

[CONTENTS]

EDITORIAL :	348
ARTICLES :	
Presidential Address : On Raman Effect <i>Sir C. V. Raman</i>	350
Plant Growth Promoting Rhizobacteria in Plant Disease Management—An Overview <i>T. Saravanan and T. Marimuthu</i>	357
The Tale of a Neglected Mathematician, His Works and Beyond <i>P. Choudhury</i>	361
Phytoplasmas—The Plant Parasitic Mollicutes <i>Hisamuddin</i>	371
Role of Insect—Nematode Associations in Sustainable Development <i>Nethi Somasekhar</i>	376
Xenotransplantation : Pigs as Source of Organs for Man <i>R. K. Yadav, D. P. Mishra and B. R. Yadav</i>	384
Values and Moral Judgement of Adolescent Girls Studying in Non-Missionary and Missionary Schools in Kolkata <i>Sudakshina Gupta</i>	391
There is a Hole in My Bucky and There is a Boat in My Bottle <i>D. Balasubramanian</i>	398
KNOW THY INSTITUTIONS	401
BOOK REVIEWS	405
CONFERENCES / MEETINGS / SYMPOSIA	407
ANSWER TO DO YOU KNOW	408
S & T ACROSS THE WORLD	409

EDITORIAL

It is a global phenomenon that best young brains are being attracted more towards technology education. Science and technology are complementary in nature and have to grow together. Besides generation of new knowledge and acquisition of knowledge to describe the natural phenomena, research in fundamental science adds an inevitable input to the advancement of technology. Similarly, technological advances help research in fundamental science. Quick and highly paid job prospects have always been an added advantage for the technology graduates. Nevertheless best young minds used to be attracted to basic science courses in the fifties and sixties of the last century. This situation has undergone a complete change throughout the globe. In the developed western countries many premier universities cannot sometimes get sufficient number of students in some of the science streams. American universities can compensate them by admitting students from other countries. In Indian universities post graduate science course seats are always filled because the demand is more than the fixed capacity. But the science courses usually have to be content with students of lower grades.

This loss of enthusiasm of students in science education is often ascribed to more job opportunities in Information and Computer Technology. But this may be an oversimplification of the actual problem. There is no dearth of opportunities for the best people. If the present situation continues, there will be serious problems to have manpower in scientific

research. The question arises if this loss of interest is because science has lost the charm that it used to have earlier. New scientific discoveries in the last two to three centuries prompted man to think about the world in completely new directions. They always motivated people to think and to add new ideas to enrich our knowledge. As an example, the discovery of Non-conservation of Parity by Yang and Lee at Columbia was not only a work of beauty and originality, but it made us all think about some of the fundamentals of the physical world. Intuition or common sense had to be recast. How many such thought provoking original work are coming out these days? There are new discoveries in Chemistry and Biology that reveal new facts or data, which have a long-term effect on human civilization. But if we go back to the period of Renaissance, nature was just one of the elements in the all-embracing enterprise of philosophy. The word Science originated from the Latin word "scientia" meaning knowledge. Science was a part of natural philosophy. In 1800 Thomas Jefferson listed science subjects as "botany, chemistry, zoology, anatomy, surgery, medicine, natural philosophy, agriculture, geography, mathematics, astronomy, politics, commerce, history, ethics, law, arts, fine arts." Physics was included in Natural Philosophy. The term science was later interpreted in a more narrow sense to refer to physical and natural phenomena subjected to experimental methods. Well-established mathematical methods and mathematical rigour as well as high precision measurements

originating from improved technology have become the starting point of young science researchers. This has definitely enriched science and reaffirmed our faith in the science establishment. But they have little scope to go beyond the established facts.

The complete divide between the cultures of science and humanities and the complete deviation of science from philosophy have reduced the sphere of scientific thoughts. For nearly half a century science could not show any new path with definite yardsticks of success towards revelation of the still unexplained facts of nature. Even today Physics and Chemistry have to offer much to unfold the unknown, unlimited mysteries of the universe. The world still expects new path-breaking ideas originating from intelligent young minds not solely dependent upon new results from big machines in different parts of the world.

It is a matter of concern that most of our bright students are now more inclined to solving complicated, sometimes tedious problems and spend most of the time with standard textbook exercise. Very few develop the habit of thinking over a problem in their own way. They are not encouraged to have crazy ideas. The current

system of teaching and evaluation does not provide any opportunity for this purpose. In an attempt to be more focused on some subjects, students disregard other subjects. As an example, they are not told that an accomplished physicist should be good also in chemistry. Can we experiment with our school curricula up to the twelfth class by including one or two humanities subjects (e.g. philosophy or sociology) for the science students? This may need reduction of science syllabi. The present emphasis is on maximization of the quantity of information that can be imparted, leaving no room for imagination or recreation of minds. We forget that a creative mind has no problem of acquiring information on its own. To a certain extent defocusing at the school and undergraduate level may enlarge the sphere of knowledge. Science educators may think over the problem. Science research planners cannot take up any new project for generation of new thoughts. It should come from the young researchers, of course, some gifted ones. It is natural that most scientists would like to be on the crest of the wave, but we should not forget that someone has to create the wave. This creation can draw the brightest students to the fold of science.

Prof. P. N. Ghosh

The object of teaching a child is to enable him to get along without his teachers.

—Albert Hubbard

PRESIDENTIAL ADDRESS

ON RAMAN EFFECT

SIR C. V. RAMAN*

It is the privilege to a physicist to concern himself with what may be regarded as the fundamental entities of the material universe we live in. His theories and experiments are directed towards obtaining a clearer understanding of the nature of those entities and of their relationships with each other. His results if expressed in plain language should be intelligible not only to those who profess other branches of Science, but to all who take an interest in the varied phenomena of Nature. The work of the physicist has the closest possible bearing on the interpretation of facts observed in other fields of scientific knowledge. No apology is therefore needed for my decision to devote this address to an exposition of the nature and significance of a new phenomenon recently discovered in my laboratory at Calcutta which has a bearing on the fundamental problems of Physics and Chemistry.

Every one of us is or should be interested in the nature of that phenomenon which we call *light* and which is a species of the genus *radiation*. Light is emitted by matter under

suitable condition of excitation. We heat an atom or excite it by electric discharge. It becomes luminous and gives off radiation. What is radiation? On this point, the physicists of the nineteenth century had come to very definite conclusion, based on evidence which it seemed impossible could ever be shaken, that light is a kind of wave motion travelling through space, and of the same physical nature as the electromagnetic waves discovered by Hertz and now so familiar to all as the waves of wireless telegraphy and telephony. Remarkable enough, however, the present century has witnessed a re-opening of the question. I will not pause here to trace in detail the history of the development of what is known today as the quantum theory of radiation. It is associated with the names of three great living physicists, namely, Planck, Einstein and Niels Bohr. It will suffice for my purpose to indicate the very definite and intelligible form it received in Bohr's well-known theory of spectra. According to Bohr, the emission of light from an atom is not a single process but takes place in two distinct stages. The first stage is the energizing of the atom, in other words, its passing over from a normal or non-luminous condition into a new state of higher energy

* General President, Sixteenth, Indian Science Congress, held during 30th January to 4th February, 1929 at Madras.

content. The second stage is the return of the atom to a condition of lower energy accompanied by the emission of light. Bohr found it necessary, in order to interpret the facts of spectroscopy, to assume that the different states of the atom are sharply differentiated from each other in their energy content. The atom therefore takes up energy or gives up energy as the case may be, in passing from one state to another, in discrete bundles or quanta. Radiation is thus absorbed or emitted by the atom in discrete bundles of energy. It follows naturally that while travelling through space, light also remains as discrete bundles or quanta of radiation. A distinctly unitary character is thus indicated for radiation.

Further powerful support for a corpuscular idea of radiation came to hand a few years ago when Prof. A. H. Compton, now of Chicago University, discovered a remarkable phenomenon which is now known by his name as the Compton Effect, and for which he received the Nobel Prize in Physics a year ago. Briefly, what he found was this: When X-rays fall upon matter and the scattered rays are analysed by an x-ray spectroscope, the lines in the X-ray spectrum are found to be doubled. Prof. Compton gave a very simple and remarkable explanation of this fact. He regarded the incident X-rays as consisting of corpuscles which moved with the velocity of light and on hitting an electron in the scattering material dislodged it and were themselves deviated from their straight path. It is obvious that in such a process the deviated corpuscle would lose part of its energy, this being taken up by the recoiling electron. Prof. Compton's explanation of his effect is supported

by the fact that the recoil of the electron is actually observed in experiment. A change in energy of the quantum is equivalent to a change in the frequency of scattered radiation, which therefore appears in the X-ray spectrum as a line in a shifted position. Measurements of the change of wavelength and of the velocity of the recoil-electron appeared strongly to support Prof. Compton's theory, and the latter has therefore gained general acceptance.

We appear thus to have reached the astonishing position that two distinct theories of light both claim our acceptance. In other words, light consists of waves expanding spherically outwards from a luminous atom into ever-increasing volumes of space, and it also consists of a corpuscle shot off in some one specific direction from the luminous atom and therefore moving along a straight line to infinity. I have often seen it suggested that there might be no real conflict between these two widely different points of view, if we regard the light corpuscle statistically. In other words, if we had a sufficiently large number of atoms giving out corpuscles, the two pictures of radiation may be statistically equivalent. So indeed they would be, if a corpuscle emitted from one atom and a corpuscle emitted from another could be regarded as equivalent. But such a conception would be totally repugnant to wave principles. For, when we consider a luminous gas, the waves emitted by the different atoms in it would not be equivalent unless all the atoms were at the same place and emitting light-waves in identical phase. It is obviously difficult to accept the latter proposition, and in fact we may be fairly certain that it is untrue. The particular

suggestion here made for securing a statistical equivalence of the wave and quantum theories of radiation seems therefore untenable. My own feelings are that it is impossible to accept the wave and quantum theories of radiation as simultaneously true if Compton's idea of a localised quantum is a correct and universal description of the process of radiation from atoms. In order to explain the familiar facts of optical interference and diffraction, we are compelled to assume that the light emitted by a luminous atom spreads out spherically with identical velocity and phase in all directions. Theoretically it is possible to analyse a spherical wave into a set of plane-directed waves passing simultaneously through the centre of the sphere in all directions, *provided they are all in identical phases at the centre*. We may, of course, regard a plane wave as equivalent to a directed quantum in the sense of Compton, but as a single atom can only radiate one quantum at a time, it is impossible to explain interference if we assume the emission to consist generally of directed quanta. In Compton's own experiment, we are dealing with the secondary radiation from an atom illuminated by X-rays of wave length much shorter than the diameter of the atom. This is a very different problem from that of an atom radiating spontaneously in all directions. In a paper appearing in the *Indian Journal of Physics*, I have discussed the case of Compton from what I believe to be rather a novel point of view, and shown that so far from the Compton Effect being opposed to the classical wave principles, the latter actually indicate the existence of such an effect, and quantitatively predict its observed characters. On the view developed in my paper, Compton's experiment

is not a disproof of the spreading wave theory. We do not regard the beam of radiation thrown out in a straight line by a light house and travelling for miles without appreciable spreading as a contradiction of wave principles, but explain it as an effect produced by the lenses and mirrors of the light house. In an analogous way, I utilise the relation between the wavelength of the radiation and the size of the atom to explain Compton's results. The investigation shows that the classical and quantum theories of radiation are indeed statistically equivalent, but this equivalence is secured by the properties of the atom and not by filling space with localised quanta. I will go so far as to say that in my view, it is entirely futile to regard the light quantum as a particle having any specifiable shape, size or position.

