and it is possible to "cure TB" but not cancer. Although the counter-argument is that percentage wise, more people die from TB than from cancer, the situation is not so simple. The presently used drugs—Rifampicin, Isoniazid, Ethambutol, and Pyrazinamide, are good, but require careful monitoring if drug resistance is to be avoided. Standard therapeutic duration is 6-9 months.

Besides, multi-drug resistant TB (MDR) and extensively drug resistant TB (XDR) are emerging as severe headaches for healthcare workers. The bacterium itself relies on cunning strategy to remain in the body by going into latent state, whereby it survives in host tissues for a very long time. There are no effective drugs for latent TB. As *Francoise Louis*, MSF TB advisor puts it, "*Using the current TB tools to cope with Drug resistant TB is like trying to put out a forest fire with a garden hose.*"

CURRENT GLOBAL INTEREST IN TB

There is no questioning the burning need for a new and affordable drug for TB. But even though the complete genome sequence of the caustive pathogen *Mycobacterium tuberculosis* was published about a decade ago, a TB vaccine and better drugs are still awaited. There are far too few compounds that represent new chemical classes with novel mechanisms of action and a low probability of encountering drug resistance. Early stage drug discovery is the major block on the route to discovering novel drugs for TB. Development of a TB drug pipeline is essential after decades of lack of attention in this area. However, TB is not a priority of the established, large pharmaceutical companies, which are more focused on the disorders and diseases that stalk the affluent countries. As a business proposition, drugs for TB does not represent lucrative profits.

The launch of any modern new drug is prohibitively expensive, because the entire process of drug discovery is resource-extensive. The discovery and development of a new drug costs approximately US\$ 250-800 million. Much of that cost comes from counting the cost of failures along the way, since for every 150 drug discovery projects initiated, only one, makes it to market.. 12 years later! The necessity of providing safeguarding Intellectual Property Rights, maintaining confidentiality of drug development and overheads etc., substantially raises costs. Market size is also a major driving force for new drug discovery programmes. Pharmaceutical companies hesitate in investing in diseases of the Third World primarily because developing economies simply do not represent the market these companies seek for a profitable return of their investments.

Any pharmaceutical company seeking to launch a new drug actively works to guarantee profitable sales. Such companies actively scout the published research papers in their search of drug targets for diseases and disorders that will yield more "returns"

on investments. Very few companies venture into the realm of diseases such as malaria, leishmaniasis, and tuberculosis—essentially problems of the poverty-stricken Third world. Yet can we, in India at least, disown the responsibility that the burden of TB places on us ?

Affordable healthcare is a right for all. But, pragmatically speaking, one needs to strike a balance between health as a right and health as a business. OSDD leaves the latter to large pharmaceutical houses. The OSDD philosophy is that it is the responsibility of public-funded institutions to participate in an open collaborative mode. The success of CSIR's NMITLI project to find an anti-tubercular molecule at low cost has boosted confidence that the collaborative mode through Private Public Partnership could drastically reduce the cost of drug discovery. This new molecule is currently under Phase II Clinical trials by Lupin Laboratories.

THE NEED FOR OSDD

It is clear that we cannot look to the developed countries to solve what is essentially the problem of developing nations. We must help ourselves because these are *our* problems. We must aggressively target these diseases that the world chooses to ignore but which still cast a dark shadow over our country. We also need to make these drugs *at low cost*. In an environment where implementing subsidies and controls may not always be easy, it is best to *discover/invent drugs at a low cost*.

However, this is easier said than done, by classical ; routes at least. OSDD therefore aims to use all available information on TB ; be it on host-pathogen interaction, drug interactions, drug reactions, knowledge available in the literature, or as patents, that can help in target discovery with the help of *in silico* systems biology. Present IT infrastructure, connectivity and high throughput analysis capabilities make this possible. Web-based submission and collaboration and Open Source

approach will allow National as well as Global participation without confidentiality barrier. Web based data will be "Click-Wrap" protected to avoid creation of private good from public good. These will reduce the time taken and also considerably reduce the cost of drug discovery.

Confidentiality and IPR Protection increase cost and decrease free knowledge sharing for drug discovery. Targeted drugs that are market driven—or that which only the affluent can afford—may tread the patent-protected route. But for drugs that are needed by the poor, one may explore the advantages of the Open Source way. The choice of the route taken would depend on the product being considered. An analogy might explain it in an easier way. The strategy used to protect a factory is different from the strategy used to protect a paddy field. It might be worth building a wall around a factory and restricting access, but one does not build walls around paddy fields. This is not to say that paddy is worth less than the goods produced in a factory or that we do not need to protect the paddy field. However, we do need to distinguish between the type of protection that is practical and affordable in the light of the demand and in the light of the potential consumer-base. If we build a wall around a paddy field, then the cost of building and maintaining the wall will add to the price of rice, and the poor will no longer be able to buy it. Open Source works for the 'paddy fields' not for the factory. OSDD will not erect "walls" around drugs that are required by the masses such as those to combat Hepatitis or TB. These will remain inexpensive, because the OSDD programme is dedicated to finding cures for diseases that affect the world's poorest of the poor.

WHY 'OPEN SOURCE' DRUG DISCOVERY ?

"Open Source" is part of a larger IP strategy for CSIR. It is evident that the patent-led approach is a formidable barrier to sharing and exchange of information and knowledge. The emphasis on

privacy and security, and lack of competition, have led to knowledge-deficiency. As a result, many of the pharmaceutical companies have not been able to tap the fruits of the genomic revolution. CSIR hopes to use Open Source for two different projects which may be roughly divided, for purposes of explanation, into (a) Open Source in drug discovery for infectious diseases (especially TB) and (b) Open Source in Pharmacogenomics.

ADVANTAGES OF THE OSDD WAY

Open Source is a development methodology that harnesses the power of distributed peer-review and bestows transparency on a project. The term gained popularity with the rise of LINUX Operating System and more recently, in biology with the Human Genome Sequencing Project (HUGO initiative). Open Source is expected to provide better quality, higher reliability, more flexibility, lower cost, and an end to closed-door activities which increase the drug discovery cost to a great extent.

Drug discovery programs have traditionally followed the closed-door approach and procedures employed therein stunted creative ideas. Entry for the young with dreams in their eyes was barred. Integrative thinking did not receive due importance. Reductionist hypotheses are pursued and the response of the system is usually obtained from direct trial/experimentation. Modeling and bioinformatics are, either not used, or used in a very limited way. Drug discovery, needs to move out from behind the closed doors of pharmaceutical companies and to the Open Sky which is the limitless and borderless land of Intellect. These are the weaknesses that OSDD targets. The sub-projects of OSDD with defined short goals can be implemented at low cost. The Intellectual challenges posed will motivate brilliant young students. OSDD believes a systems-biology approach is indicated, as a large number of genome sequences of various *M. tuberculosis* strains are available.

WORKING THE OSDD WAY

Independent and registered contributors of OSDD share their work through the Internet. CRDD (Computational Resources for Drug Discovery) is an important module of the *in silico* module of OSDD. The CRDD web portal provides computer resources related to drug discovery on a single platform. Any idea, software, article or molecule that helps in expediting the process of drug discovery is treated as a contribution. As part of an on-line community, the contributors work only at their convenience.

The entire process of drug discovery is divided into Work Packages (WPs). The OSDD website posts the WPs and throws these open to anyone with the expertise and desire to solve them. The ability to contribute meaningfully is decided by the type of challenge posted. But since drug discovery calls for many areas of expertise, contributors with different sets of skills can contribute in the area(s) of their choice. This may range from *in silico* target identification to protein purification or even clinical trials. The submitted solutions are peer-reviewed. Appropriate recognition is given for the correct solutions. In addition, challenges are also posted on the OSDD website and rewards (not always cash) given for correct solutions.

Students may register, work and report online as part of their summer projects. Those who contribute get Certificates as per recommendations of a review committee. OSDD welcomes all who are ready to share their time/resources. Registered Users may contribute Intellectual property over which they have exclusive rights, provided they hold the copyright and their action(s) are not in conflict with the policies of their organization.

The OSDD initiative is the second Quit India movement—this time directed against *Mycobacterium tuberculosis*. For more details please visit : <http://www.osdd.net>.

CONCLUSION

A brainchild of Prof. Samir Brahmachari, Director General, CSIR, OSDD provides a global platform for the best minds to collaborate and collectively endeavour to solve the complex problems associated with drug discovery. OSDD believes that drug discovery needs to move out from behind the closed doors of Pharmaceutical companies to the open minds of the younger

generation. It delivers the power of genomics and computational technologies into the hands of the young, the capable and motivated, enabling students, scientists, technocrats, universities, institutes and corporations to work together. OSDD aims to discover new chemical and to make them generic as soon as these are discovered, so as to expedite the processes of drug discovery. It is a decentralized web-based global community-wide effort.

DO YOU KNOW ?

- Q3. What circles the Globe on the logo of the Missionaries of Charity?
- Q4. There are some plants that have no leaves. What are they called?

THE PSYCHOLOGY OF EATING

Paromita Ghosh*

It would be an oversimplification to regard eating as an act entirely governed by biology. Researches reveal that psychological, socio-cultural and economic factors are intertwined with biological ones in the mechanism of eating. The role of psychology manifests itself in learning of food preferences and aversions, the food-mood linkage, the causation of eating disorders, etc.

INTRODUCTION

Although we eat to live, yet most of us harbour the impression that it is the other way round. One reason for this could be that among all our life-sustaining activities, eating is perhaps the most pleasurable. Food comes in umpteen varieties to satisfy the human palate. So eating is determined not solely by biological factors but also by psychological ones.

HUNGER AND EATING

Hunger is generally considered a biological motive. Physiologists tell us that hunger is aroused when the rate of use of nutrients by the body fall below certain set points. The rate of use of glucose¹, free fatty acids and ketones² play significant roles in hunger arousal. Neurons in the brain mainly use glucose as fuel. So neurons of the brain stem and hypothalamus monitor glucose levels. When the level plummets, the activities of these neurons are hampered. This triggers a signal throughout the brain producing hunger³. Besides, receptors in the liver can detect changes in blood nutrients such as

complex carbohydrates, proteins and fats after digestion. The signals from liver are transmitted to the brain through the vagus nerve generating hunger⁴. Two areas of the brain—the lateral hypothalamus and the ventromedial hypothalamus (Figs 1 & 2) integrate the hunger signals.

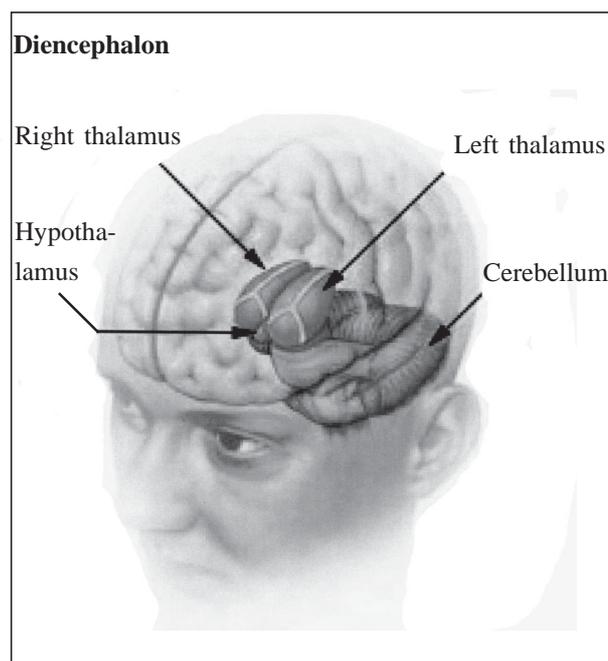


Fig. 1 : Picture of Diencephalon (Posterior Part of forebrain) Showing the Location of Hypothalamus.