This theoretical paper on the Compton Effect was worked out during a holiday at Waltair in October, 1927. Apart from any little intellectual satisfaction which its writing may have given me, its chief interest is that it prepared the ground for the experimental work of the following months which I shall now mention.

Eight years ago, we commenced at Calcutta a series of experimental studies on the scattering of light in transparent media of all kinds. These studies were largely inspired by a desire to understand and explain fully such natural optical phenomena as the light of the sky, the dark blue colour of the deep sea and the delicate opalescence of ice in glaciers. It soon became evident that the laboratory studies intended in the first place to reproduce these natural phenomena on a small scale would carry us some way towards a solution of such

fundamental problems of Physics as the constitution and structure of molecules, their number, arrangement and thermal movements in gaseous, liquid and solid media, and the nature of radiation itself. I will not fatigue you by reciting the numerous experimental and theoretical researches carried out by us on these subjects. Associated with me during these eight years were a great many young physicists from all parts of India who received their research training in my laboratory. Amongst them, I would specially mention the names of Dr. K. R. Ramanathan and of Mr. K. S. Krishnan, both by reason of their conspicuous originality in research and in view of the importance of their personal contributions to the development of the subject now under discussion. To them and to my numerous other collaborators from Bengal and Madras and Northern India, I owe a debt of gratitude.

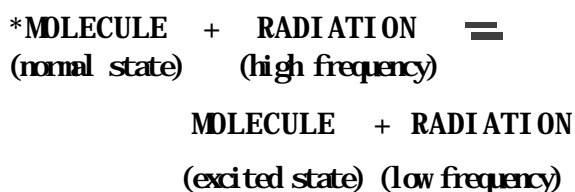
At a very early stage in our investigations, we came across a new and entirely unexpected phenomenon. As early as 1923, it was noticed when sunlight filtered through a violet glass passes through certain liquids and solids, e.g., water or ice, the scattered rays emerging from the track of the incident beam through the substance contained certain rays not present in the incident beam. The observations were made with colour filters. A green glass was used which cut off all light if placed between the violet filter and the substance. On transferring the glass to a place between the substance and the observer's eye, the track continued to be visible though feebly. This is a clear proof of a real transformation of light from a violet into a green ray. The most careful chemical purification

of the substance failed to eliminate the phenomenon. Subsequent investigations showed the same effect in a considerable number of liquids and solids, and we even attempted a spectroscopic investigation of it.

Though, from time to time, we returned to the study of this new phenomenon and published accounts of it, its real significance as a twin brother of the Compton Effect first became clear to me at the end of 1927 when I was preoccupied with the theory of the subject. I regarded the ejection of the electron in the Compton Effect as essentially a fluctuation of the atom of the same kind as would be induced by heating the atom to a sufficiently high temperature, and the so-called directed quantum of Compton as merely an unsymmetrical emission of radiation from the atom which occurs at the same time as the fluctuation in its electrical state. The conception of fluctuations is a very familiar one in optical and kinetic theory, and in fact all our experimental results in the field of light-scattering had been interpreted with its aid. There was, therefore, every reason to expect that radiations of altered wavelength corresponding to fluctuations in the state of the scattering molecules should be observed also in the case of ordinary light.

The idea was energetically taken up and the experiments showed it to be completely correct. It became clear that we had here a new radiation effect far more general and universal in its character than the Compton Effect, and of which the latter could be regarded as a special case. The ejection of an electron is a very violent type of fluctuation. There are numerous other comparatively mild types of fluctuation possible

in the electrical state of atoms and molecules. Such fluctuations correspond to relatively small changes in the energy level of the atomic system in the sense of Bohr. If a change of energy level is produced by the incident radiation and is simultaneous with it, the quantum of radiation emitted under these conditions may be greater or smaller as the case may be than the quantum of incident radiation. We may represent this change as a chemical reversible reaction



If the reaction proceeds in the direction of the upper arrow, we have a diminution in frequency of the radiation, and if in the direction of the lower arrow, we have an increase of frequency. The relative importance of the two types of reaction would obviously be determined by the law of mass-action, that is to say, upon the populations of the normal and excited states of the molecules present in the irradiated substance. In ordinary cases, the presence of excited states is determined by temperature. Other causes of excitation of molecules if present must also be taken into account.

Since atomic and molecular systems have many possible energy levels as shown by the facts of spectroscopy, we see in the foregoing chemical equation the possibility of observing a great many new lines in the spectrum of the scattered radiation

The most convenient way of studying the effect is by using the intense mono-chromatic radiation of the mercury arc and to condense its

light into the substance, or better, actually to bring the arc into close proximity with the substance as in the well-known work of R. W. Wood on resonance spectra. The spectrum of the scattered radiation is then readily photographed and shows a multitude of new lines, bands, and in addition continuous radiation. The relation between the frequencies of the incident and scattered radiations will be readily noticed from the equation written above symbolically. The difference between the incident and scattered quanta is equal to the quantum of absorption or emission, or the case may be, of the molecules. The characteristic frequency of the molecule is, therefore, subtracted from or added to the frequency of the incident radiation to give that of the scattered light.

In one sense, this combination of the incident frequency with the frequency of the molecule is an analogue of the classical phenomena of Tartini's Tones which we are familiar with in acoustical theory, and which are explained in terms of the forced vibrations of a non-harmonic oscillator. This analogy may no doubt be used to find the intensity of the modified radiations approximately, by applying the correspondence principle to a non-harmonic molecular model of suitable type. The difference between this classical analogue and the actually observed optical effect is in the extraordinary disproportion between the intensity of the lines corresponding to the differential and summational tones respectively, which is far greater than in the acoustical analogies.

An extremely interesting and fundamental point regarding the new type of secondary radiation is that, in general, it is strongly

polarised. In this respect, the phenomenon is analogous to the experimentally known polarisation of the Compton type of X-ray scattering. We notice, however, that the different lines corresponding to different molecular frequencies are polarised to very different extents. It may be presumed that this is due to the molecular oscillators involved not possessing spherical symmetry. Whether this explanation is sufficient or not remains to be tested by computation and comparison with observation.

We may here pause a little to consider more closely the real significance of our phenomenon. Some, no doubt, will claim to see in it a further confirmation of the quantum theory of radiation. My own view, however, is that there is nothing in the effect that in any way contradicts the wave principles, and that on the other hand the fact that we can cut up or add to the quantum of energy to any arbitrary extent is unfavourable to the idea of a real, corporeal existence for it. We may, of course, get over this difficulty by assuming that the incident quantum in some way disappears on collision with the molecule, and that a new quantum of smaller or larger energy arises from the combination. But the observed fact of the strong polarisation of the lines is unfavourable to the latter idea. As already indicated in the foregoing discussions, the concept of localised quanta is irreconcilable with the phenomena of wave optics, and the necessity for introducing it is even less in the present case than in the Compton type of scattering.

I shall now pass on to consider some applications of the new effect. Its potential value perhaps is greatest in the field of Chemistry. The method of investigation affords us an

extraordinarily easy and convenient process of mapping the infrared spectra of chemical compounds. The geometry of the chemical molecule and the forces of chemical affinity determine the frequencies of molecular vibrations. In many cases, they lie in the far infrared, a region of the spectrum which has hitherto been difficultly accessible to observation. The study of light-scattering enables us, as it were, to photograph the whole infrared spectrum with the same facility and ease as the visible and ultraviolet spectra. The determination of the fundamental vibration frequencies of the chemical molecule, their relative importance as gauged by the intensities of the lines, and even more, their peculiar polarisation characters promise to take us deep into the fundamental problems of Chemistry. As an illustration, I will mention a recent paper by Daure in the *Comptes Rendus* of the French Academy. Daure investigated the spectra of the chlorides of carbon, silicon, titanium, arsenic, lead, antimony and bismuth by this method. The investigation revealed hitherto unknown spectra in the far infrared for each of the compounds studied, exhibiting remarkable analogies and differences amongst each other in the position, intensity and polarisation of the lines.

In Organic Chemistry also, the method opens up an illimitable field of research. Numerous lines appear whose positions in many cases are accurately measurable, and are influenced notably by changes in chemical constitution. A very surprising feature is the extreme sharpness of some of the lines. The frequencies of the vibration of the carbon-carbon bond in benzene can be determined, for example, with

extraordinary precision unapproachable by other methods. It is precisely this accuracy of measurement and the rich and varied mass of data obtainable that indicate for this method a real future.

The study of the influence of changes of temperature and pressure, and of a change of physical state on the intensity, positions and widths of the spectral lines promises to furnish information of value in the field of Molecular Physics. Already in our earliest observations, it was noticed that the spectral lines obtained with ice are sharper and somewhat displaced in position relatively to the broad bands found with liquid water. The sharpness of the lines observed with transparent crystals appears to be a general feature. As an example, I may mention the case of selenite in which Mr. Krishnan found that the water of crystallisation also gave well-defined lines instead of the bands observed with water.