Source : Wikipedia (2008).

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These two areas play significant roles in seeking of food, eating and satiety after eating⁵.

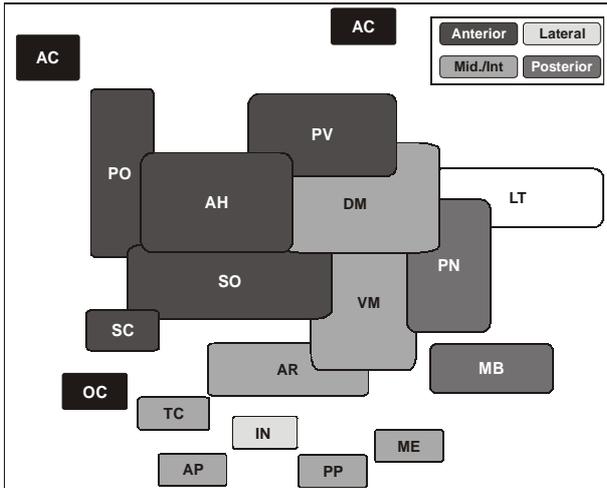


Fig. 2 : Image Of Hypothalamic Nuclei Showing Locations Of Lateral Nucleus (LT) And Ventromedial Nucleus (VM).
 Source : Wikipedia (2008).

The signals of satiety reach the brain in two ways. Firstly, the distended stomach and the chemicals of the consumed food activate the receptors on the wall of the stomach which transmit satiety signals through the vagus nerve to the brain. Besides, when food reaches duodenum (a part of the intestine), a hormone—cholecystokinin (CCK) is released to help in digestion. This hormone travels through the bloodstream to reach the brain. There, CCK is detected by special receptors and the feeling of satiety is generated³. Experience of satiety temporarily inhibits eating.

INCENTIVE VALUE OF FOOD

But there are exceptions to these rules. We eat more of tasty food than our bodies demand. The aroma of *biryani* would prompt an individual to devour it even if he or she is not exactly hungry. The look and odour of tasty foods can promote eating even in the absence of any internal need state⁶. In fact, the senses of smell and taste are

closely related⁷. No wonder, fragrant *pulao* tastes like saw-dust on occasions when our noses are blocked due to cold. However, hunger can enhance the palatability of even ordinary tasting food by means of a neurological mechanism⁸.

EATING AS LEARNING

It is said that one man's food is another man's poison. The impact of learning on eating is perhaps best highlighted by the phenomenon of acquired tastes. For instance, many people would shudder at the mention of the Bengali penchant for fish-heads. Observational learning and conditioning exert powerful influences on eating behaviour. A child born into a vegetarian family observes and learns only to savour vegetarian food. Parents tend to reward children's good behaviour with good food. So children are conditioned to associate eating with feeling good. Frequently food imbues symbolic meanings of love and acceptance. This may be partly because parents express pleasure and praise children for eating well. Such eating experiences firmly establish the linkage between food and feeling good. The linkage is so strong that many adults crave for food to drive away feelings of rejection, disappointment, loneliness and sadness⁹.

The peer-group¹⁰ and the mass-media¹¹ influence eating behaviour specially among adolescents. Teenagers abide by their peers in deciding what is fashionable to be eaten and which food must be avoided. Restricting food-intake is also dictated by the urge to win peer-approval in respect of physical attractiveness. But even peer-culture is controlled by the powerful influence of the media. We are guided by the media in believing certain foods to be beneficial for health, tasty or even fashionable. The Japanese food—*Sushi* has caught our fancy after the media reported it's popularity among celebrities.

EATING DISORDERS

A devastating outcome of the acceptance of the media-generated ideal of slimness has been the rising incidence of eating disorders particularly anorexia and bulimia nervosa. Anorexia is an eating disorder more frequently found among adolescent girls. Persons suffering from anorexia are determined to lose body weight, great deal of it, by self-induced starvation and vomiting, laxative abuse as well as exercising to excess¹². Anorexics typically become alarmingly thin and shrivelled in appearance. The condition can be life-threatening. Apart from biological ones, a constellation of psychological factors may be responsible for the causation of anorexia. These include anxiety over one's emerging sexuality, fear of maturity, burning desire for attaining the ideal of ultraslimness¹², cognitive rigidity¹³ and obsessive compulsive traits¹⁴.

Bulimia is another eating disorder which is found more in females in their late teens to late twenties. In this disorder, the affected person experiences recurrent episodes of secretly consuming large quantities of food and purging it out of the body with self-induced vomiting and laxative abuse. The body shape and weight are thereby maintained within normal limits¹⁵. Bulimics seem to be plagued by impulsivity¹⁶, low self esteem and preoccupation with body-weight¹⁷. Men also suffer from anorexia and bulimia. But the proportions of the male-sufferers are less than those of the females. The sociocultural phenomenon of the objectification of the female body explains the greater prevalence of these disorders among girls and women. This phenomenon mandates that women have to look beautiful (hence slim). The media propagate such objectification so powerfully that many women learn to regard their own bodies as objects. They succumb to eating disorders as they constantly monitor their appearance in order to look as desirable as possible. Anorexic and bulimic men,

albeit, fewer, tend to underestimate their body sizes and desire more muscular bodies. They typically rely more on excessive exercising in their quest for the perfect physique¹⁸.

The other end of the spectrum of eating disorders are inhabited by obese persons. Their body-weights are abnormally high. Obesity can be life-threatening because co-morbidities include hypertension, heart disease, stroke and Type II diabetes¹⁹. Besides the biological causes of obesity, the psychosocial causes include compulsive overeating and recurrent bingeing (i.e. uncontrollably eating a large quantity of food within a short period). Obesity is thus associated with faulty dietary habits, inability to identify bodily signals of hunger and satiety²⁰, habit of overeating to relieve emotional distress⁹ and lack of restraint²¹. However, eating disorders do not merely pertain to undereating or overeating of food but also include eating of non-food substances.

EATING INEDIBLES

Pica is an eating disorder which is characterised by persistent and compulsive urge to eat non-food items like coal, soil, chalk, paper, paint, glue etc²². Although babies have tendencies of exploring the environment by putting any substance they come across into their mouths, yet they are not considered as pica-sufferers because such behaviour is developmentally-appropriate at that age. Only a person over two years of age can be diagnosed as suffering from pica provided he/she displays this maladaptive behaviour pattern persistently. Pica may result in fatalities due to lead poisoning, severe anaemia, etc²³. It may be found in persons with autism, mental challenge, brain damage, epilepsy, obsessive-compulsive disorder and schizophrenia²². However, some apparently normal people may also be suffering from pica. The psychosocial causes of pica include early experiences of maternal deprivation, parental separation, parental neglect, child abuse²³, enduring

tendency of oral fixation (the person is comforted by having things in his/her mouth) and lingering stress²².

THE FOOD-MOOD LINK

There seems to exist a two-way relation between food and mood. On the one hand, mood may influence food selection and consumption pattern. For instance, stress may bring about preferences for unhealthy, high-fat foods over healthy, low-fat alternatives²⁴. On the other hand, food may alter the mood experienced by a person. Eating carbohydrate-rich foods like rice, *roti*, sweets etc. increases the level of the neurotransmitter—serotonin making us feel calm, content and happy. Cutting down such foods lowers serotonin level inducing insomnia, aggressive behaviour, food craving and sad mood²⁵. The mood-uplifting action of chocolate can be attributed not only to serotonin-release but also to its caffeine-content which stimulates and energises a person²⁶.

CONCLUSION

Thus there is some truth in the adage—we are what we eat. The apparently simple act of eating embodies complex interplays of biological, psychological, socio-cultural, geographical and economic factors. Of course, we are oblivious of these mechanisms when we enjoy the sensual pleasures of eating.

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DO YOU KNOW ?

- Q5. What is the graphic symbol of Euro?
- Q6. From which animal do we get *catgut*?

INSECTS : FRIENDS OF MAN AND ENVIRONMENT

R. K. Choudhary* and M. C. Bhargava*

Insects play a vital role in maintaining the quality of life in the biosphere. In this article the beneficial role of insects in human welfare is dealt critically. The diversity of insects play a crucial role in maintaining the quality of ecosystem.

INTRODUCTION

Insects belong to the Phylum Arthropoda (Arthropoda = Joint legged) and class Insecta (Hexapoda=six legged) and form the largest group among all animal kingdom. Of all the 1.7×10^6 species described approximately 45,000 are vertebrates, 25,000 are plants and 950,000 (56%) are insects. The described insect species are coming under 30 orders. They are one of the most diverse groups of animals. Having their origin in the Carboniferous period of Paleozoic era, insects conquered almost all ecological habitats. No other group of animals is adapted to live in so diverse a habitat as the insects. They live in all corners of the earth from the poles to the equator, in soil, in fresh water, in hot springs, on all sorts of plants and animals (dead or alive), in pools or crude petroleum, in argol, opium, pepper or stychnine. Their highly adapted features enable them to lead aerial, arboreal, burrowing and aquatic life. From the very childhood we tend to look upon these creatures as the most disgusting things on the earth because of their damaging activities to crops and other human welfare. But this is not always true ; this does not diminish their beneficial roles in any

way. Some of the beneficial roles are discussed below :

USEFUL PRODUCTS

Many insects and insect products have been in the use of mankind from time immemorial. Insect products of commercial importance are the following :

(i) Honey and bee wax : Honey has been used by man for various purpose from ancient days. It is used as food, medicine and preservative. There are about 20,000 kinds of bees, all belonging to the insect order Hymenoptera. Of them, three families of social bees, *i.e.* Bombidae, Maliponidae and Apidae, are honey producing. Among these, Apidae is the main honey producing family. All the four species of honey bees, *viz.*, *Apis carana*, *A. dorsata*, *A. florea* and *A. mellifera* are found in India. The *A. mellifera* has been introduced and acclimatized in India for the last about 40 years. The present production of honey in India is estimated at about 30,000 tonnes. Bee wax made from honeycomb is used for making candles, polishes, wax threads.

(ii) Silk : Extraction of silk was a contribution of Chinese civilization. Silk has been used as thread, fabric, etc. for hundreds of years. Silk is extracted from the cocoons of silk worm moths (*Bombyx*), wildy reared species for the production of silk is *Bombyx mori* (family : Bombycidae,

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order : Lepidoptera), *Antheraea paphila* (Tassarworm) and *Philosamia (Attacus) ricini* (Eriworm) (Family : Saturnidae) are other silk producing species which are reared on low scale. A single cocoon yields more than 3000 meters of fine silk thread. Textile industry is heavily dependent on natural silk as the world market requires about 30 million kg of silk every year.

(iii) Lac : Lac is the resinous substance by a scale insect popularly known as the lac insect (family : Lacciferidae, order : Hemiptera). The Indian lac insect, *Laccifer lacca*, females of which provide the stick lac which is commercially very important. Other species that occur in India includes *Laccifer albizziae*, *L. ebrachiate*, *L. fici* and *L. indicola*. Lac, one of the ingredients of shellac, has got multiple uses in the manufacture of sealing wax, varnishes, polishes, pottery, toys. etc.

(iv) Dyes : Dyes are used to colour textiles, paper, leather, etc. Dried bodies of certain scale insects (Coccidae, Datctylopius) yield dyes like tannin, cochineal and crimson colour dyestuff, which was earlier used to dye the robes of the kings and nobles and in the west, also the sweets. These scale insects mainly live on cacti plants feeding on its plant juice. Advent of synthetic dyes like Aniline dyes have replaced natural dyes to a greater extent.