Preliminary studies have shown that it is perfectly practicable to photograph the lines in the spectra of vapours. Hence it will be possible in many cases to investigate the changes in molecular spectra in the passage from vapour to liquid as well as those in the passage from liquid to solid. In the change from vapour to liquid, we have a partial destruction of the

freedom of rotation of the molecules. Such observations as we have made seem to indicate that exchanges of energy between the incident quantum and the molecule can also occur with respect to the rotational states of the molecule. The optical anisotropy of the molecule appears to be involved in the possibility of such induced molecular rotation. Whether the removal of restriction on rotational freedom when the molecule passes from liquid to vapour results in a fuller development of such rotational spectra remains to be investigated.

At low temperatures, many liquids as is known refuse to crystallise, become highly viscous and ultimately are transformed into glasses. Glycerine is a typical example of such a liquid. Mr. Venkateswaran has observed in it a remarkable development of a continuous spectrum whose intensity falls with rise of temperature or by dilution with water. The precise origin of this phenomenon and the existence of similar effects at low temperatures in the case of other viscous liquids remain to be studied. The problem of the amorphous solid condition is related to this. Already Pringsheim has noted that fused quartz, unlike the crystalline substance, does not show any lines in the scattered spectrum. The explanation of this may be that the lines have become too broad and diffuse to be photographed.

DO YOU KNOW?

- Q1. What is Chinese Gooseberry ?
- Q2. At any time how does the blood stay distributed in human body ?

PLANT GROWTH PROMOTING RHIZOBACTERIA IN PLANT DISEASE MANAGEMENT—AN OVERVIEW

T. Saravanan* and T. Marimuthu**

Plant Growth Promoting Rhizobacteria (PGPR) is being exploited recently for plant disease management. The species of this group is not only used for plant disease, but also used for inducing systemic resistance against various pathogens in the crop plants. The traits of PGPR namely Lipopolysaccharides, Siderophores, Hydrogen Cyanide and Salicylic Acid production have been proved to be effective in inducing systemic resistance against the invading pathogens. PGPR treatment in plants causes cell wall structural changes and induces several biochemical or physiological changes in the host plants leading to the synthesis of resistance inducing proteins in the host. Some species of PGPR have been exploited commercially for plant disease management.

INTRODUCTION

The crop plants are being affected by various biotic and abiotic factors. In the biotic factors, fungi, bacteria and virus strongly influence the productivity of the crops. Several chemicals have been identified and proved as effective in eradicating the harmful pathogens. But indiscriminate and continuous use of these chemicals leads to creation of resistance of pathogens to the chemicals and environmental degradation. So to avoid such consequences, several beneficial microorganisms have been exploited for the management of diseases. Among them, plant growth promoting rhizobacteria gains popularity in plant disease management because of broad-spectrum activity of this group of organisms. Plant growth promoting rhizobacteria is involved in induction

of systemic resistance in the host plant. Induced resistance is defined as an enhancement of the plant defense capacity against a broad spectrum of pathogens and pests and it is acquired after appropriate stimulation.

The species of *Pseudomonas* are the potential biological control agents to suppress the plant pathogens. They act on different mechanisms which include competition for nutrients and space¹, antibiosis by producing metabolites like phenazine, pyrrolnitrin, pyocyanine, 2, 4-diacetylphloroglucinol² and production of siderophores like pseudobactin³. They also produced enzymes such as chitinases and β 1, 3-glucanases which degrade chitin and glucan present in the cell wall of pathogenic fungi⁴.

Several attempts have been made use of plant growth promoting rhizobacteria for the inducing systemic resistance against the pathogens in various crops. Application of *Pseudomonas* sp strain WCS 417 r has protected

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camation plants from Fusarial wilt disease caused by *Fusarium oxysporum* f. sp. *cubense*⁵ and *Pseudomonas putida* strain 89B-27 and *Serratia marcescens* strain 90-166 also reduced the incidence of Fusarium wilt disease in cucumber⁶. PGPR treatment as soil or seed treatment protected the crop plant against anthracnose disease under field conditions.

PGPR also reduced the severity of bacterial diseases. The control of common beans haloblight was achieved by seed bacterization with *Pseudomonas fluorescens* strain 97. The seed treatment of cucumber with *P. putida* strain 89 B-27 induced systemic protection against angular leaf spot disease.⁷ Besides, PGPR proved to be effective against viral diseases in cucumber and tobacco plants. The reduced viral disease severity and delayed symptom development were achieved in cucumber seeds treated with *P. fluorescens* strain 90-166 and *S. marcescens* strain 90-166. Similarly, *P. fluorescens* strain CHA0 reduced Tobacco Necrosis Virus Infection in tobacco. These findings suggested that PGPR strains afford protection against plant diseases⁸.

TRAITS OF PGPR

Several traits were identified and involved in the induction of systemic resistance against the plant diseases. The traits include lipopolysaccharides, siderophores and salicylic acid production have played a major role in disease suppression.

Lipopolysaccharides, present in outer membrane of PGPR, are the major determinants of ISR in certain PGPR strains. The strain WCS 417 of *P. fluorescens* has induced the resistance

in camation against wilt disease because of IPS present in outer membrane. Similarly, Strain WCS 374 and WCS 417 have induced systemic resistance in radish against *Fusarium oxysporum* f. sp. *raphani*⁹.

Siderophores are produced by PGPR under iron limited conditions. Under such conditions, PGPR is to starve the pathogens for want of iron. Siderophores can effectively compete for iron with microorganisms that produce siderophores in lower concentration or with a lower affinity for iron that are unable to use the siderophores produced by the strains. Research findings indicated that under low iron condition, IPS of the bacterium is not involved in ISR, but siderophores are a major factor in inducing the resistance. Under low iron availability, both IPS plus and minus strains of *P. fluorescens* had induced resistance against *Fusarium* wilt in Radish plant. This finding indicates that the factor for ISR is not IPS of the outer membrane of the bacteria. Other bacteria factors, expressed only under the low iron conditions namely different siderophores, are responsible for the induction of resistance.

Application of salicylic acid delayed or decreased disease development in tobacco against Tobacco Mosaic Virus and Tobacco Necrosis Virus. Salicylic acid production encoded strains of *P. fluorescens* renders significant improvement in tobacco to induce systemic resistance against Tobacco Necrosis Virus¹⁰.

In contrast to this finding, salicylic acid production by *S. marcescens* 90-166 is not important in the induction of systemic resistance in cucumber. *S. marcescens* 90-166 mutant's strain induces the same level of resistance in

cucumber. Salicylic acid involved in phenyl propanoid pathway in the plant cell system and enzymes in the pathway are involved in inducing protection against the pathogens in the plant system. All these experiments show that the various traits of PGPR are involved in inducing systemic resistance against the pathogens and the actions vary with different conditions, bacterial strains and hosts.

MECHANISMS OF PGPR IN PLANT DISEASE MANAGEMENT

PGPR induce resistance level in crop plants through fortifying the physical and mechanical strength of the cell wall, as well as changing the host physiological reaction leading to synthesis or increased level of defense chemicals against particular pathogen.

The success of a plant on invading pathogens depends primarily on its ability to construct a barrier of defense for protecting their cell wall against the development or colonization of the pathogen. PGPR is involved in cell wall structural changes in response to pathogen growth. Several mechanisms have been identified in their structural changes. The mechanisms include lignin and callose accumulation, phenolic compounds accumulation—thereby it contains the pathogen attack. Generally, the phenolic substances confer strong rigidity to cell wall structures through peroxidase mediated cross linking with constitutive and newly formed wall carbohydrates. In addition to acting as physical barrier, phenolic compounds are fungitoxic to several fungal pathogens. The responses will take place very rapidly at the site of potential fungal entry which may constitute delaying the

infection process, which allow the host to build up other defense reactions against pathogen.

Various physiological and biochemical changes in the plants induced by PGPR were reported. The induced resistance is associated with the accumulation of pathogenesis related proteins (PR protein), synthesis of phytoalexins and the other antifungal metabolites.

P. fluorescens strain CHAO, induced systemic protection against Tobacco Necrosis Virus in tobacco is associated with induction of PR proteins viz., β -1, 3-glucanases and endochitinases accumulation¹¹. The accumulation of hydrolytic enzyme viz., chitinases and β -1, 3-glucanases were identified in pea, following seed bacterization with *P. fluorescens* against *F. oxysporum* f. sp. pisi. However, in certain crops, PR proteins is not involved in the induction of resistance. In Arabidopsis, the resistance induced by *P. fluorescens* WCS 417r is not associated with PR gene induction¹². It is now recognized that some plant growth promoting rhizobacteria may promote plant growth by secreting plant hormones.

In these findings, the resistance induced by PGPR against plant pathogens is associated with host anatomical modification in a way to prevent the invasion of the pathogens followed by the biochemical changes in the host.

APPLICATION IN PLANT DISEASE MANAGEMENT

Development of formulation or field level application of PGPR or any biocontrol agents, is

the main criterion in biological disease management. The developed formulation would preserve microbial activity for long time. PGPR can be applied in the form of bacterial suspension or powder formulation¹⁴. A dried powder formulation of PGPR is important for seed treatment and soil application. The survival of PGPR in a dried formulation and effectiveness of methylcellulose in a powder formulation to coat PGPR on sugar beet seed has been well documented. The possibility of replacing chemical control of plant root disease with a biological alternative remains an exciting and challenging objective for sustainable agriculture. Some fluorescent *Pseudomonas* species do appear to be prime candidates for this role. Research along these lines will increase the impact of PGPR on the biocontrol of plant root diseases in the world.

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THE TALE OF A NEGLECTED MATHEMATICIAN, HIS WORKS, AND BEYOND

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D R Kaprekar is a not-so-well-known Indian mathematician of the last century. Very few of today's scientists are aware of his discoveries. What is more appalling is that Indian scientific societies started recognizing him only after he received importance from outside India. The present article discusses some of his works and beyond on the occasion of his birth centenary.

PROLOGUE

Consider a four-digit number. The digits should not be all alike. That is, 1111, 2222, ... etc. will not do. From this number form two other numbers by arranging the digits in the ascending and descending order. Subtract the first from the second. You get a new four-digit number, the remainder of the subtraction. (Occasionally, the remainder is a three-digit number, put a zero in the left to make it four-digit in such cases.) This process is called the *reverse subtraction process*. Now the question is, if you keep repeating this process with the remainders, will you go on getting new numbers or something else happens? Let us look at one example.

Let us consider a number, say, 2485.

First Step: From 2485 we get 8542 and 2458. The subtraction yields 6084.

2nd Step: from 6084 we get 8640 and 0468. The subtraction yields 8172.

3rd Step: from 8172 we get 8721 and 1278. The subtraction yields 7443.

4th Step: from 7443 we get 7443 and 3447. The subtraction yields 3996.

5th Step: from 3996 we get 9963 and 3699. The subtraction yields 6264.

6th Step: from 6264 we get 6642 and 2466. The subtraction yields 4176.

7th Step: from 4176 we get 7641 and 1467. The subtraction yields 6174.

8th Step: from 6174 we get 7641 and 1467. The subtraction yields 6174.

And now, there is no use of repeating this process any more, because, every time it will repeat the 8th step. So, starting from 2485, the numbers that we generate, converge to a number, and that number is 6174. What is more astonishing, you start with any four-digit number (not repeated-digit numbers like, 1111) in eight steps or fewer you will converge to this one and the same number, 6174. This interesting feature with the constant 6174 was discovered¹ by an Indian mathematician, named D R Kaprekar. The constant is, eventually, known as

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Kaprekar constant and the process for obtaining the constant, the *Kaprekar process*.

THE MATHEMATICIAN

For whatever reasons, Dattatreya Ramachandra Kaprekar is not so well-known in the scientific community. He was born on January 17, 1905 at Dahanu in the district Thane, Bombay. His schooling was in Thane. For further education he joined Ferguson College, Pune in 1923. After graduating from the University of Bombay in the year 1929 he started his career as a school-teacher at Derali, near Nasik, Maharashtra. He retired in 1962 and died on July 5, 1986.

Since his college time, Kaprekar acquired interest in number theory, mainly, recreational number theory. It is understood that his father was an astrologer and taught him astrology. As astrology is a play of numbers, Kaprekar was introduced to the world of numbers through it. In 1927, he received the Wrangler R P Paranjape award for his original piece of work on the theory of envelopes. Apart from Kaprekar constant, *Kaprekar numbers*, *Harshad numbers*, *Self-numbers*, ... are all created by him. He did a lot of work on *Demlo numbers*, once again, his own creation. He studied in detail the subject of recurring decimals. It needs to be mentioned that Kaprekar never received any formal course on number theory. His discoveries were absolutely his own. In most cases the scientific society did not give any recognition to his works and set them aside as too trivial to be paid any importance. Kaprekar, however, didn't get disheartened at this and kept himself engaged in further discoveries.

Kaprekar published many articles not only in Indian journals, but also in foreign journals. Nearly 40 of his notes/articles/curiosa were published in *Scripta Mathematica*. Several papers were published in *Journal of Recreational Mathematics*. He also published around 30 booklets, which were made available at a very low price. He had written a book on *Demlo numbers*. This is a book of collected papers, most of which were contributed by Kaprekar himself and some in collaboration with others. He had written a two-volume book on *cycles of recurring decimals*. In these books he compiled a wealth of interesting and exciting information regarding the structure of decimals of various fractions. The books are easy to understand and are well within the level of mathematical maturity of an undergraduate and constitute a valuable source of mathematical recreation as well as of inspiration to many amateur mathematicians.

Kaprekar had a great interest in the magic squares and mathematical puzzles. He had invented many magic squares. Notable amongst these are Copernicus Magic Square, Mahatma Gandhi Shatabdi Square, Newton's Magic, Harmonium Number Magic, Dattatreya Numbers, Magic Hexagons, etc. His puzzles on series of cross jump numbers are worth mentioning.

Kaprekar was invited by various schools and colleges to deliver talks. He delivered lectures in various Universities and Mathematical Societies also. In fact, he travelled widely and lectured extensively all over India. At the fag end of his life he received honour and recognition from a few mathematical societies like, Mathematical Association of India (Delhi Chapter), Maharashtra Ganit Mandal, Association of Mathematics Teachers of India, etc.².

HIS WORKS

The most important aspect of Kaprekar's works is that they are not only interesting but thought provoking also. For instance, knowing Kaprekar constant and how to find it, one is always struck with questions like, is it possible to obtain Kaprekar constant for three-digit numbers? What happens for five- or higher-digit numbers? Let us address these questions in somewhat detail.

Kaprekar Constants and Cycles :

Needless to say, the reverse subtraction process is not applicable to the single-digit numbers (1-9). So, no Kaprekar constant exists for one-digit numbers. For two-digit numbers (10-99), we do not find any constant, but, if the reverse subtraction process is continued, the generated numbers fall in a cycle, and that is, $09 \rightarrow 81 \rightarrow 63 \rightarrow 27 \rightarrow 45 \rightarrow 09$. Let us name such cycle as *Kaprekar cycle*. For the three-digit numbers, we get a definite Kaprekar constant, 495. As described earlier, for the four-digit numbers, the Kaprekar constant is 6174. The five-digit numbers fall in any one of three definite cycles. Similar situations obtain for other-digit numbers. In Table 1 we have listed Kaprekar constants and cycles for 2- to 10-digit numbers. It may be noted that Kaprekar constants and the numbers belonging to Kaprekar cycles, are all divisible by 9. This is an outcome of the reverse subtraction process.

Kaprekar Numbers :

Let us now discuss the Kaprekar numbers. According to Kaprekar, he discovered them³ sometime around 1940³. A number K is a Kaprekar number if K^2 is divided into a left and

a right part such that the sum of the two parts equals K . Mathematically, K is a Kaprekar number if

$$K^2 = p \times 10^n + q \quad (n \geq 1, \quad p \geq 0, \quad 0 < q < 10^n) \quad (1)$$

$$\text{and} \quad K = p + q. \quad (2)$$

Some examples are

$$(a) \quad 99^2 = 9801 \quad 98 + 01 = 99$$

$$(b) \quad 703^2 = 494203 \quad 494 + 203 = 703$$

$$(c) \quad 4879^2 = 23804641 \quad 238 + 04641 = 4879.$$

According to the definition given above, 1 is a Kaprekar number but 10, 100, 1000, etc. are not. On the other hand, 9, 99, 999, ..., etc. i.e., all $10^n - 1$ ($n \geq 1$) numbers are Kaprekar numbers. The first few Kaprekar numbers are

1, 9, 45, 55, 99, 297, 703, 999, 2223, 2728, 4879, 4950, 5050, 7272, 7777, 9999, ..., etc.

It is observed that for any Kaprekar number K_1 , there exists another Kaprekar number K_2 such that

$$K_1 + K_2 = 10^n \quad (n \text{ is an integer } > 0). \quad (3)$$

For example, (a) $45 + 55 = 10^2$
(b) $297 + 703 = 10^3$
(c) $4879 + 95121 = 10^5$, etc.

Self-numbers and digitaddition process :

Having discussed the Kaprekar constants and Kaprekar numbers, let us now describe another creation of Kaprekar, the self-numbers⁴. Let me first explain the underlying process, which Kaprekar called *digitaddition process*. Take any positive integer number, for example, 57. Add to it the sum of its digits $57 + 5 + 7 = 69$. The

Table 1. KAPREKAR CONSTANTS AND CYCLES UP TO 10 DIGITS

Digits	Kaprekar constants and cycles
2	09 → 81 → 63 → 27 → 45 → 09
3	495
4	6174
5	53955 → 59994 → 53955 61974 → 82962 → 75933 → 63954 → 61974 62964 → 71973 → 83952 → 74943 → 62964
6	420876 → 851742 → 750843 → 840852 → 860832 → 862632 → 642654 → 420876 549945 631764
7	7509843 → 9529641 → 8719722 → 8649432 → 7519743 → 8429652 → 7619733 → 8439552 → 7509843
8	43208766 → 85317642 → 75308643 → 84308652 → 86308632 → 86326632 → 64326654 → 43208766 63317664 64308654 → 83208762 → 86526432 → 64308654 97508421
9	554999445 753098643 → 954197541 → 883098612 → 976494321 → 874197522 → 865296432 → 763197633 → 844296552 → 762098733 → 964395531 → 863098632 → 965296431 → 873197622 → 865395432 → 753098643 864197532
10	4332087666 → 8533176642 → 7533086643 → 8433086652 → 8633086632 → 8633266632 → 6433266654 → 4332087666 6333176664 6431088654 → 8732087622 → 8655264432 → 6431088654 6433086654 → 8332087662 → 8653266432 → 6433086654 6543086544 → 8321088762 → 8765264322 → 6543086544 9751088421 → 9775084221 → 9755084421 → 9751088421 9753086421 9975084201

new number, 69, is called a generated number, the original number, 57, being the generator. From 69, we can generate 84 (= 69 + 6 + 9). The process can be repeated endlessly, forming a digitadition series

57, 69, 84, 96, 111, 114, 120, ...

Do all numbers have a generator? The answer is : No. There are certain numbers, which has no generator. They are self-numbers. In Kaprekar's words, they are self-born

(Sayambhu). For example, 20, 53. How many self-numbers are there? Of course, infinite, but much rarer than generated numbers. Below 100, there are only 13 such numbers

1, 3, 5, 7, 9, 20, 31, 42, 53, 64, 75, 86 and 97.

Below 10, all odd numbers are self numbers. Above 10, the density of such numbers decreases and attains a stable value. Table 2 lists total number and density of n -digit self-numbers for $n = 1$ to 6

Table 2. LIST OF TOTAL NUMBER AND DENSITY OF N -DIGIT SELF-NUMBERS FOR $N = 1$ TO 6.

Number of digits (n)	Number of self-numbers			Percentage
	odd	even	total	
1	5	0	5	50
2	4	4	8	8.8889
3	44	45	89	9.8889
4	441	440	881	9.7889
5	4400	4401	8801	9.7789
6	44001	44001	88002	9.7780

Can a generated number have more than one generator? Yes, for instance, 101. It can be generated both from 91 and 100. Numbers having more than one generator are termed (by Kaprekar) *junction numbers*. 101 is the smallest junction number which has two generators. The next junction numbers are 103 (generators 92 and 101), 105 (generators 93 and 102), and so on. The smallest junction number with three generators is 10 000 000 000 001. The generators are : 10 000 000 000 000, 9 999 999 999 901, and 9 999 999 999 892.

The smallest number with four generators, discovered by Kaprekar, is

1 000 000 000 000 000 000 102.

How can one generate self-numbers ? No one has yet discovered a non-recursive formula that generates all self-numbers. That means, if a particular number, say p , is to be examined then one has to generate the digitadition series for all numbers from 1 to $(p - 1)$ and see whether p belongs to any of these series. If not, then p is a self-number. Definitely, this is a lengthy and tedious process, particularly, for large p . However, there is an easier method. This method does not require checking the digitadition series for all numbers from 1 to $(p - 1)$. If the testing number p is of n digits, one has only to check for all numbers from $(p - 9n)$ to p . This is because, if p is a member of any digitadition series, the previous number to p in that series must lie between $(p - 9n)$ and p . The proof is very simple and is omitted here.