(v) Galls : Galls are tumourous outgrowths on the surface of plants induced by insect inflicted injuries. They yield valuable materials like tannic acid and dyes. Tannic acid occurs in high percentage (30-70 per cent) in many of these galls which is used for tanning animal skin (leather) from centuries. Dyes obtained from some galls make the finest and most permanent ink. African Somali women use gall dyes for tattooing. Certain galls are of genuine medicinal value. Aleppo gall or gallnut of Western Asia and Eastern Europe have been used in medicine since 5th century B. C. It is a powerful vegetable astringent, tonic and antidote for certain poisons.

INSECT BIODIVERSITY

The more diverse the animal community in an ecosystem, it is more stable. Species diversity among insects is amazing which varies from microscopic forms (Hymenopteran parasitoids, 0.2 mm) to large form (Atlas moth, 120 mm), and from wingless to winged ones. Many insects are awaiting discovery especially in the tropical rain forests of Asia, Africa and American continents. The diversity of insects plays a crucial role in maintaining the quality of ecosystems. Species diversity is also a source of genetic diversity, the future use of which to the mankind is even beyond prediction. Insect genetic resources may especially help in agricultural and medical researches. Many insects act as control agent in plant population dynamics, other help in pollination, seed dispersal etc. Actually insect diversity is an indication of plant diversity and *vice-versa*, some of the insects being highly specific to certain kinds of plants.

POLLINATORS

Nature prefers cross-pollination to self-pollination as the former enhance the diversity, vigour and viability of plants. Of the wide variety of pollination mechanism evolved by nature, entomophily (pollination with the help of insects) is unique in many ways. Insects, particularly the bees, butterflies, moths and thrips are the main pollinators. In many cases, floral parts of plant species are especially modified to facilitate entomophily (e.g. bean flower). Some plants would produce no fruits and seeds unless pollinated by insects. They are all common fruits, figs in particular, peas, many vegetables, sunflower, chrysanthemum, yukka and ornamental plants. Some insects and plants are mutually dependent on each other as the flower provides nectar and pollen to insects and the insect in turn help in pollination. It is estimated that insects pollinate 50-70 per cent of the grain crops, bulk of it by bees alone.

INSECTS ACT AS BIO-CONTROL AGENTS

Apart from pollinating agricultural crops, insects act as effective bio-control agents against pest. In the present context, as we are becoming aware of the harmful effects of chemical insecticides, the role of bio-control agents are more relevant. Many insects act as predators and parasitoids of destructive pests of the insect order Lepidoptera, Diptera, Coleoptera, Hemiptera and Orthoptera. Major predators are dragonflies, mantids, ladybird beetles, wasps, antlion, ground beetles, belong assassin bug, hoverflies and robberflies. Major groups of entomophagous parasitoids belong to order Hymenoptera and Diptera. The well known Hymenopteran parasitoids acting as bio-control agents are Ichneumonids, Chalcids, Proctotrupoids, Evanoids, etc. The first well planned and successful biological control attempt was undertaken during 1987-88, when the developing citrus industry in California (USA) was seriously threatened by the cottony cushion scale, *Icerya purchasi*, which was controlled by Vedalia beetle (*Rodolia cardinalis*) imported from Australia. In india, many predators and parasitoids are employed against different crop pests, for example species of *Trichogramma* are used against paddy stem borers, sugarcane shoot borers, cotton bollworms as egg parasitoids, *Epiricania melanoleaea* employed against sugarcane pyrilla as egg and nymphs parasitoids. The soft-bodied insects like aphids, jassids, white flies are effectively controlled by the beetles of family Coccinellidae (*Coccinella septempunctata*, *Menochilus sexmaculatus*) and larva of *Chrysoperla* sp. Recently, an entomologist of the Department of Agriculture, Tifton, Georgia (USA) extended biological (truly a microbial) control by virus spread by honebees. As the bees crawl out of their hive, they are made to walk on talc mixed with virus in a tray. When they move from flower to flower in search of pollen and nectar, on plants attacked by corn earworm, they infect the worms with the virus, which later kills them. Many insects are

widely used as laboratory host for the production of biocontrol agents ; the eggs and larvae of *Corcyra cephalinica* are used for the production of different egg and larval parasitoids. Predator *Crysoperla*; the larvae of *Heliothis* spp, and *Spodoptera litura* are used for the production of larval parasitoid *Compoletis chloridae*; *Cydia pomonella*, *Heliothis* spp, *Agrotis segetum* are used for the mass production of viruses; the larva of *Corcyra cephalinica* and *Spodoptera litura* are used as host in the mass multiplication of entomophagous nematodes.

INSECTS AS SCAVENGERS

Scavengers play a prominent role in the ecosystem, effectively utilizing the energy and nutrients from the dead bodies and waste material of plants and animals by decomposing them. Insects consume dead bodies of plants and animals and thus keep our air clean. It is a common sight to see insects collecting over bodies of dead road-side animals and eating them. Such road-side deaths are much fewer than those occurring in inaccessible places like jungles, deserts and mountains. If the carcass are not quickly eaten away by insects, the environment of the entire earth will get filled with stench of rotting flesh making it impossible for us to live. Well known insect scavengers are the dung roller beetles, borers of dead wood, termite, fleshflies, hoverflies, etc. Termites, ants and beetles degrade plant materials and enrich the soil with nutrients.

INSECTS SERVE AS FOOD FOR ANIMALS AND EVEN MAN

There is not a single phylum of animals from Amphibian to Mammalian whose members do not feed on insects. Various insects and their larvae are a source of food to different kinds of animals including man, fish, frogs, snakes, lizards, birds, anteater, etc. In many parts of the world, from ancient time to the present day, man has extensively

consumed insects. Grasshoppers, locust, crickets, beetles, caterpillars, pupae of moths and butterflies, termites, insect's eggs, etc. have been prized as food for most of the primitive races of the world including India. Termites are widely eaten in tropics. Native of America eat many kinds of ants. Insects serve as food for many carnivorous plants.

INSECTS IN SCIENTIFIC RESEARCH AND MEDICINE

A numbers of insects are used in biological research, a well-known example is *Drosophila*, used in genetic studies. Low cost of upkeep, rapid multiplication, easy to handle and their hardiness make insects ideal experimental animals for investigations in all branches of biological sciences. Studies on social insects (bees, ants and termites) have thrown new lights in the field of socio-biology. Insects and their products have medicinal value also. Maggots of certain flies have been used in the treatment of wound healing. Honey is a natural antiseptic applied on wounds and burns. Bee poison is used in the treatment of certain nerve disorders, arthritis and in the preparation of certain antivenoms. Bee wax is used as base for ointments. Cantharidin, a substance obtained from blister beetle, act as internal stimulant, diuretic and hair tonic. The eggs of red ants are used as a constituent of medicine for the control of Malaria. Extract of mulberry silk cocoons is believed to check profuse menstruation and chronic diarrhoea.

POLLUTION INDICATORS

Many insects can be used as environmental pollution indicators (they indicate the quality of the ecosystem) in both aquatic and terrestrial ecosystem. A 100 years ago all individuals of the moth, *Biston betularia* were white, lightly speckled with black and so their name, peppered moth. To day, they have turned dark or black in heavily industrialized regions of the English midland due to smoke produced by the industries. Caddisflies

are affected by the changes in quality of water. Many flies are immediate sufferers of acid rains. Studies in Europe show that the mayflies (*Baetis rhodani*, *B. lapponicus* and *B. macani*) usually disappear from acidic system.

AESTHETIC AND ENTERTAINMENT VALUE

Insects have catered to the aesthetic needs of man for a long time. Their structure, beauty, wing colour, flight and sound served as models for artists, florists, textile designers and interior decorators. Butterflies and moths are preserved in show cases. Paintings of many insects can be seen in ancient artwork. Beautiful insects serve as the subject matter of poems from time immemorial. Colored wings and elytra of some Coleoptera are used in jewellery, embroidery, pottery and basket making, brilliant luminescence of glowworms and fireflies create interest in both scientists and layman alike.

INSECTS IN FORENSIC SCIENCE

Insects are being used to solve murder mysteries and evidences based on them are now being accepted by courts of law. Insects are utilized in searching dead bodies and murders weapons. By identifying insects and their stages on the corpse, the scientists are able to estimate "the time since death". From forensic entomology, one can know the time approximate near the occurrence of crime (murder) which of course can go a long way in solving the mystery of crime.

SUMMARY

Insects play a vital role in maintaining the quality of life in the biosphere. We should pay equal or more attention to the beneficial role that insect play for human welfare. Even traditional knowledge on insects and insect products are not fully evaluated. Rearing of honeybee and silkworm moth can be further expanded on commerical lines,

which in turn may provide ample employment opportunities to the rural population. Insect diversity and its usefulness to mankind are not fully explored. Currently more attention is being paid to the destructive insects, particularly in their control strategies. Biological control programmes employing insect predators and parasitoids are in full swing in developed countries. As an agricultural

country, in India there is tremendous scope for such researches. Industrial and medicinal entomology possibly can make use of the potential of many more insect species that are yet to be discovered. But indiscriminate destruction and over exploitation of natural habitats are leading to the extinction of several insect species even before they are given a chance to service us.

DO YOU KNOW ?

- Q7. When was the *second* first used as a unit of time?
Q8. How small can be a full grown horse?

ELECTRONIC WASTE

Dipak Bagai*

The article deals with the emerging problem of electronic waste as a serious environmental concern. Every year due to fast obsolescence along with rapidly evolving technology, a large number of electronic products have been discarded which pose a serious crisis in human health and environment.

Our planet is at a critical crossroads. As the high tech revolution evolves at an ever accelerating pace, so do the health and environmental concerns. The "Information Age" has created a society that is global, informed, wired and connected. In the past few years, technological advances in electronics have boosted the economy and improved the general lifestyle of a common man. The ever growing dependence on electronic products has paved the way for an emerging environment concern, called "Electronic Waste". Every year, an estimated 100 million computers and other electronic devices break or become obsolete and are discarded. Electronic waste, or e-waste, is an emerging problem as well as a business opportunity of increasing significance, given the volumes of e-waste being generated and the content of both toxic and valuable materials in them. E-waste is a popular informal name for electronic products nearing the end of their "useful life." Computers, televisions, VCRs, stereos, copiers, mobile phones and fax machines are common electronic products. Many of these products can be reused, refurbished or recycled. Unfortunately, electronic discards is one of the fastest growing

segments of our nation's waste stream. E-waste has become a problem of crisis proportions because of two reasons. Firstly, E-waste is hazardous as the vast amount of computers, televisions, mobile phones and other electronic products that are disposed of every year all contain a variety of toxic substances. When discarded electronics is dumped in landfills, or when the waste is incinerated, contaminants and toxic chemicals are generated and released into the ground or air risking pollution of the environment and toxins entering the food chain are astronomical. Another reason is E-waste being generated at an alarming rate, due to fast obsolescence along with rapidly evolving technology.

CONSTITUENTS OF E-WASTE

Electronic and Electrical equipment, consist of multiple components, some having toxic substances that can affect human health and environment, if not properly managed. Generally, these hazards occur on account of improper recycling and disposal methods adopted. There are number of harmful substances (metals) found in e-waste. "*Antimony*" is used primarily in flame proofing, paints, ceramics, alloys, electronics and rubber. Antimony is increasingly used as an alloy that greatly increases lead's hardness and strength. Its most important use is as a hardener in lead for storage batteries.

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Antimony and its compounds in small doses cause headaches, dizziness and depression, while larger doses can cause violent and frequent vomiting. "**Arsenic**" is found in small quantities in the form of gallium arsenide in light emitting diodes. Arsenic is a poisonous metallic element and chronic exposure to it can lead to skin diseases and lung cancer. "**Barium**" is a metallic element used in sparkplugs, fluorescent lamps and in vacuum tubes. It generates poisonous oxides in contact with air. Exposure to barium can lead to muscle weakness, liver and heart problems. "**Brominated Flame Retardants (BFRs)**" is used in the plastic housings of electronic equipment and in circuit boards to prevent flammability. More than 50% of BFR usage in the electronics industry consists of tetrabromo-bis-phenol—(TBBPA), 10% is polybrominated diphenyl ethers (PBDEs) and less than 1% is polybrominated biphenyls (PBB). "**Beryllium**" found in power supply boxes contain cancer causing agent for lungs. "**Cadmium**" is present in rechargeable NiCd-batteries, CRT screens, printer inks and toners. Cadmium components, absorbed through respiration, seriously affect the kidneys. "**Chromium**", found in data tapes and floppy disks, is used because of high conductivity and anti corrosive properties. Chromium (VI) compounds are irritating to eyes, skin and mucous membranes. It can also result in DNA damage. "**Lead**" is found in CRT screens, batteries and printed circuit boards. It is also used in solder, lead acid batteries, electronic components and cable sheathing. Exposure to high amount of lead can result in vomiting, diarrhoea, appetite loss, abdominal pain, constipation, fatigue and sleeplessness. "**Mercury**" is used extensively in fluorescent lamps, LCDs, alkaline batteries and mercury wetted switches. It is a toxic heavy metal, that bioaccumulates, causing brain and liver damage, if inhaled. Excessive exposure to "**Selenium**" used in photocopying machines, can cause selenosis, leading to hair loss, nail brittleness, and neurological abnormalities. "**Polyvinyl**

chloride" (PVC) is an extensively used plastic in electronic appliances. PVC is harmful as it contains about 55% chlorine, which when burned, gives rise to hydrogen chloride gas. This combines with water, to produce hydrochloric acid and if inhaled, can lead to respiratory problems.

There are a number of valuable substances in electronic waste. Gold, Silver, Aluminium, plastic etc. are prestigious materials, which recyclers recover from e-waste. "**Silver**" is used mainly in connectors and PWBs to provide conductivity. In mobile phones, it is typically used in the electronics and keypad contacts in the elemental form. "**Gold**" is used in marginal amounts in connectors and PWBs. It is used to provide conductivity and connectivity. Gold has no harmful effects on environment and humans and it can be obtained again after recycling process. "**Aluminium**" is present in almost all electronic products in large quantities. It also provides conductivity. Its less cost, compared to gold & silver and because of its easy recyclability, aluminium is used extensively.

DISPOSAL OF E-WASTE

The e-waste that is generated can be recycled, reused, and disposed off in landfills or incinerators. The reuse and recycling of outdated electronic products minimize the hazardous effects of electronic waste on the environment. Reuse and recycling also boost energy and resource conservation. After all possibilities for reuse have been exhausted and a computer is slated for disposal, is sent for recycling. By this it is meant that the old raw materials are reclaimed for use in making new products. However, the costs of recycling are still very high due to which most recyclers are not very much willing to take computers for recycling. If the waste cannot be even recycled then it is either sent to landfills or is burnt in incinerators.

Dumping waste in to landfills contaminates the ground water and soil. Toxic chemicals in

electronics products leach into the land over time or are released into the atmosphere. These toxic substances can migrate into ground waters, and eventually into lakes, streams, or wells, and raise a potential exposure to humans and other species by entering the food chain.

Burning electronic products into incinerators leads to the formation of toxic gases due to the presence of heavy metals such as lead, cadmium and mercury. Mercury released into the atmosphere can bioaccumulate in the food chain, particularly in fish – the major route of exposure for the humans. Brominated flame retardants generate brominated dioxins and furans when e-waste is burned. If incineration is not at a sufficiently high temperature and sustained for a sufficient time, the plastics and other hydrocarbons may not be completely oxidized to carbon dioxide and water, and may combine with halogens to form new halogenated hydrocarbons, including dioxins and furans.

E-WASTE AND INDUSTRY

It is a proven fact that, all who produce, distribute, use and dispose of electronic products, have a moral responsibility towards managing electronic waste. Electronic equipment manufacturers should ensure that their products contain lesser toxic constituents, more recycled content and are designed for easy upgradation and disassembly. Initiatives have been taken by some leading companies in this regard.

- A new packaging technology is already in the offering at Anadigics, which will enhance its product's moisture sensitivity level.

- National Semiconductor reveals that most of its products are now lead free (except solder). It has also banned the use of cadmium, mercury and chromium in its products.

- Nokia has created a list of hazardous substance which will not be used in their products and has sent the same to its suppliers.

- The design of Hewlett-Packard's Office Jet 500 multi-purpose printer has eliminated the need for plastic flame retardants by using a metal chassis and power supply enclosure, utilizes light-emitting diodes (LEDs) instead of a mercury lamp for the scanner, and eliminates the need for batteries by using flash memory technology.

- Apple's Macintosh Power Books have used longer-life, less toxic rechargeable lithium-ion batteries for the last three product generations, in place of nickel cadmium batteries.

- The primary plastic resin used in Intel's PCs and servers (ABS + Polycarbonate) have no flame retardants containing PBBs or PBDEs. None of their products contain asbestos, or include lead or cadmium as plastic additives.

- Panasonic is the first company to apply reflow type lead-free soldering to compact portable mini-disc player PC boards. Its video equipment division has been developing a low-cost tin-copper base solder.

- At Motorola, housings are made of standard engineering plastics. Several Motorola phone models have eliminated the use of brass inserts in their plastic housings.

Finding methods to keep electronic waste out of landfills is a challenge now for all the electronic product manufacturers, recycling and waste management organizations, government agencies and environment management organizations. Indian Govt. should draft legislation in this direction. If all consumers plan to phase out their obsolete computers and other electronic products at the same time, the country may face a tsunami of e-scrap. Ultimately, it is the balance of nature, which always holds supreme.

PRODUCT DEVELOPMENT USING WATER HYACINTH

Meenu Srivastva and Priaynka Rawat*

The present study was conducted in Udaipur city to explore potential uses of water hyacinth for its eradication by developing value added products. It has been found that the water hyacinth pulp has good potential in developing handmade paper that can be used in making value added products.

INTRODUCTION

Water hyacinth (*Eichhornia crassipes*) is a noxious aquatic weed which changes its bio-diversity with devastating effects on environment by blocking canals and pumps in irrigation projects, interfering with hydro electricity production; and clogging river and canals such that the drainage becomes impossible and there are floods. It has posed ecological and economical problems especially in tropical and subtropical countries where environmental conditions help grow hyacinth althrough the year. Water hyacinth is well known for its ability to loose water rapidly through its leaves by transpiration. Thus the plant appears to derive its Hindi name “*samundra sokh*” which can absorb ocean. In Rajasthan, it is widespered and Udaipur, famous as the city of lakes or Venice of the east, is no exception, with most of its lakes, ponds etc. covered with water hyacinth, badly affecting the beauty of the lakes and in turn tourism.

The massive growth of water hyacinth is a direct result of human activities—We pollute water bodies and the water hyacinth thrives on nutrient rich water. Though there are various physical and chemical methods of controlling aquatic weed, all are painstaking and expensive.

Complete eradication of noxious species has never been possible. Mechanical removal generates large amount of plant biomass which, if not removed, adds to the same problem. Therefore, scientific interests have been directed towards the utilization aspects of water hyacinth for fibre extraction and pulp for paper making in conjunction with manual or mechanical harvesting to recoup some costs.

Products development from water hyacinth requires study of the morphology and physical properties of water hyacinth, fiber and pulp processing and assessment of the usefulness and cost effectiveness of the developed products.

METHODOLOGY

Various steps in water hyacinth work are follows :

- *Collection of raw materal* : The water hyacinth—an aquatic weed was collected from Udaipur city. The stems were used for the extraction of fibre and pulp making.

- *Extraction of fibres* : Water hyacinth fibres were extracted by chemical retting process. The cut, split stems were air dried for 4-6 hours in the direct sun and then dried stems were immersed in sodium meta-bisulphine/aqueous KOH in required amount of water.

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- *Testing of physical properties of extracted fibres* : The water hyacinth fibre were conditioned for 48 hours under the testing atmosphere of $65 \pm 2\%$ rh and $20 \pm 2^\circ\text{C}$ temperature. The fibre were tested for various physical test such as fibre length, diameter/breadth, cell wall thickness, fineness, tensile strength/elongation.

- *Pulp making and development of handmade paper sheet* : The cellulosic material obtained as waste after the fibre extraction process were used for making pulp. The pulp was utilized for developing hand made sheet in three different ratios i.e. 1:1, 1:2, 2:3.

- *Testing of physical parameters of developed handmade sheet* : The developed handmade sheets of selected different ratio and a varied GSM were analysed for its usefulness. The different papers conditioned for 24 hours kept in a chamber under the testing atmosphere of $65 \pm 2\%$ rh and $27 \pm 2^\circ\text{C}$ temperature. Sheets were tested for various physical parameters such as brightness of paper, opacity, porosity, bursting strength, tear strength, basis weight, printability.

- *Brightness of paper* indicates the degree of whiteness measured through reflectance by white or near white paper at a single wave length, 457 mm (blue region of visible spectrum). It is a test to measure the effectiveness of bleaching in removing yellowness from pulps and for measuring ageing of paper. For testing the brightness of paper, Technibrite Micro TB instrument was used.

- *Opacity* is the ratio of the reflection of a single sheet backed by black body to the reflectance of a single sheet backed by a white body having an absolute effective reflectance of 89 percent. For testing the opacity of paper, Technibrite Micro TB lc. was used.

- *Porosity* of containing connected air voids depends upon the number of voids and their distribution in size, shape and orientation. It indicates how a sheet will respond to fluid penetration. The rate of filtration of air through a paper was measured by using Gurley Densometer.

- *Bursting Strength* of paper was determined using IS : 1060 (Part-1) 1966 test method. It is the ability of a sheet to resist rupture when pressure is applied to one of its side. It is measured by the pressure developed behind a circular rubber diaphragm to burst the paper. For testing the Bursting strength, Messmer bursting tester 1555 instrument was used.

$$\text{Burst Factor} = \frac{\text{Bursting Strength (gm/cm}^2\text{)}}{\text{Substance in gm/m}^2}$$

- *Tear Strength* of the paper can be expressed as an amount of work done in tearing the paper through a specified distance after the tear has been started. For testing the tear strength, ED-20 tear tester was used.

$$\text{Tear Factor} = \frac{\text{Tear resistance}}{\text{Substance in gm/m}^2}$$

- *Basis weight* of paper is in square meter area in gm/sq. m.

$$\text{Substance in g/m}^2 = 10,000 \text{ w/ab}$$

Where

w = Weight in gm of specimen, a = Length in cm of specimen, b = Width in cm of specimen.

- *Printability* is the property of a paper which yields printing matter of good quality. It is judged by uniformity of colour of the printed area, uniformity of ink transfer, and contrast between the printed and unprinted area, rate of ink setting and drying.

- *Value added products* like hand made sheet of varied GSM were utilized for developing sixteen different products.

- *Assessment of usefulness and cost effectiveness of value added products.*

➤ The assessment of consumer preferences for the developed products was done by 30 sample subjects/panel of judges. The respondents, 10 from each category were housewives, home scientist, owner of handicraft personnel. A 5 point rating scale performa was given to 30 respondents for this purpose.

➤ The cost of each products was calculated by determining the cost raw material, labour charges etc. Cost of various accessories used in developing products was also taken in to account to assess the final cost of the product.

RESULTS AND DISCUSSION

The fibres extracted with sodium meta-bisulphate were testd for their physical properties like length, diameter, cell wall thickness, fineness, tensile strength/elongation (Table-1).