The method of testing a self-number described by Kaprekar is even easier. Obtain p 's digital root by adding its digits, then adding the digits of the result and so on until only one digit remains. If the digital root is odd, add 9 to it and divide by 2. If it is even, simply divide by 2. In either case, call the result q . Subtract q from p . Check the remainder to see if it generates p . If it does not, subtract 9 from the result and check again. Continue subtracting 9's, each time checking the result to see if it generates p . If this process fails to produce a generator of p in k steps, where k is the number of digits in p , then p is a self-number.

Let us test, for example, whether the number 2347 is a self-number.

The sum of the digits of 2347 = $2 + 3 + 4 + 7 = 16$ (a two-digit number).

The sum of the digits of 16 = $1 + 6 = 7$.

So, the digital root of the number 2347 is 7.

7 is an odd number so adding 9 and dividing by 2 we get $(7 + 9) / 2 = 8$.

Subtracting 8 from the testing number 2347, we get $2347 - 8 = 2339$.

Now, it is to be checked whether the testing number 2347 belongs to the digitadition series of 2339.

$$2339 + 2 + 3 + 3 + 9 = 2356. \quad 2356 > 2347.$$

So, 2339 does not generate the testing number 2347.

Next, the same procedure is to be followed with the number $2339 - 9 = 2330$.

$$2330 + 2 + 3 + 3 + 0 = 2338$$

$$2338 + 2 + 3 + 3 + 8 = 2354$$

So, 2330 fails to generate 2347.

Next, the procedure is to be followed with the number $2330 - 9 = 2321$.

$$2321 + 2 + 3 + 2 + 1 = 2329$$

$$2329 + 2 + 3 + 2 + 9 = 2345$$

$$2345 + 2 + 3 + 4 + 5 = 2359$$

So, 2321 fails to generate 2347.

Next, the procedure is to be followed with the number $2321 - 9 = 2312$.

$$2312 + 2 + 3 + 1 + 2 = 2320$$

$$2320 + 2 + 3 + 2 + 0 = 2327$$

$$2327 + 2 + 3 + 2 + 7 = 2341$$

$$2341 + 2 + 3 + 4 + 1 = 2351$$

So, 2312 also fails to generate 2347.

The testing number, 2347 is a 4-digit number.

We have checked with 4 remainders, viz, 2339, 2330, 2321 and 2312, and all of them fail to generate 2347. So, 2347 is a self-number.

So, we have learnt one new series – the digitadition series. Well, for an A.P. or G.P. series we have definite formulae for evaluation of the n th term or sum of n terms of the series. Does there exist any such formula for digitadition series? No, there is no non-recursive formula for the partial sum of a digitadition series. However, given its first and last terms, there is a simple formula for the sum of all the digits in a digitadition series. Simply subtract the first term from the last term and add the sum of the digits to the last number. You will get the answer. For example, let us consider the digitadition series

$$48, 60, 66, 78, 93, 105.$$

One has to find the sum of the digits of the terms. As per prescription above, we proceed as follows

$$105 - 48 = 57$$

$$57 + (1 + 0 + 5) = 63.$$

So, 63 is the desired result. For certainty, check it

$$(4 + 8) + (6 + 0) + (6 + 6) + (7 + 8) + (9 + 3) + (1 + 0 + 5) = 63.$$

Harshad numbers :

In 1980, Kaprekar published these numbers⁵. If an integer n is exactly divisible by the sum of all its digits (equal to d , say) then n is called a Harshad number for the sum d . For example, 133 is a Harshad number because, 133 is divisible by $1 + 3 + 3 = 7$. Kaprekar says, 133 is a harshad number for 7. There exists several other harshad numbers for 7, for instance, 70,

322, 700, etc. Similarly, 247 is a harshad number for 13 as are 364, 481, 715, etc.

'The word *harsad* is a sanskrit word which means giving joy. There is great joy in creating these numbers' –says Kaprekar. He provided a list of several harshad numbers for various values of d .

Kaprekar understood that with the help of the digit 0, one can produce infinite harshad numbers for any d . For instance, for 7, one can list 7, 70, 700, 7000, etc. So he had talked of zeroless harshad numbers, which are finite in number and rarer too. For some values of d there is no zeroless harshad numbers, for example, for 10, and more surprisingly, for 11. No analytical procedure for generating harshad number has yet been presented.

Demlo numbers :

In 1923 Kaprekar introduced these numbers*. Demlo numbers are those numbers which may be partitioned into three parts of which the middle part is of the form $a^{(i)}$ and the sum of the first and last parts is of the form $a^{(n)}$. Here, $a^{(i)}$ represents the digit a repeated i times. In this notation, $1^{(2)}029^{(3)}$ represents 1102999. Thus, 12488764 is a demlo number of which the middle part is 88 and the extreme groups 124 and 764 add up to 888. 2553 is a Demlo number because $2 + 3 = 5$. 126654 is a Demlo number as $12 + 54 = 66$. A Demlo number is generated by a process called *demlofication*. In demlofication, we go on adding numbers

* It is said, while waiting for a local train in Dombivili station (on Bombay-Thane line) Kaprekar discovered these numbers and named 'demlo numbers' after the name of the station.

diagonally, or in other words, we shift each successive number one place to the left and then add them all together. For example:

$$\begin{array}{r} 351 \qquad \qquad \text{or} \qquad \qquad 894 \\ 351 \qquad \qquad \qquad \qquad 894 \\ 351 \qquad \qquad \qquad \qquad 894 \\ 351 \qquad \qquad \qquad \qquad 894 \\ - - - \qquad \qquad \qquad \qquad 894 \\ 389961 \qquad \qquad \qquad - - - - - \\ \text{where } 38 + 61 = 99. \qquad \qquad 9933234 \end{array}$$

$$\text{where } 99 + 234 = 333.$$

Later, Kaprekar introduced *wonderful demlo numbers*⁶ which are defined as the square of an integer of the form $1^{(i)}$ where $1 < b \leq 9$. Thus,

$$\begin{aligned} \{1^{(2)}\}^2 &= 11^2 = 121, \\ \{1^{(3)}\}^2 &= 111^2 = 12321, \\ \{1^{(4)}\}^2 &= 1111^2 = 1234321, \\ \{1^{(6)}\}^2 &= 111111^2 = 12345654321, \\ \{1^{(9)}\}^2 &= 12345678987654321, \text{ etc.} \end{aligned}$$

are all examples of wonderful demlo numbers. Here the middle part consists of a single digit while the first and last parts consist of digits in ascending and descending order. Certainly, these numbers are palindromic numbers also. According to the definition given by Kaprekar there are only nine such numbers ($1 < b \leq 9$). Redefining the demlo numbers as

$$D_n = R_n^2 \quad (4)$$

where D_n is the n th demlo number and $R_n = 1^{(n)}$, one can obtain demlo numbers for $n \geq 10$ also. Now, the first demlo number is 1, the second one is 121 and so on. The 10th, 11th, ..., etc. demlo numbers are

$$\begin{aligned} &1234567900987654321, \\ &123456790120987654321, \\ &12345679012320987654321, \\ &1234567901234320987654321, \quad \dots \end{aligned}$$

AND BEYOND

As stated earlier, Kaprekar's findings are not only interesting to learn but leave room for newer discoveries also. In fact, various aspects and properties of Kaprekar's revelations have been ascertained later and even today. For instance, application of Kaprekar process to n -digit numbers leads to the generation of several other Kaprekar constants and cycles*. In this section, we shall discuss some of the advancements that have been made by his successors.

On Kaprekar constants and cycles :

Of the Kaprekar process, the most surprising part is that, starting with any n -digit numbers the process always leads to one or the other constants or cycles. On a second thought, however, one understands that it is not so surprising. Why? Start with any n -digit number. Application of Kaprekar process on this starting number generates a sequence of numbers. Two features are to be noted. First, each number in the sequence uniquely determines the next number. For instance, any 4-digit number, say 9172, always generates 8442 (= 9721 – 1279), no other number ever. Secondly, from an n -digit number, Kaprekar process always produces another n -digit number only. Occasionally, the generated number may be of one digit less, consisting of $(n - 1)$ 9's (for instance, 4443 – 3444 = 999), but no other non- n -digit number. And, since there is only finite number of n -digit

numbers, eventually the sequence has to return to a number it hit before, leading to a cycle. For any particular value for n , there may exist several cycles and the number of members in a cycle may also vary from cycle to cycle. Coincidentally, for $n = 4$, we get only one cycle and that too has only one member, leading to what is called Kaprekar constant.

On realizing what is explained above, one may inquire whether such cycles are possible for other processes similar to that of Kaprekar? The answer is an emphatic 'yes'; only point is that the process should have the characteristic that a n -digit number must generate another unique n (or lesser-) digit number by that process. One can design several such processes. Suppose, instead of reverse subtraction process, one introduces *reverse addition process*. Of course, addition of two n -digit numbers often results in a $(n + 1)$ -digit number, and so, to preserve the characteristic described above, one may introduce the rule of eliminating the leftmost digit (say) in such cases. As if one has a n -digit decimal register to store the results. So the process, in detail, is the following. Consider a n -digit number. From this number form two other numbers by arranging the digits in the ascending and descending orders. Add these two numbers. If the result is a $(n + 1)$ -digit number, cut off the leftmost digit. What you get is the number generated by this process. One can now examine whether this process results to constants or cycles. In reality, however, there exist several other processes, which lead to cycles though the convergence is not apparently straightforward. We may discuss such processes elsewhere.

* To the author's knowledge, the constant 495 for 3-digit numbers and the three cycles for 5-digit numbers (see Table-1) were presented by Kaprekar himself. The others were listed by his successors.

On the Kaprekar numbers :

After the launching of Kaprekar numbers, several additions and modifications ensued. The definition of the Kaprekar numbers has been made more specific. Wells⁷ described the kaprekar numbers as follows. If the original number has d digits, then after squaring you should split it into a 'right half' of d digits and a 'left half' of d or $d - 1$ digits. According to this definition, 4879 is not a Kaprekar number, though Kaprekar himself enlisted this number³. On the other hand, Kaprekar enlisted 9 as a Kaprekar number, but overlooked 99, 999, ..., which was noted by Charosh⁸.