Tabel 1 : Physical properties of water hyacinth fibre

Sl. No.	Physical properties	Values
1.	Fibre length (mm)	1.51
2.	Diameter/breadth (mm)	0.020
3.	Cell wall thickness (μ)	3.4
4.	Fineness (μ)	35
5.	Tensile strength/elongation (lbs/mg)	78.98

It was revealed that the strength of water hyacinth fibre is quite low which must be increased by blending with other conventional fibres for its commercial utilization. Further, the pulp obtained

could be utilized for handmade sheets as the cell wall thickness contribute towards paper strength.

Good quality handmade paper sheets can be manufactured using cellulosic pulp of unconventional fibre plants in combination with other conventional fibres, cotton rags, recycled paper, etc to improve its strength, opacity and other parameters as per requirement of end products. In the present work, water hyacinth pulp was mixed with cotton rags in shredded form to improve thickness and viscosity of the pulp for manufacturing handmade sheets in three different ratios i.e. 1:1, 1:2 and 2:3. The sheets were produced in two different GSM-100 and 200 with different thicknesses. Pure pulp of water hyacinth was also used to develop paper. The results of the testing of physical parameters of develped handmade sheets of 100 GSM have been presented in Table 2.

It was found that the paper produced from pure water hyacinth pulp was deficient in most of the parameters except opacity and porosity. Tear and burst strength were found to be high in 1:2 i.e. 8.66 mNm²/gm and 1.94 Kpa. m²/gm. On the other hand, the 1:1 ratio was also found suitable with respect to all the physical parameters tested.

Tabel 2 : Testing of physical parameter of handmade sheet

Sl. No.	Particulars	100% water hyacinth	1:1 water hyacinth : cotton rags	1:2 water hyacinth : cotton rags	2:3 cotton rags : water hyacinth
1.	Basis weight (gm/m ²)	50.78	148.23	150.12	152.61
2.	Burst index Kpa.m ² /gm	0.49	1.87	1.94	0.86
3.	Tear index (mNm ² /gm)	0.78	7.39	8.66	5.71
4.	Porosity (sec/100 ml)	60.65	–	–	–
5.	Brightness (% ISO)	–	26	27.65	14.2
6.	Opacity (%)	92.0	98.0	94.21	95.68

Handmade sheets developed were evaluated by the respondents and responses obtained are presented in Table 3.

Table 3 : Mean scores obtained by uniformity of color of the printed area

Sl. No.	Parameters	Water hyacinth	Water hyacinth cotton rags		Cotton rags : water hyacinth
			1:1	1:2	
		100%			
1	Ball pen	1.2	2.4	3.0	4.2
2	Ink pen	1.8	1.8	2.2	4.6
3	Gel pen	2.4	1.8	4.2	3.8
4	Market	2.6	2.2	2.6	3.2
5	Typing ink	1.4	2.2	3.2	4.0

It was found that the uniformity of colour of the printed area was found to be less from pure water hyacinth in case of typing ink and ball pen. The uniformity of colour in 2:3 ratio was found to be very good in ink pen and ball pen.

Similarly, the printability of the handmade sheet on uniformity of ink transfer was found to be best in combination of 1:2 as well as 2:3 in ball pen. Typing ink uniformity on transfer was found to be less in ink pen and typing ink in pure form of water hyacinth.

Again, marker and gel pen were found to be best with 4.2 and 4.6 in 1:2 and 2:3 ratios on the parameter of contrast between printed and unprinted area.

As regards the rate of ink setting and drying ball pen and ink pen scored high (4.2) in combination of 2:3 and were found to be the best.

The result of the physical testing of water hyacinth fibre revealed its unsuitability for developing yarn in pure form. On the other hand, handmade sheets showed bright prospect in developing a variety of handicraft items as per development of different value added articles using variety of colours.

The development of various handicraft items required different GSM (Basis weight). For the light weight/delicate articles, sheets of lower GSM

(i.e. 60-150) and for strong/heavy weight articles, higher GSM (i.e. 200-300) handmade paper sheets are required. Hence, for developing value added articles of two different categories, handmade sheets of 100 and 200 GSM were produced.

Sixteen value added articles have been made from handmade paper sheets. For surface enrichment of developed articles, different accessories were also used like beads, mirrors, *ghungroo*, etc. Table 4 lists the articles developed.

Table 4 : Categories of developed value added articles

Articles of 100 GSM	Articles of 200 GSM
● Book mark	● Bandanwar
● Bell	● Carry bag
● Envelope	● Clip board
● Place mat	● Flower pot
● Photo frame	● Lamp shade
● Traditional Bahi	● Multipurpose box
-	● Mobile stand
-	● Photo album
-	● Telephone diary
-	● Invitation card

The articles were assessed on the basis of selected parameters viz. suitable of design, color combination, utility of article, overall appearance and marketing potential. It was found that telephone diary achieved the first rank. Photo frame got first rank in design. After telephone diary, the envelope and clip board achieved second and third rank respectively under parameter of utility of article. The clip board was also appreciated.

Effort was made to calculate the cost of developed handmade sheets of various GSM. Table 5 shows that the total cost of seven sheets of 100 GSM was found as Rupees 76.09 and sixteen sheets of 200 GSM was found at Rupees 173.92. These costs are less compared to readymade handmade sheets available in the market.

Table 5 : Cost estimation of developed handmade sheet

Parameters	Particulars	Amount
Cost of raw material	Water hyacinth	60 kg
	Pulp extracted	12 kg
	Transportation cost	50.00
	Manufacturing charges	200.00
Cost price of hand made sheet	Total number of developed handmade sheets	23
	100 GSM sheet (total No. 7)	76.09
	200 GSM sheet (total no. 16)	173.92

The cost of each developed handmade sheet was found to be Rupees 10.87 as compared to readymade sheet that sell for about Rupees 12 the market. Hence, it can be concluded that these developed handmade sheets have good market potential. The price of the developed handmade sheet can be lower if manufactured in bulk.

● **Cost of developed value added articles**

Table 6 : List of estimated price of different articles .

Sl. No.	Articles	Cost of handmade Rs. paper	Cost of other Rs. material	Labor charges (Rs.)	Total Cost (Rs.)
1	Traditional Bahi	3	2	3	6
2	Bandanwar	2	2	1	5
3	Photo frame	12	8	15	35
4	Clip board	10	15	15	40
5	Multipurpose box	3	5	2	10
6	Flower pot	12	10	12	34
7	Place mat	4	3	5	12
8	Lamp shade	6	35	12	35
9	Photo album	12	10	10	32
10	Carry bag	2	2	1	5
11	Envelopes	1	—	1	2
12	Book mark	1	1	1	3
13	Mobile cover	1	2	2	5
14	Bell	3	5	7	15
15	Invitation card	1	2	1	4
16	Telephone diary	13	10	25	48

The labour charges of some of these articles were higher due to requirement of creative skill of the handicraft personnel, which can be brought down by increasing the number of articles are made. The costs are not comparable to those of readymade handicraft products available in the market.

For assessment of economic benefits of the value added handicraft items, a Proforma was developed in which total cost and approximate profit percentage ranging from 20-50 percent and more than 50 percent were added. This proforma was given to 30 respondents.

The overall opinion was that maximum profit can be gained by the sale of envelopes and traditional Bahi. Flower pots and lamp shade could be sold on 20 percent profit easily. Multipurpose box could be sold on 50 percent profit and rest of the items can fetch 20 percent profit. Thus, it is apparent, that developed articles were found highly acceptable in terms of utility and marketability.

CONCLUSION

It can be suggested from present study that water hyacinth, a noxious weed can be a potential source of income if cottage industry is established in nearby areas of its occurrence in plentiful amount. It is expected that rural people will be benefited, by way of collecting, drying, supplying thereby adding to their income. It will also help in eradicating this weed simultaneously reducing water pollution. Water hyacinth has great potential in textile and paper industry.

ACKNOWLEDGEMENT

The authors are grateful to *Handmade paper industry of Vidhya Bhavan Society, Udaipur (Rajasthan)* for rendering help in developing handmade paper sheets of water hyacinth and *Kummarappa National Handmade Paper Institute, Jaipur (Rajasthan)* for testing and analyzing various physical parameters of the sheets produced by

selecting different ratios and also of varied GSM/
basis weight.

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SOMETHING TO THINK ABOUT

WHY DO GRINDING AND POUNDING ACTIVATE SOME SOLIDS ?

Hem Shanker Ray

It is well known that solutes dissolve faster if particle size is made finer. Thus fine sugar dissolves faster in water compared to sugar crystals and 'microfined' tablets for headache is claimed to allviate the discomfort rapidly. Fine coal particles burn more vigorously than hemsps of coal. In all these cases higher reactivity results from availability of greater surface area of the solid. If the coverage particle size is reduced to half by grinding or pounding then there would be eight times as many particles and twice as much surface area. As the size becomes smaller the surface to volume ratio increases and this increase begins to go up rapidly as one reaches smaller size ranges. Increase in reactivity, however, is not merely because of increase in surface area and other factors also come into play. This is the subject matter of this write-up.

First, when particles are broken down, new surfaces created afresh are different from the original surface that has undergone weathering. The new surface is more reactive. Furthermore, when the particle size becomes very small then the particles, specially the new surfaces created aquire newer features if one enters the 'nano' range. A micron is 10^{-6} m and nano is 10^{-9} m. All submicron particles may be considered in the nano range. Crystalline solids are made up of unit crystals where the dimensions are a few angstroms that are

a few nanos. In nano size range atomic and electronic structure of nano particles may vary with size even without a phase transformation because surface to volume ratios change drastically.

Many ayurvedic medicines are prepared after extensive grinding and pounding, in wet or dry state, of various herbs and compounds using a mortar and pestal. The mortar is specially boat shaped to help crushing of the raw materials. The ayurvedic practitioners traditionally gave much importance to this claiming that this activates the active ingredients in their medicines. Skeptics have often dismissed such claims as unscientific but the Vaid may have been correct all along.

There have been many scientific studies on activation of mineral particles by grinding. Some facts presented in a recent article published in *Science* is briefly reviewed here. (Nanominerals, mineral nanoparticles and earth systems, Michael F Hardchella et. al, *Science*, 319, 21 March 2008)

There are some 4500 mineral species many of which are more complex than previously thought because of the discovery that the chemical properties can vary as a function of particle size when the size appoaces a few nanometers to several tens of nanometers at least in one dimension. This contradicts the traditional definition of minerals as naturally occuring crystalline substances that have well defined characteristics and chemical composition (or compositional range in case of solid solution). When there are Nanominerals i.e.

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minerals with all particles in the nano range or Mineral Nanoparticles i.e. materials that contain particles in nano as well as larger size ranges, then they satisfy the criteria that there is a set of specific physical and chemical properties. However, even with a fixed composition, they may express a range in chemical and physical properties depending on size and shape.

The variations in properties are most likely due at least in part to differences in surface and near surface atomic structures as well as crystal shape and surface topography as a function of size in the nano size regimes. These differences may be reflected in geochemical and biogeochemical reactions and kinetics. If the size is in the nano range only in one dimension then one has a 'nanofilm' or 'nano sheet'. If two dimensions are in the nanorange then there are 'nanorods'. A nano particle is one where all three dimensions are in the nano range. The exact shapes that mineral particles acquire depend on the mode of applying stress during grinding and pounding let us now examine how a new factor emerges during grinding and pounding. This is mechanical activation that leads to a new kind of chemistry called Mechanochemistry. Recently, Mehrotra has discussed this thoroughly in a special lecture. (Realm of mechanochemistry in extractive metallurgy, N.P. Gandhi Memorial lecture IIM *Metal News*, I, 6. 7-17 Dec (2006).