Later, Kaprekar numbers for higher powers were introduced. It is very interesting to note that 45 is a Kaprekar number for n th power with $n = 2, 3$, and 4. This is because,

$$\text{For } n = 2, \quad 45^2 = 2025 ; \quad 20 + 25 = 45$$

$$\text{For } n = 3, \quad 45^3 = 91125 ; \quad 9 + 11 + 25 = 45$$

$$\text{For } n = 4, \quad 45^4 = 4100625 ; \\ 4 + 10 + 06 + 25 = 45$$

Some Kaprekar numbers for $n = 3$ are 1, 8, 10, 45, 297, 2322, 2728, 4445, 4544, 4949, 5049, 5455, 5554, 7172, 27100, 44443, 55556, 60434, 77778, 143857, etc. For $n = 4$ the list runs as 1, 7, 45, 55, 67, 100, 433, 4950, 5050, 38212, 65068, etc. 45 is the only number (up to at least 10^9) that is in all the Kaprekar sequences for $n = 2, 3$, and 4.

The cyclic number 142857 (the decimal expansions of the fractions $1/7, 2/7, 3/7, 4/7, 5/7$ and $6/7$ all consist of the digits 142857 repeated) is a Kaprekar number :

$$142857^2 = 20408122449 \text{ and } 20408 + 122449 = 142857.$$

Several other features of the Kaprekar numbers were introduced later.

On self-numbers :

Kaprekar discovered self-numbers for base 10. Later self-numbers for other bases were also introduced and recursive relations for generating self-numbers determined. For base 10, one such recursive relation is given by

$$c_k = 8 \cdot 10^{k-1} + c_{k-1} + 8 \quad (k = 2, 3, \dots) \quad (5)$$

with $c_1 = 9$.

For base 2 (binary numbers) the generating equation is

$$c_k = 2^j + c_{k-1} + 1 \quad (k = 1, 2, \dots) \quad (6)$$

where j is the number of digits in c_{k-1} .

For other bases (base b)

$$c_k = (b - 2)b^{k-1} + c_{k-1} + (b - 2) \\ (k = 2, 3, \dots) \quad (7)$$

where $c_1 = b - 1$ for even bases

and $c_1 = b - 2$ for odd bases.

Obviously, these recursive relations do not generate all the self-numbers. For instance, for base 10, using Eq. (5) one obtains only the following self-numbers

$$9, 97, 905, 8913, 88921, 888929, 8888937, \\ 88888945, 888888953, \text{ etc.}$$

It may be noted that, for even bases, all odd numbers below the base number are self-numbers, since any number below such an odd number would have also to be a single-digit number, which when added to its digit, would result in an even number. For odd bases, all odd numbers are self-numbers⁹. Patel showed that

$2k$, $4k + 2$, and $k^2 + 2k + 1$ are k -self for all even bases with $k \geq 4^{10}$.

EPILOGUE

In the previous sections we have made an attempt to present the mathematician D R Kaprekar and some of his works. Needless to say, it is hardly possible to cover all his works within this short space. We have not touched upon his works on the cycles of recurring decimals. Nor have we discussed any of his so many magic squares. Many other topics had to be left out. And, Kaprekar did all these almost alone. What's more, he was just a graduate and had no formal training in number theory. As stated earlier, in his time he received very little recognition for his works. This did not bother him. He used to lead a very simple and hard-working life. In 1975 Martin Gardner introduced Kaprekar in his column in *Scientific American* with the following words—D R Kaprekar is a 70-year-old mathematician, diminutive in body but large in brain and heart, who lives in India. For more than 40 years he has been doing highly original work in recreational number theory,¹¹. And, as we understand, that opened to the world a window on Kaprekar.

Today Kaprekar is widely studied. His works find a place in hundreds of websites. He figures as an eminent mathematician in *The World Directory of Mathematicians* published in Sweden and in many other literatures.

The year 2005 is Kaprekar's birth centenary. The present article is a small tribute to this loan explorer.

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PHYTOPLASMAS – THE PLANT PARASITIC MOLLICUTES

Hi samuddi n *

Phytoplasmas were earlier known as mycoplasma like organism (MLOs) because of their similarities with mycoplasmas when observed under electron microscope. These are plant parasitic prokaryotes that lack a cell wall and occur in phloem elements of the shoots. The most common symptoms of affected plants are yellowing, phyllody and witches' broom. In India, these have been reported on citrus and coconut plants.

MOLLICUTES

Presence of cell wall is the fundamental characteristic of bacteria, absence of wall in certain prokaryotic organisms incited some workers to work out their systematic position. Nocard¹ and their collaborators first cultured a wall less contagious microbe, causing pleuropneumonia of cattle, on artificial broth in 1898. They observed small colonies with dark center and light peripheral area that resembled with fried eggs. Like viruses, these microbes were filterable. Cell wall free and filterable prokaryotes discovered until 1930s were named as "Pleuro-Pneumonia Like Organisms" or "PPLOs."

In 1960s, these wall-less prokaryotes were given the collective term "Mycoplasmas" (Greek noun *myccs* meaning fungus and the Greek noun *plasma* meaning something formed or moulded) since it was proposed that all such similar organisms be assigned to the genus *Mycoplasma*. This terminology became obsolete

when new microorganisms such as *Acholeplasma* and *Ureaplasma*, etc., were being isolated and characterized. Therefore, a revised classification scheme was devised whereby all filterable, wall-less prokaryotes were covered under a broad system called the Class-Mollicutes (from the Latin adjective *mollis* meaning pliable and the Latin noun *cutis* meaning skin).

Mollicutes are the smallest biologically self-replicating cells with their diameter between 0.30 μm and 0.80 μm . Out of all living organisms, the Mollicutes have smallest reported genomes. The size of their genome is as small as 400 Mda. Mollicutes have evolved specifically from a branch of the phylogenetic tree containing Gram positive bacteria with an unusually low (23 - 46%) G + C ratio. Although they are equipped with DNA and RNA for performing protein synthesis, but their limited biosynthetic capabilities create a huge dependence on their environment. The pleomorphic characteristics of Mollicutes range from coccoid to filamentous form, but often demonstrate the characteristic 'Y' shape appearance. They are able to pass through

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0.45 μm and 0.22 μm filters commonly used in biological sterilization. Mycoplasma was the common term for all cell wall less organisms belonging to the Class Mollicutes. This class encompasses eight genera, *Spiroplasma*, *Ureaplasma*, *Mycoplasma*, *Acholeplasma*, *Anaeroplasm*, *Asteroleplasma*, *Entomoplasm* and *Mesoplasm*.

PHYTOPLASMAS

Many yellowing diseases of plants were thought to be caused by viruses because of the symptoms and mode of transmission and reproduction of the causative organisms. Doi et al² proposed that some yellowing disease could be the result of cell wall less prokaryotes instead of viruses. This idea led to the discovery of pleomorphic, wall free prokaryotic endoparasites residing in the phloem of diseased plants. Cell wall free prokaryotes infecting plants were previously termed as "Mycoplasma Like Organisms" or "MLOs", because of their structural resemblance to mycoplasma. Mycoplasmas cause various kinds of disorders in humans and animals and are sensitive to tetracycline and penicillin both, whereas MLOs are sensitive to tetracycline only³. In contrast to mycoplasma, the plant parasitic MLOs cannot be cultured *in vitro* in cell free media⁴. In the last decade evidences provided by fluorescence and electron microscopy and application of molecular techniques resolved that MLOs are the mollicutes quite distinct from mycoplasmas. This finding led to a proposal that the term MLO be replaced with the generic name of PHYTOPLASMA^{5, 6}.

Phytoplasmas are the smallest known phloem limited plant pathogenic unicellular obligate

endoparasites. These are bacteria-like prokaryotic organism surrounded by plasma membrane that lack true nucleus and membrane bound organelles. Their mode of multiplication is through binary fission. Phytoplasmas have no characteristic cell wall and have neither been isolated, nor purified, nor cultured on an axenic medium so far. These are pleomorphic that can stretch and can cross the sieve plates to migrate towards the roots in autumn and towards the shoot in spring.

Phytoplasmas are thought to be evolved from the Gram positive bacteria, they have a DNA genome which is A-T rich, some phytoplasmas have the lowest G-C content (23 to 26.3%) of any living organism. The size of genome of these microbes ranges from 640 to 1185 kb⁷. Phytoplasmas have a long incubation period that can spread as epidemic causing significant economic damage. Symptoms on infected plants become evident only one or two years after infection, when the disease has already spread to other plants. Phytoplasmas are considered to be quarantine organisms in the European Union. Transportation of Phytoplasma infected plants is forbidden even if the specific vector species is absent in the importation area.

OCCURRENCE AND MAINTENANCE

Like mycoplasmas, phytoplasmas are organ/tissue specific. They are found more frequently in the roots, but can also be found in many places in the plant. Phytoplasmas are obligate endoparasites located inside the cell walls of their hosts, either as extra-cytoplasmic in mature sieve tubes or as intra-cytoplasmic in young

sieve tubes. Since leafhoppers and planthoppers are their vectors, therefore, these have been discovered in their body parts also. Phytoplasmas have not yet been grown *in vitro* on cell free nutrient media in the laboratories. All efforts to culture these microorganisms under artificial conditions have been failed. Phytoplasmas are maintained in the host plants. This can be achieved by tissue culture techniques, by grafting infected twigs on susceptible plants, or by insect transmission.

DETECTION

Unlike typical bacteria, phytoplasmas cannot be cultured on artificial media in the laboratory. However, they can be detected with phytoplasma-specific stains such as DAPI (4, 6-dianilino-2-phenylindole) a nucleic acid stain, which stain bacteria in phloem⁸. Dienes' stain is metabolized by phytoplasmas that produces blue color. Healthy phloem does not impart color⁹. Dienes' stain is more specific than DAPI. Phytoplasmas are detected by grafting infected twigs to susceptible host plants such as periwinkle (*Catharanthus roseus*). These can also be detected using light or electron microscopy, molecular techniques including DNA probes, enzyme linked immuno-absorbent assays (ELISA) and DNA amplification using the polymerase chain reaction (PCR).