Grinding and pounding of solids increase dissolution rates not only because of increase in surface area but also because of accumulation of mechanical energy that seeks release during dissolution. In fact, increased dissolution can be achieved even without increase in surface area. If a strip of brass is twisted and turned repeatedly then one introduces stress energy within. This strip will now react with an acid more vigorously because the mechanical energy stored within will seek release through exothermic heat of increased dissolution rate.

Thus prolonged milling and grinding implies something more than creation of larger surface areas. Energy can be stored in a material through brittle to ductile transformation. Sometimes mechanical force can cause decomposition. For examples halides of gold, silver and platinum as well as mercury compounds decompose to metal and halogen on fine grinding in a mortar. Since mercury chloride sublimes and silver halides melt during heating the decompositions due to grinding cannot be linked to possible rise of temperature during grinding. Effect of mechanical metallurgy is distinct from that of heat. As is well known some polymers also become less viscous after mechanical agitation and the change is not related to heating.

Mechanical activation of solids by pounding, milling and grinding is thus a result of various factors which may be listed as follows :

- Disintegration and fracturing of particles, formation of new surfaces, enlargement of surface area. (Negative factors are surface aggregation and surface oxidation)
- Materials abrasion and material transitions between solid particles.
- Plastic deformation and disordering of crystal structure.
- Phase transformation in polymorphic materials.
- Chemical reaction, decomposition, ionic changes, complex formation, etc.
- Various changes in crystal lattice, electrostatic charge-discharge, changes in magnetic properties, etc.
- Local heating etc.

The changes introduced, as mentioned previously, depend on the mode of activation device (mills employing attrition, vibration, impact, tumbling, etc.)

It is again emphasized that the purpose of mechanical activation is not only creation of extra new surface but also induction of structural changes and defects. For many not-so-hard minerals, a few hours of milling increase the surface area from around 0.5 m²/g to 20m²/g. While the change in particle size can be measured easily that in the surface energy cannot. Some hard minerals are made more amenable to leaching by repeated heating and quenching, which not only breaks down particles by splitting them but also introduces internal cracks and stress on particle surfaces. An indirect method of estimating the relative effects of surface and defects introduced by mechanical

activation is to measure the change in melting point and enthalpy of melting. Both should change with time of milling and/or repeated heating and quenching.

The main application of mechanical activation will be in hydrometallurgical steps, leaching, cementation, etc. There are others. For example, reactivity of flyash, used for cement manufacture, can be enhanced by milling. Other potential areas of application include mechanical alloying, advanced ceramics, catalysis, coal gasification, paints and dyes, drugs, fertilizers, pharmaceuticals etc.

ANSWERS TO "DO YOU KNOW ?"

1. Land of snow.
2. Solid carbon dioxide that emits 'fumes' or white clouds of water vapour.
3. Rosary.
4. Aphyllous Plants.
5. The Greek letter epsilon.
6. Not from cat but sheep and horses.
7. Only in 17th century, when clock construction began and people went back to Babilonian and then Ptolemy's system of division of arc into base-60 system. That is 60 minutes to 360 degrees and 60 division to each minute.
8. The Falabella Horse, a breed from Argentina, is very small. Some are only 15-1 inches (38-40 cms) tall weighing as little as 18-20 Kg.

KNOW THY INSTITUTIONS



INTERNATIONAL CENTER FOR GENETIC ENGINEERING AND BIOTECHNOLOGY, NEW DELHI

Set up in 1987, ICGEB has been operating, since 1994, as an independent inter-governmental organisation offering top level research programs in areas dealing with human health and agricultural sciences. In addition to this ICGEB focuses on imparting scientific training to scientists from member states as well as to develop and transfer technologies to industrial partners of member states and developing countries.

HUMAN HEALTH RESEARCH

The Malaria Group at ICGEB, New Delhi is interested in understanding the basic biology of the malaria parasite to develop novel vaccines to provide protection against malaria. The Malaria Group is trying to understand the molecular interactions between erythrocyte receptors and

parasite ligands that mediate the invasion process. These studies have focused on a family of erythrocyte binding proteins including the *P. vivax* Duffy binding protein, which binds the Duffy antigen during invasion, and *P. falciparum* erythrocyte binding antigen EBA175 and have provided support for the use of these antigens as recombinant vaccines against *P. vivax* and *P. falciparum* malaria. Other parasite proteins such as merozoite surface protein 1 (MSP1) have also been shown to play a role in erythrocyte invasion. Efforts to develop a vaccine based on the conserved C-terminal region MSP1₁₉ are also underway. In addition to these candidates, efforts are on to identify novel merozoite proteins that play a role in erythrocyte invasion with the goal of understanding their functional roles and exploring their potential as vaccine candidates against malaria.

The Malaria Group has a strong translational research program directed towards developing blood-stage vaccines against *P. falciparum* and *P. vivax* malaria. The group has developed expertise in development of methods to produce recombinant protein-based vaccines. Following validation of vaccine candidates, methods to produce recombinant proteins are developed at pilot scale and used for production of candidate antigens for use in pre-clinical testing. Methods for production are then transferred to Indian biotechnology industry for production of recombinant vaccines under cGMP for use in clinical trials. So far, a *P. vivax* vaccine candidate based on Duffy binding proteins and two *P. falciparum* vaccine candidates based on MSP1 and EBA175 have been produced under cGMP for use in human clinical trials.

In a relatively new program supported by the Department of Biotechnology in the form of a Centre of Excellence in Tuberculosis research at ICGEB, the focus is on a system biology approach, in an attempt to discover crucial host biomolecules that support the pathogen's survival in the host. The initiative in TB research is also actively engaged in attempts to discover biomarkers suitable for the detection of the disease. A national facility supported by the DBT has been erected to test novel vaccines and drug molecules in appropriate animal challenge systems. Developing novel vaccines, validated drug targets and finding better ways to detect TB are our long term goals.

ICGEB is also involved in research on viral diseases like Hepatitis, HIV, Influenza and Dengue. The focus is on developing diagnostic tests and vaccine related research. A novel Dengue vaccine construct is being considered for preclinical trials.

PLANT RESEARCH

The Plant Biology groups are involved in understanding molecular events in plants upon biotic and abiotic stresses. The group has identified 2000

differentially expressed salinity responsive ESTs from root and shoot tissues of a rice cultivar. These ESTs are being evaluated for their role in salt tolerance. Major focuses in the biotic stress tolerance efforts are the development of transgenic crops with improved resistance to insects, virus and fungal diseases. In addition the groups are carrying out work on farming of pharmaceutical molecules using chloroplast genetic engineering. Proteomics and genomics of cotton for understanding factors responsible for the development of cotton boll and fiber are being pursued intensively. The research on the identification of virus based suppressors for neutralising plant RNAi pathway is likely to lead to identification of mechanism/s towards development of virus resistant plants.

TRAINING

The development and application of microbe-based biopesticides is being carried out in collaboration with commercial partners at various agro climatic zones.

Training of scientists from member states is major activity at ICGEB which makes available long term and short term programs. Post Doctoral fellows can join selected laboratories and participate in ongoing projects. Three to four year fellowships are available for Ph.D. course, in association with Jawaharlal Nehru University, New Delhi. About a third of Ph. D. students at New Delhi component are from member countries. Practical and theoretical courses, ranging from two to four weeks duration, are held every year. Among topics covered are genome mapping, bioinformatics, biopharmaceutical productions, transgenic organisms, bacterial and yeast genetics, transgenic organisms, bacterial and yeast genetics, molecular medicine etc. So far more than 1000 young scientist have been through more than 50 training programs organized by ICGEB that has now established itself

as a major focal point for training in modern techniques using genetic engineering and biotechnology.

ICGEB researchers benefit from a sprawling and serene campus adjacent to Jawahar Lal Nehru University, New Delhi that follows singular focus on scientific pursuits. The center also has a comprehensive compliment of central facilities such as Process Development Laboratory (GMP facility) set up with support of DBT, a Biosafety Level 3 (BSL-3) facility, a Bioinformatics Facility, Confocal microscope and Biacore-2000. Apart from above mentioned facilities state of the art FACS, RT-PCR, DNA Sequencer, Protein Synthesizer, Microrarray

Scanner are also available centrally, just to name a few.

Having arrived at the stage with critical mass of talent, vision and resources, ICGEB, New Delhi is set to play a lead role in finding solutions to some of the basic problems faced by the humanity as whole and the developing world in specific.

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PROF. R. C. MEHROTRA COMMEMORA- TION LECTURE.

Prof. Satinder Vir Kessar, Chandigarh

JAWAHARLAL NEHRU PRIZE

Center for Science and Environment, New Delhi

The Hindu Media Resource Center, MSSRF

EXCELLENCE IN SCIENCE & TECHNOLOGY AWARD

Prof. Ashok Jhunjhunwala, Chennai

PROF. HIRALAL CHAKRAVARTY MEMORIAL AWARD

Dr. Sneh Lata Singla Pareek, New Delhi

PRAN VOHRA AWARD

Dr. Pradeep Sharma, Karnal

DR. B. C. DEB MEMORIAL AWARD FOR SOIL/PHYSICAL CHEMISTRY

Dr. G. Narahari Sastry, Hyderabad

**DR. B. C. DEB MEMORIAL AWARD FOR
POPULARISATION OF SCIENCE**

Dr. Sanjay Verma, Gorakhpur

**DR. (MRS) GOURI GANGULY MEMORIAL
AWARD FOR YOUNG SCIENTIST IN
ANIMAL SCIENCES**

Dr. Amlan Kumar Patra, Kolkata

**PROF. UMAKANT SINHA MEMORIAL
AWARD**

Dr. Ashima Bhardwaj, Gandhinagar

PROF. R.C. SHAH MEMORIAL AWARD

Dr. Uday Bandyopadhyay, Kolkata

PROF. ANIMA SEN MEMORIAL LECTURE

Dr. Madhu Mathur, Meerut.

YOUNG SCIENTIST AWARDS

Satendra Kumar Mangrauthia, New Delhi

Paresh Nath Chatterjee, Burdwan

Sohini Basak, Kolkata

Bikash Kumar Jena, Bhubaneswar

Nimisha Vedanti, Hyderabad

Munawar Abdul Shaik, New Delhi

Rekha Shukla, Jabalpur

Koushik Sinha, Bangalore

Sanjib Majumder, Mumbai

Shikha Singh, Kanpur

Pinki Chowdhury, Kolkata

P.M. Krishna Mohan, Mumbai

Yashashchandra Dwivedi, Varanasi

Swarup Roy Chudhury, Kolkata

BEST POSTER PRESENTATION AWARDS

AGRICULTURE AND FORESTRY SCIENCE

Sharmistha Barthakur, New Delhi

Panna Das, Shillong

**ANIMAL, VETERINARY AND FISHERY
SCIENCES**

Navneeth K. Sethi, Lucknow

Ujjwala Shivaji Deshmukh, Amravati

**ANTHROPOLOGICAL AND BEHAVIOURAL
SCIENCES (INCLUDING ARCHAEOLOGY
AND PSYCHOLOGY & EDUCATIONAL
SCIENCES)**

Kapil Mitra, Darjeeling

Nisha Chaudhary, Delhi

CHEMICAL SCINENCES

Dhrubajyoti Mahanta, Dibrugarh

Keisham Sarjit Singh, Goa

EARTH SYSTEM SCIENCES

S. A. War, Shilong

Gulab C. Gautam, Varanasi

ENGINEERING SCIENCES

Mohamed Ismaeel, Chennai

Samrat Paul, Tezpur

ENVIRONMENTAL SCIENCES

Rashmi Dubey, Jabalpur

Beula S. Challam, Shillong

**INFORMATION AND COMMUNICATION
SCIENCES AND TECHNOLOGY
(INCLUDING COMPUTER SCIENCES)**

Indra Kanta Maitra, Kolkata

MATERIALS SCIENCE

N. Das, Tripura

M. K. Deore, Nandgaon.

MATHEMATICAL SCIENCES (INCLUDING STATISTICS)

J. Dutta , Shillong

Himadri Ghosh, New Delhi.