VECTORS

Phytoplasma vector species belong to hemipters that are phloem-feeding insects. Three families (Jassidea, Cixidae and Psyllidae) contain the known vector species. It has been found that phytoplasmas circulate, multiply and persist in the body of leafhopper vectors. It is considered

that phytoplasmas are not transmitted vertically to the progeny of infected specimen. Among planthoppers, species in the cixiid family are known to transmit phytoplasma belonging to "stolbur" group. Among psyllids, several species have been shown to transmit diseases of fruit trees. Leafhoppers, and psyllids are the most common vectors of phytoplasma.

SPREAD AND TRANSMISSION

Phytoplasmas are completely dependent on their host for existence, as these are obligate endoparasites. They live in phloem of the plants. Phytoplasmas generally move to a new area by grafting, planting infected cuttings, by parasitic plants such as dodder (*Cuscuta Spp*) and by leafhoppers, which migrate annually. Phytoplasmas are phloem limited and cannot be transmitted through seeds. It is unlikely that phytoplasmas could survive the desiccation usually associated with seed formation.

DISEASE SYMPTOMS

Symptoms on plants include virescence (the development of green flowers), phyllody (the development of floral parts into leafy structures), sterility of flowers, proliferation of adventitious or axillary shoots resulting in witches-broom appearance, abnormal elongation of internodes resulting in slender shoots, generalized stunting (e. g. small flowers, leaves, shortened internodes), unseasonal discoloration of leaves or shoots (e.g. yellowing, purple discoloration), leaf curling or cupping, bushy appearance of growth at the ends of stems, brownish discoloration of phloem tissues, and generalized decline (stunting, die back of twigs of trunks, lethal yellowing).

Diseases associated with the presence of phytoplasmas in phloem typically exhibit an array of symptoms mentioned above.

IDENTIFICATION

(1) Enzyme linked immunoabsorbent assay (ELISA), using polyclonal and monoclonal antisera ; (2) Dot hybridization assay, using cloned phytoplasma DNA and their complementary RNA probes ; (3) Southern hybridization assay, by analyzing RFLP of part of or total genomic DNA using selected cloned DNA probes, including highly repetitive sequences in the genome ; (4) Polymerase chain reactions (PCR), using primers based on cloned DNA fragments specific to a given phytoplasma or a subgroup and (5) RFLP analysis of DNA sequences with various degrees of conservation, using various conserved sequences such as 16S rRNA gene, ribosomal protein, operon, *tuf* gene and other chromosomal DNA fragments.

CLASSIFICATION

Phytoplasma diseases were initially classified either on the basis of the symptoms (decline, proliferation and virescence) they develop, or type of plants infected by them, or type of insect vectors (leafhoppers, planthoppers and psyllids) that transmitted them to the plants. In the previous decade, identification of phytoplasma has been resolved through novel techniques of restriction endonuclease digestion of PCR-amplified rDNA products, electrophoresis of digests on agarose or polyacrylamide gel, and comparison of resulting fragments with those of known phytoplasmas. In 1993, Lee et al.¹⁰ identified a total of 16 groups of 16S rDNA on the basis of dissimilarities of restriction sites detected by rDNA RFLPs.

Garritty et al.¹² divided the domain Bacteria into 23 phyla of which 13th phylum Firmicutes comprises of three classes (namely Clostridia, Mollicutes and Bacilli). The Class-Mollicutes, consists of wall less bacteria and has been divided into five orders ; the order Acholeplasmatales has a single family Acholeplasmataceae that comprises only two genera- *Acholeplasma* and *Phytoplasma*.

Domain : Bacteria (23 phyla)

Phylum : Firmicutes (3 classes)

Class : Mollicutes (5 orders)

Order : Acholeplasmatales (1 family)

Family : Acholeplasmataceae (2 genera)

Genus : *Phytoplasma*

Phytoplasma	16SrI	Aster yellows group
Phytoplasma	16SrII	Peanut WB group
Phytoplasma	16SrIII	X-disease group
Phytoplasma	16SrIV	Coconut lethal yellows group
Phytoplasma	16SrV	Elm yellow group
Phytoplasma	16SrVI	Clover proliferation group
Phytoplasma	16SrVII	Ash yellows group
Phytoplasma	16SrVIII	Loofah witches' broom group
Phytoplasma	16SrIX	Pigeon pea witches' broom group
Phytoplasma	16SrX	Apple proliferation group
Phytoplasma	16SrXI	Rice yellow dwarf group

Phytoplasma	16SrXII	Stolbur group
Phytoplasma	16SrXIII	Mexican periwinkle virescence group
Phytoplasma	16SrXIV	Bermuda white leaf group
Phytoplasma	16SrXV	Hibiscus witches' broom group.

Seemuller et al⁶ described eight more genera which are given below and were not mentioned in the previous classification AUSGY-Australian Grapevine yellows, IBS-Italian bineweed stolbur, BWB- Buckthorn witches' broom, SpaWB-Spartium witches' broom, IAWB-Italian alfalfa Witches' broom, CirP-Circium phyllody, BGWL-Bermuda grass whiter leaf and Tanzania lethal decline.

CURE AND MANAGEMENT

Many plants can be cured of phytoplasmas with heat treatments and/or by passing them through tissue culture¹². Phytoplasma infected plants are passed through seed cycle, since phytoplasmas are not seed transmitted. Remission of symptoms and curing a plant can be achieved through the application of the antibiotic tetracycline¹³.

Conventional control methods include sanitary selection, in some cases pruning of branches of woody plants with localized symptoms, destruction of phytoplasma reservoir plants, monitoring of vector species, thermotherapy, cross protection and genetic selection for tolerant of resistant varieties.

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ROLE OF INSECT-NEMATODE ASSOCIATIONS IN SUSTAINABLE DEVELOPMENT

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Insects and nematodes, individually and through their interactions, play a significant role in sustainable development of mankind. The significance of insect-nematode associations lies in the role insects play in harbouring and vectoring nematode parasites of plants, humans and other animals and also in the potential of nematodes as biological control agents of pestiferous insects.

INTRODUCTION

Insects and nematodes are fascinating groups among the animal kingdom, having high level of diversity, abundance and ability to adapt to the environment in a way most suitable to them. Insects and nematodes share an important character “exoskeleton” which accounts for a great deal of their evolutionary success, despite the differences in chemical composition of exoskeleton in the groups. Insects and nematodes, independently as well as through their interactions, play a significant role in the sustainable development of mankind. By virtue of their abundance and trophic and functional diversity, insects and nematodes fulfil many important ecological functions including decomposition of organic material, nutrient cycling, regulation of natural populations and energy transfer in food chains. They interact with humans as competitors for food, either in the field or in storage, as pests of agricultural

crops and as causative agents/carriers of livestock or human diseases. Insect-nematode associations range from simple phoresis to complex parasitism. The significance of insect-nematode associations lies in the potential of nematodes as biological control agents of pestiferous insects and also in the role insects play in harboring and vectoring nematode parasites of plants, humans and other animals. The main focus of this paper is to discuss the various forms of insect-nematode associations and their implications for sustainable development.

TYPES OF INSECT-NEMATODE ASSOCIATIONS

Two fundamental types of associations occur between nematodes and insects. One is phoresis and the other is parasitism.

I. PHORESIS

In phoretic associations, the nematode is transported from one substrate to another by an insect. A phoretic association may be either non-essential or essential and can be external or internal or a combination of both. Non-essential

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phoresis involves the accidental transport of nematodes by insect. For example, when a fly visits dung or decaying substances, which contain bacterial or fungal feeding nematodes, these nematodes may adhere to the legs of fly and get transported to a new substrate. Such type of associations does not involve formation of specialized resistant stages of nematodes nor is the phoresis essential for existence of the nematode.

In contrast to the non-essential phoresis, essential phoresis is necessary for the completion of life cycle and perpetuation of nematode species. This type of phoresis generally involves formation of a specialized stage in the nematode's life cycle that is carried by the insect. Normally, it is the third stage larval nematode that is transported by the insect. An example of essential phoresis is the association between a free-living rhabditid *Pelodera coarctata* and dung beetle *Aphodius fumentarius*¹. The nematode is commonly found in dung where it feeds on bacteria. As the dung begins to dry, the third stage juvenile nematodes attach themselves to the external surface of adult dung beetles in the surrounding area. Once attached to the insects, the nematodes are transformed into a resistant stage called dauer larvae. When the dung beetle visits fresh dung, the nematodes revive and leave the beetle to resume the life cycle. Essential phoresis can be either external (nematodes are carried on external surface of insect, e. g. *Bursaphelenchus xylophilus*) or internal (nematodes are carried internally by insect, e. g. *Bursaphelenchus* (= *Rhadenaphelenchus*) *cocophilus*).

II. PARASITISM

In parasitism, the nematode undergoes partial or total development at the expense of the living host and this may or may not involve pathology. Nematodes exhibit different types of parasitic relationships with insects. In case of facultative parasitism, the nematode alternate between successive free-living/plant-parasitic generations and successive parasitic generations (e. g. *Deladenus siricidicola*, *Ferguobia curriei*). In case of obligate insect parasitism, insect is the sole source of energy and nutrition necessary for the completion of the nematode life cycle (e. g. *Romanomermis culicivora*). In some instances, nematodes use insects as intermediate hosts or vectors for vertebrate parasitism (e. g. *Onchocerca volvulus*). In some other cases, nematodes act as lethal parasites or vectors of lethal insect pathogens (e. g. *Steinernema* and *Heterorhabditis*).

ECONOMIC IMPORTANCE OF INSECT-NEMATODE ASSOCIATIONS

Insect-nematode associations not only play a vital role in regulating ecological balance and energy transfer in food chains in natural ecosystems but also have great economic significance in managed ecosystems. These associations significantly influence the plant, insect and vertebrate parasitism of nematodes. Some associations are beneficial in improving plant and animal productivity by suppressing the invasive weeds and pestiferous insects, while others are detrimental as they facilitate the spread of plant, animal and human disease and cause disease epidemics. The following are a few examples of economically important insect-nematode associations.

Insect-nematode Associations and Plant Parasitism

(A) Associations Deterimental to Plant Production

(i) *Bursaphelenchus-xylophilus-Monocahmus alternatus* association : The pine wood nematode *Bursaphelenchus xylophilus* causes wilt disease of pines in countries like Japan and USA. This nematode has an external phoretic association with wood boring longhorn beetle *Monocahmus alternatus*. The beetle helps in transporting the nematode to soft healthy plant tissues and the nematode in turn provides the beetle dead necrotic tissues needed for oviposition.