MEDICAL SCIENCES (INCLUDING PHYSIOLOGY)

Debamita Kilikdar, Kolkata

Aurelia Syngkon, Kolkata

NEW BIOLOGY (INCLUDING BIOCHEMISTRY, BIOPHYSICS & MOLECULAR BIOLOGY AND BIOTECHNOLOGY)

Yashmin Choudhury, Shillong

Joshua Manohar, Chennai

PHYSICAL SCIENCES

N. Dehingia, Dibrugarh

Manish Kumar, Darbhanga

PLANT SCIENCES

Jaya Singh, Jabalpur

Bilal Ahmad Mir, Jammu

INFOSYS FOUNDATION-ISCA TRAVEL AWARDS TO SCHOOL STUDENTS

Ananya Nayak, Class VIII, Stewart School, Bhubaneswar, Orissa

Crystal Saxena, Class XII, Kendriya Vidyalaya, North Eastern Hill University, Shillong.

Homagni Saha, Class IX, The Assembly of God Church School, Haldia

Jwllery Mittra, Class V, St. Marry's Convent School, Cleman Town, Dehradun, Uttarakhand

Abhilash Kumar, Class IX, Chandramoni, Moradabad, U. P.

Aditya Sinha, Class IX, Raman Munjal Vidya Mandir, Sidhrawali, Haryana

Vratul Kumar, Class IX, Baldwin Boys High School, 14, Hosur Road, Richmond Town, Bangalore

Conferences / Meetings / Symposia / Seminars

The International Conference in Modeling Health Advances 2009 San Francisco, USA, 20-22 October, 2009

A host of new diseases, like HIV/AIDS, BSE, Avian Flu, West Nile Virus and others have appeared on the scene during the last twenty five years and undoubtedly, more will come in the coming years. To tackle these illnesses, the cooperation of modelers, mathematicians, statisticians, computer scientists, and others, and of researchers from the medical community is absolutely essential. Modeling is important because it gives important insight into the method of treatment. In the case of HIV/AIDS, for example, mathematical modeling indicated that a combination of both protease inhibitors and reverse transcriptase inhibitors would be far more effective than any one of these two drugs.

The purpose of this conference is to bring all the people working in the area of epidemiology under one roof and encourage mutual interaction.

The congress has the focus on the frontier topics in the theoretical and applied engineering and computer science subjects. All submitted papers will be under peer review and accepted papers will be published in the conference proceeding (ISBN : 978-988-17012-6-8). The abstracts will be indexed and available at major academic databases. The accepted papers will also be considered for publication in the special issues of the journal Engineering Letters, in IAENG journals and in edited books by publishers like America Institute of Physics, IEEE Computer Society and Springer.

Important Dates :

Draft Paper Submission Deadline : 2 July, 2009

Camera-Ready Papers Due & Registration Deadline : 30 July, 2009

ICMHA 2009 : 20-22 October, 2009

Contact : **B. D. Aggarwala**, (Chair), Professor Emeritus, Department of Mathematics and Statistics, University of Calgary, Canada.

10th INDO-PACIFIC Congress on “Legal and Forensic Science”, October 25-30, 2010 organised by INDO Pacific Association of Law, Medicine and Science at the Amity Institute of Advanced Forensic Science Research and Training, New Delhi, India.

The Scientific Programme will include sessions on DNA Profiling, Crime Scene Investigation, forensic Education and Training, Criminalistics, Forensic Biology, Forensic Anthropology and Human Identification, Arson and Fire Investigation, Hairs and Fibres, Forensic Medicine, Clinical Forensic Medicine, Medical Law and Ethics, Forensic Odontology, Drugs and Alcohol, Firearms and Explosives, Forensic Chemistry

and Toxicology, Forensic Entomology, Examination of Questioned Documents and Hand writing, Forensic Psychiatry, Finger Print and Foot Print Identification.

Contact : **Prof. P. K. Chattopadhyay**, Vice President, INDO-Pacific Association of Law, Medicine & Science, Fax : 91-120-2431268, 2431878 E-mail : pkchattopadhyay@amity.edu.

11th International Conference on “Public Communication of Science and Technology” organized by National Council for Science & Technology Communication, December 06-10, 2010, New Delhi, India.

The Focal theme of the conference is “towards a Scientifically Aware & Attitudinally Rational World.”
The Sub themes are :

- A Critical Review of Science Communication in the world
- Scientific Temper & Conflict Management
- Science Communication Studies and Research
- Networking Science communication
- Developing Science and Craft of Science Communication
- Role of Science Museums, Science Centres and Science Cities
- Emerging Scenario of Science Communication through Mass Media
- Globalizing & Localizing Science Communication
- Novel Practices in Science Communication
- Innovation in Science & Technology Communication

Contact : **PCST-2010 Secretariat**, National Council for Science & Technology Communication, Department of Science & Technology, Govt. of India, Technology Bhavan, New Mehrauli Road, New Delhi-110016, India, Phone : +91-11-26537976 ; Fax : +91-11-26866675, E-mail : editorijsc@gmail.com ; mkp@nic.in, Websites : www.pcst-2010.org ; www.vichar.nic.in ; www.dst.gov.in

S & T ACROSS THE WORLD

CANCER-CAUSING GENE

The discovery made by researchers from the Dana-Farber Cancer Institute (Boston, MA, USA), of unsuspected gene CDK8's role in cancer was made possible by new tools for assessing the activity of specific genes according to the investigators of the new study. This study provides confirmation that many of the genes involved in cancer have yet to be identified. The new study started with a focus on a protein called β -catenin, a transcription factor that is overactive in nearly all colorectal cancers. Although overactive β -catenin plays a role in the initial formation of tumors, other genetic abnormalities must occur for tumors to become fully malignant. To determine which genes control the production of β -catenin and are involved in the proliferation of colon cancer cells, the researchers ran three screening tests. In the first two, they used RNA interference to deactivate more than a thousand genes one by one, and recorded the instances where β -catenin activity decreased and the cells stopped growing. They then analyzed colon cancers for genes that had extra copies. This study demonstrates that blocking CDK8 interferes with the proliferation of colon cancer cells that have high levels of the CDK8 protein and overactive β -catenin.

(Biotech Today, Oct 18, 2008)

IDENTIFYING PROTEINS CELLS

A new technology which enables scientists to identify proteins by making a map of the energy flow inside the protein was revealed recently in Proceedings of the National Academy of Sciences (PNAS) journal. The scientists hope to develop a tool which can be used to analyse human cells and find out which proteins are present and in what

quantities. Being able to sensitively analyse the protein make-up of cells is important because proteins are involved in every process in human cells, from facilitating immune responses to cell-to-cell communication, and when a cell becomes diseased, for example with cancer, the number of different kinds of proteins in a cell changes. The new research outlines how an imaging technique known as coherent two-dimensional infrared spectroscopy, 2DIR, has been used to successfully identify proteins in laboratory tests. The technique uses an ultra short pulse of infrared laser light to cause a vibration in one part of the protein molecule. Further specific process enables them to identify what kind of protein it is.

(Biocompare News, Sep 22, 2008)

WIRELESS AT FIBER SPEEDS

As at present, no commercial wireless system can beat the raw speed of optical fiber, which can carry tens of gigabits per second. One way to achieve faster speed is to harness the millimeter-wavelength frequency of the wireless spectrum, although this usually requires expensive and very complex equipment. Now, engineers at Battelle, a research and development firm based in Columbus, have come up with a simpler way to send data through the air with millimeter-wave technology. Earlier this year, in field tests of a prototype point-to-point system, the team was able to send a 10.6-gigabit-per-second signal between antennas 800 metres apart, and more recently, the researchers demonstrated a 20-gigabit-per-second signal in the lab. A senior researcher at Battelle says that the technique could be used to send huge files across college campuses, to quickly set up emergency networks in a disaster, and even to stream uncompressed high-definition video from a computer or set-top box to a display.

(Technology Review, Oct 3, 2008)

HYDROCARBON BIOFUELS

Researchers at the University of Wisconsin-Madison have developed a simple catalytic process which converts plant sugars into gasoline, diesel and jet fuel. Several companies are making hydrocarbon biofuels—which can be cheaper to produce than ethanol and have higher energy density—using microbes. Startups, such as LS9 and Amyris, are trying to genetically engineer the metabolic systems of microbes so that they ferment sugars into useful hydrocarbons.

The catalytic process, presented online in *Science*, requires two main steps, which can be integrated and run sequentially with the output from one reactor going to the other. Both the catalyst mechanism and the continuous process design are reported to make the new approach promising. Moreover, the catalysts can be recycled, whereas the microbes die and have to be replenished. Compared to using enzymes or microbes, catalysts have more potential as found by scientists.

The researchers' final goal is to use sugars derived from cellulosic biomass, such as agricultural waste and switchgrass instead to using food sources such as corn and sugarcane. That would be the key

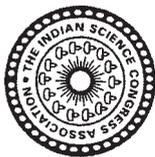
to making environmentally beneficial hydrocarbon fuels from plants that are economically competitive with petroleum fuels.

(*www.technologyreview.com. Sep 22, 2008*)

FOOD SAFETY TEST

Microbiologists at Oregon State University have developed a new technology to detect illness-causing bacteria—an advancement that could revolutionize the food industry, improve the actual protection to consumers while avoiding the costly waste and massive recalls of products that are suspected of bacterial contamination but are perfectly safe. The technology has been patented, and the findings were published in *Microbial Biotechnology*, a professional journal. Further studies will be needed before the system is ready for commercial use. Rapid methods are not readily available to directly assess the toxicity of bacterial contamination in a user friendly fashion. The new approach, made possible by fundamental research on the colour changes in pigment-bearing cells from Siamese fighting fish, should be easier to use, faster and more directly related to toxicity assessment than conventional approaches now used to test food for bacterial contamination and safety.

(*EurekAlert, Oct 17, 2008*)



भारतीय विज्ञान कांग्रेस संस्था

14, डॉ० विरेश गुहा स्ट्रीट, कोलकाता 700 017, भारत

THE INDIAN SCIENCE CONGRESS ASSOCIATION

14, Dr. Biresb Guha Street, Kolkata-700 017, INDIA

Telegram : SCICONG : CALCUTTA Fax : 91-33-2287-2551
Telephone : (033) 2287-4530, 2281-5323 E-mail : iscacal@vsnl.net
Website : <http://sciencecongress.nic.in> iscacal_2004@yahoo.com

Terms of Membership and Privileges of Members :

Membership of the Association is open to persons with *Graduate or equivalent academic qualification* and interested in the advancement of science in India.

1. **Member** : A person willing to be enrolled as new Member has to pay an annual subscription of Rs. 200/- **along with an admission fee of Rs. 50/-** (for foreign* U.S. \$70) only. The annual subscription of a Member shall become due on the 1st April of each year. Anyone who fails to pay the subscription on or before the *15th July* in any year shall lose the right of voting and / or holding any office of the Association for that year. A Member failing to pay the annual subscription by the end of March of the following year shall cease to be a Member.

Members may contribute papers for presentation at the Science Congress. They will receive, free of cost, reprint of the Proceedings to Session of any one section of their interest and also the bi-monthly journal of the Association "Everyman's Science".

2. **Sessional Member** : Sessional members are those who join the Association for the Session only. A Sessional Member has to pay a subscription of Rs. 250/- (for foreign U.S. \$60) only.
3. **Student Member** : A person studying at the under-graduate level may be enrolled as a Student Member provided his/her application be duly certified by the Principal/Head of the Department. A Student Member shall have the right to submit papers for presentation at the Session of the Congress of which he/she is a member, provided such papers be communicated through a Member, or an Honorary Member of the Association. He/she shall not have the right to vote or to hold any office. A Student Member shall not be eligible to participate in the Business meetings of the Sections and the General Body. Subscription Rs. 100/-
4. **Life Member** : A Member may compound all future annual subscriptions by paying a single sum of Rs. 2000/- (for foreign U.S. \$ 500) only. Any person who has been continuously a member for 10 years or more, shall be allowed a reduction in the compounding fee of Rs. 50/- for every year of such membership, provided that the compounding fee shall not be less than Rs. 1,200/- (for foreign U.S. \$ 12.50 and U.S \$ 300 respectively). A Life Member shall have all the privileges of a member during his/her lifetime.

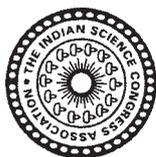
*Admission fee of Rs. 50/- is needed only for becoming a new annual member and not for sessional member / life member / Institutional member / student member / donor.

5. **Institutional Member** : An Institution paying a subscription of Rs. 5,000/- (for foreign U.S. \$ 2,500) only, can become an Institutional Member of the Association. It shall be eligible to nominate one person as its representative to attend Annual Session of the Science Congress. An Institutional Member shall be eligible to receive, free of cost, a copy of the complete set of Proceedings of the Annual Science Congress Session as also a copy of the Association's journal "Everyman's Science".
6. **Donor** : Any person paying a lump sum of Rs. 10,000/- (for foreign U.S. \$5000) only, can become a Donor of the Association. An **INDIVIDUAL DONOR** shall have all the rights and privileges of a member during his/her lifetime. An Institution paying a lump of Rs. 50,000/- (for foreign U.S. \$25,000) only, can become **INSTITUTIONAL DONOR** of the Association, which shall have the right to nominate one person as its representative to attend Annual Session of the Science Congress. An Institutional / Individual Donor shall be eligible to receive, free of cost, a copy of the complete set of Proceedings of the Annual Science Congress as also the Association's journal "Everyman's Science".

-
- A) **Presentation of Papers** : A copy of complete paper accompanied by an abstract in triplicate not exceeding one hundred words and not containing any diagram or formula, must reach the Sectional President General Secretary (Hqrs) Latest by *September 15*, each year.
- B) Members of all categories are entitled to railway Concession of return ticket by the same route with such conditions as may be laid down by the Railway Board for travel to attend the Science Congress Session provided that their travelling expenses are not borne, even partly, by the Government (Central or State), Statutory Authority or an University or a City Corporation.
- C) Members of all categories are entitled to reading facilities between 10.00 a.m. to 5.30 p.m. on all weekdays (except Saturdays & Sundays) in the library of the Association.
- D) Members of all categories may use Guest House facilities, Lecture Hall hiring at the rates fixed by the Association from time to time.

Note : All Money Orders, Bank Drafts etc. should be drawn in favour of "*Treasurer, The Indian Science Congress Association*". Members are requested to mention their Card No. while making any correspondence to ISCA office.

* (A Foreign Member means one who is normally resident outside India.)



भारतीय विज्ञान कांग्रेस संस्था

14, डॉ० विरेश गुहा स्ट्रीट, कोलकाता 700 017, भारत

THE INDIAN SCIENCE CONGRESS ASSOCIATION

14, Dr. Biresh Guha Street, Kolkata-700 017, INDIA

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Telephone : 2287-4530, 2281-5323
Website : <http://sciencecongress.nic.in>

Fax : 91-33-2287-2551
E-mail : iscacal@vsnl.net
iscacal_2004@yahoo.com

APPLICATION FORM FOR MEMBERSHIP

To
The General Secretary
The Indian Science Congress Association
14, Dr. Biresh Guha Street,
Kolkata-700 017

Stamp
Size
Photograph

Dear Sir,

I like to be enrolled as a Member / Life Member / Donor / Sessional Member / Student Member / of The Indian Science Congress Association.

I am sending herewith an amount of Rs. in payment of my subscription by Bank Draft / Money Order / Cash for Membership / Life Membership Subscription / from the year 1st April 200 to 31st March 200

I am interested in the following section (Please tick any one).

SECTIONS

- | | |
|---|---|
| 1. Agriculture and Forestry Sciences | 8. Information and Communication Science & Technology (including Computer Sciences) |
| 2. Animal, Veterinary and Fishery Sciences | 9. Materials Science. |
| 3. Anthropological and Behavioural Sciences (including Archaeology and Psychology & Educational Sciences) | 10. Mathematical Sciences (including Statistics) |
| 4. Chemical Sciences | 11. Medical Sciences (including Physiology) |
| 5. Earth System Sciences | 12. New Biology (including Bio-Chemistry, Biophysics & Molecular Biology and Biotechnology) |
| 6. Engineering Sciences | 13. Physical Sciences |
| 7. Environmental Sciences | 14. Plant Sciences |

(Please type or fillup in Block Letters)

Name (in block letters) :

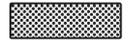
SURNAME

FIRST NAME

MIDDLE NAME

Academic Qualifications :
(Evidence to be submitted)

Designation :



Address for Communication :
(including State, City/Town and Pin code)

Phone No. & e-mail

Permanent Address :

Yours faithfully

Date :

Signature

- *As per resolution of Executive Committee in its meeting held on October 10, 2004 application for membership of ISCA in 'Care of' of some other person is generally discouraged. However, if in the application form "care of" address is given then there should be also signature of the person in whose name "care of" is given.*
- *Admission fee of Rs. 50/- is needed only for becoming a new annual member and not for sessional member / life member / Institutional member / student member / donor.*

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Co-opted Members of the Finance Committee

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Prof. S. P. Mukherjee, Kolkata

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Prof. N. K. Gupta, New Delhi

GUIDELINES FOR SUBMISSION OF MANUSCRIPTS

1. Everyman's Science intends to Propagate the *latest message of science* in all its varied branches to its readers and through them, to every one interested in Science or Engineering or Technology. *Research articles* usually meant for publication in periodicals devoted to particular branches of Science & Technology and addressed to specialised sections of the readers, are not appropriate for Everyman's Science. Instead, popular or easily intelligible expositions of new or recent developments in different branches of Science & Technology are welcome.

2. Manuscripts should be typewritten on one side of the paper with double spacing. Articles should be written generally in non-technical language and should not ordinarily *exceed 2000 words*. Articles must be understandable by the average enthusiastic readers with some modest scientific background but outside the field. It should not be a review article in a specialised area. Without being too technical, it must also reflect state of the art situation in the field. A *summary* in 50 words should be submitted along with the paper highlighting the importance of the work. *Two copies* of the manuscript complete in all respects should be submitted. The title should be written in capital letters and name(s) of the author(s) should be given along with the Department, Institution, City and Country of each author.

3. Illustration & Tables : The size of illustrations should be such as to permit reduction to about one-third. Legends and captions should be typed on a separate sheet of paper. Photographs should be on glossy paper with strong contrast in black and white. Typed tables should be in separate pages and provided with titles and their serial numbers. The exact position for the placement of the tables should be marked in the script. Authors are specially requested to reduce the number of tables, illustrations and diagrams to a minimum (maximum of 3)

4. References : References to be given on a selective basis, (maximum of 10) and the order of placement should be numerically with (a) name(s) of the author(s) (surname last), (b) name of the journal in abbreviated form according to the 'World list of Scientific Periodicals' and in italics, (c) volume number (in bold) (d) page number and (e) year of publication.

For citations of books the author's name should be followed by the (a) title of the book, (b) year of publication or edition or both, (c) page number, (d) name of publishers, and (e) place of publication.

5. The Indian Science Congress Association and the Editors of Everyman's Science assume no responsibility for statements and opinions advanced by the contributors to the journal.

Reprints : The communicating author will receive 1 copy of the journal and 10 reprints free of cost.

All manuscripts and correspondences should be addressed to the *Hony, Editor, Everyman's Science, The Indian Science Congress Association 14, Dr. Biresh Guha Street, Kolkata-700 017.* Email : iscacal@vsnl.net. iscacal_2004@yahoo.com, Fax : 91-33-2287-2551

THE INDIAN SCIENCE CONGRESS ASSOCIATION
14, DR. BIRESH GUHA STREET
KOLKATA-700 017

YOUNG SCIENTISTS AWARD PROGRAMME : 2009-2010

To encourage Young Scientists, The Indian Science Congress Association has introduced a number of awards in different disciplines in January 1981. These awards carry a sum of Rs. 25,000/- besides a Certificate of merit.

1. Applications are invited from members (Life & Ordinary) of the Association who had paid their subscription **on or before May 31, 2009**. The upper age limit of the candidates for the award is 32 years as reckoned on December 31, 2008 (only those born on or after January 1, 1977 are eligible).
2. Four copies of full paper along with four copies of the abstract (not exceeding 100 words) shall have to reach the office of the General Secretary (Hqrs.) not later than May 31, 2009. At the top of each copy of the paper and its abstract, the name of the Section where the paper is to be presented should be indicated. The Sections are : (1) Agriculture and Forestry Sciences (2) Animal, Veterinary and Fishery Sciences (3) Anthropological and Behavioural Sciences (including Archaeology and Psychology & Educational Sciences) (4) Chemical Sciences (5) Earth System Sciences (6) Engineering Sciences (7) Environmental Sciences (8) Information and Communication Sciences & Technology (including Computer Sciences) (9) Materials Science (10) Mathematical Sciences (including Statistics) (11) Medical Sciences (including Physiology) (12) New Biology (including Biochemistry, Biophysics and Molecular Biology and Biotechnology) (13) Physical Sciences and (14) Plant Sciences.
3. Four copies of the bio-data of the candidate including full name and address (with Phone, mobile Number, Fax and E-mail) along with the date of birth (duly supported by an attested copy of the certificate), research experience and membership number etc., should be appended to the full paper.
4. Work should have been carried out in India and this has to be certified by the Head of the Institution from where the candidate is applying.
5. The candidate should give an undertaking that the work which is being submitted has not been published in any journal or presented in any other Conference/Seminar/Symposium or submitted for consideration of any award.
6. In case of a paper by more than one authors, the candidate (young scientist) has to be acknowledged by the other author(s) (in terms of a certificate) as having made the major contribution. A Young Scientist could present only one paper in any one Section (and not a second paper with the same or related work in any other Section).
7. Full paper will be assessed for their content and at the most **six** Young Scientists in each section will be invited to make oral presentation of their papers in October at Tiruvantapuram. The selected scientists will be provided admissible travelling and daily allowances by the ISCA.
8. The final selection for the awards will be done by a duly constituted committee and the awards will be given at *97th Indian Science Congress* to be held at Tiruvantapuram from January 3-7, 2010.
9. The last date for receiving papers is **31st May, 2009**.
10. *All correspondences should be made to* : **The General Secretary (Hqrs.), The Indian Science Congress Association, 14, Dr. Biresw Guha St., Kolkata-700017. Tel. Nos. (033) 2287-4530/2287-5323 Fax No. 91-33-2287-2551, E-mail : iscal_2004@yahoo.com/iscal@vsnl.net Website : <http://sciencecongress.nic.in>**

**14, DR. BIRESH GUHA STREET
KOLKATA-700 017**

To encourage Young Scientists, The Indian Science Congress Association has introduced a number of awards in different disciplines in January 1981. These awards carry a sum of Rs. 25,000/- besides a Certificate of merit.

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