Pine wilt disease induced by nematodes is extremely serious in pine forests. Two-year old trees can be killed in the span of a single summer. Affected trees show symptoms of wilting coupled with a significant reduction in resin flow. Wilted trees will turn from yellow to brown within 3 months after becoming infected and eventually die. In Japan, as many as 20 per cent of trees in some stands have been killed by the disease. The control of beetles, which helps in the spread of nematodes, has been suggested as a control measure for this disease².

(ii) *Bursaphelenchus cocophilus-Rhynchophorus palmarum* association : *Bursaphelenchus cocophilus*, formerly known as *Rhadinaphelenchus cocophilus*, causes the red ring disease of palms, particularly coconut and oil palms. The red ring nematode *B. cocophilus* has an internal phoretic association

with the red palm weevil *Rhynchophorus palmarum*. The weevil helps in the transport of nematodes to healthy plants while the nematodes form necrotic tissues sought after by the weevil for egg laying

In coconut palms, red ring nematodes most often attack trees between three and seven years old. These young trees usually die six to eight weeks after the appearance of symptoms. Older trees can live up to 20 weeks. The major internal symptom of red ring infection, as the name indicates, is the presence a circular red coloured band approximately 3 to 5 cm wide across the horizontal section of an infected palm at seven feet above the soil. The external symptoms include short and deformed leaves, which turn reddish-brown, wilting and drying of leaves. In Trinidad, the red ring disease kills 35 percent of young coconut trees. In Tobago, one plantation lost 80 percent of its coconut trees. Over a 10-year period in Venezuela, 35 per cent of oil palms died from red ring disease. In Grenada, 22.3 per cent of coconut palms were found to be infected. Of those infected, 92 percent had been invaded by palm weevils. It is estimated that 72 per cent of those weevils were carrying *B. cocophilus*³. Considering that more than eight million acres of coconut palms are grown, red ring nematodes are one of the most important pests in the tropics. The most useful method for the management of red ring nematode is the early removal and destruction of red-ring infested palms. Controlling the vector *R. palmarum* also helps in reducing red ring nematode infestation.

(B) Associations Beneficial to Plant production

(i) *Fergusobia*-*Fergusonina* association : The nematode *Fergusobia* sp. and the fly *Fergusonina* sp. form a unique mutualism that allows them to cause a variety of gall types on plants in the eucalyptus family. The nematode has alternate plant parasitic and insect parasitic generations. The fly and nematode species attack the paperbark tree *Melaleuca quinquenervia* in its native range in Australia. *Melaleuca quinquenervia* is a weedy invasive species in the Florida Everglades. U. S. A. *Melaleuca* outcompetes native plants and is blamed for environmental losses of up to \$168 million annually.

The *Fergusobia* nematodes and *Fergusonina* flies attacking the paperbark in Australia are currently being evaluated as biocontrol agents of *M. quinquenervia* in the U. S. A. The attacked tree forms the round, pinkish-red or green galls where buds would otherwise have developed into branches. Laboratory, outdoor, and greenhouse tests determined that the insect is specific to *Melaleuca* and poses no risk to other plants, thus enhancing the prospects of using the combination as weed killers⁴.

(ii) *Deladenus siricidicola* (= *Beddingia siricidicola*)-*Sirex noctilio* association : A facultative parasitic nematode *Deladenus siricidicola*, which has an alternate parasitic generation in the wood wasp *Sirex noctilio* and mycetophagus generation on the fungus *Anylostereum areolatum*, plays an important role in the biological control of woodwasps in pine forests. The larval penetration of insect's reproductive system causes ovarian suppression

and insect's eggs generally become sterile because of nematode infection. *Deladenus siricidicola* was successfully used for the biological control of *Sirex* woodwasps in Australia and it has resulted in more than A\$50 million savings per year, to the Australian pine forest industry. The technology is now being applied on an international scale as *Sirex* has spread to Brazil, Chile and South Africa⁵.

Insect-nematode Association-Invertebrate Parasitism

(A) Association Detrimental to Plant Production

Sphaerularia bombi-*Bombus* spp. association : *Sphaerularia bombi* is one of the oldest known insect parasitic nematodes first reported by Reaumur in 1742. This nematode parasitizes and sterilizes bumblebees *Bombus* spp. Nematode infection alters the flight behaviour of the insect and eventually leads to death. Bumblebees are important pollinators of wild and cultivated plants throughout the world. Because of their long tongues, bumblebees are able to pollinate clovers, alfalfa, and many other deep blossoms that short-tongued bees cannot pollinate¹. Reduction in bumblebee population due to nematode infection adversely affects the pollination and seed set of these plant species.

(B) Associations Beneficial to Plant Production

Entomopathogenic nematodes (*Steinernema* and *Heterorhabditis*) : Entomopathogenic nematodes in the genera *Steinernema* and *Heterorhabditis* (Nematoda : *Steinernematidae* and *Heterorhabditidae*) together with their symbiotic bacteria *Xenorhabdus*/*Photorhabdus*

spp (Enterobacteriaceae) are lethal obligate insect. Species of *Steinernema* and *Heterorhabditis* have been shown to be effective in biological control of several important insect pests⁶. Entomopathogenic nematodes are currently marketed worldwide for the biological control of insect pests⁶. They possess many ideal attributes such as high virulence, safety to non-target organisms, exemption from registration in many countries and ease of mass production. At 13% of sales of bioinsecticides in industrialized countries entomopathogenic nematodes were second only to *Bacillus thuriengensis* which is at 80%⁷.

(C) Associations Beneficial in Vector Control

Romanomermis culicivorax-mosquito association : *Romanomermis culicivorax* is the most widely studied nematode for the biological control of mosquitoes with nematodes. This nematode parasitizes about 58 species of mosquitoes including *Culex*. Freshly hatched juveniles penetrate the mosquito larvae in water directly through the cuticle. The nematode is not carried through mosquito pupation and the mosquito larvae do not survive the emergence of pre adult nematode. Since nematode eggs can survive in soil, the biological control scheme persists. Once introduced into an area the nematode then becomes a permanent resident. This is the first nematode commercially produced for the biological control of insects¹.

Insect Nematode Associations-Vertebrate Parasitism

(A) Associations Deterimental to Human Health

(i) *Onchocerca volvulus*-*Simulium damnosum* association : Onchocerciasis is the world's second leading infectious cause of blindness. This disease caused by *Onchocerca volvulus*, a parasitic worm that lives for up to 14 years in the human body. The black fly *Simulium damnosum* serves as vector for the spread of this nematode. Each adult female worm produces millions of microfilariae (microscopic larvae) that migrate throughout the body and give rise to a variety of symptoms, viz. serious visual impairment, including blindness, rashes, lymphadenitis, which results in hanging groins and elephantiasis of the genitals, and general debilitation. Onchocerciasis manifestations begin to occur in persons one to three years after the injection of infective larvae⁸.

This disease is present in 36 countries of Africa, the Arabian Peninsula and the Americas. As a public health problem the disease is most closely associated with Africa, where it constitutes a serious obstacle to socio-economic development. Onchocerciasis is often called "river blindness" because of the most extreme manifestation of black fly vector and the disease in fertile riverside areas, which frequently remain uninhabited for fear of infection. A total of 18 million people are infected with the disease and have dermal microfilariae, of whom 99% are in Africa. The Onchocerciasis Control Program (OCP) was launched with the help of World Health Organization in 1974 in 11 countries. OCP's principal method for controlling

onchocerciasis has been to break the cycle of transmission by eliminating the black fly. The blackfly larvae are destroyed by application of selected insecticides through aerial spraying of breeding sites in fast-flowing rivers. Once the cycle of river blindness has been interrupted for 14 years the reservoir of adult worms dies out in the human population, thus eliminating the source of the disease. The parasite reservoir has now virtually died out in 7 countries⁸.

(ii) *Wuchereria bancrofti*-Mosquito association

Lymphatic Filariasis or elephantiasis disease is caused by the nematode *Wuchereria bancrofti* and *Brugia malayi*. The adults of this parasite live in the lymph nodes of humans, and the female worms produce microfilariae (advanced embryos) that are found in the blood. Several genera of mosquitoes transmit this parasite, including *Anopheles*. The infection causes blockage of the lymph nodes and ducts. This results in the accumulation of lymph and swelling of the tissues. The adults tend to prefer the lymph nodes that drain the lower abdominal cavity and legs, so “elephantiasis” is often marked by gross disfigurements of the genitals and legs⁹.

In India, filariasis is a major public health problem next only to malaria. As per recent estimates, about 428 million people with 21 million clinical cases are spread in thirteen States and five Union Territories. India contributes about 74% of endemic population and 81% of the disease burden in the Region. *Wuchereria bancrofti* is the most

predominant infection comprising 99.4% of the problem in the country while *Brugia malayi* another filaria worm is confined to the western coast of Kerala and a few pockets in six other States. The first pilot project in the world for the control of lymphatic filariasis was undertaken in Orissa from 1949-54 and in the subsequent year the National Filariasis Control Program was launched. After effecting many changes in the program during the last four-and-a-half decades, the country adopted a revised strategy in 1997 for elimination of lymphatic filariasis. The disease prevention measures include protection from mosquito bites, mosquito control, and treatment of whole populations in endemic areas with diethylcarbamazine¹⁰.

(B) Associations Detrimental to Health of Pets and Veterinary Animals

Insects also serve as vectors or intermediate hosts for nematode parasites/diseases of domestic and dairy animals, viz, heart worms of dogs, eye worms and air-sac worms of chickens, stomach ulcers of horses, intestinal worms of cattle etc¹. These infections significantly reduce the productivity of these animals and increase the maintenance costs.

INSECT-NEMATODE ASSOCIATIONS AND SUSTAINABLE DEVELOPMENT

Insect nematode associations have tremendous impact on sustainable development of mankind. These associations not only influence the efficiency of plant and animal based production systems and the nature and cost of plant, animal and human health care programs and associated

environmental costs. For example, spread of serious plant diseases like pine wilt and red ring diseases by insect vectors not only devastates the mature forests and palm plantations within a short span of time but also inflicts the environmental damages associated with decline in forest area and usage of pesticides for disease control. Although these diseases are presently confined to a few countries, other countries too incur considerable expenditure on implementing strong quarantine to prevent introduction of these dreaded diseases. Similarly, the nematode disease *Onchocerciasis* transmitted by black fly is the world's second leading infectious cause of blindness. In West Africa alone it has adversely affected the health and socioeconomic development of more than 30 million people in 11 countries. Over 2.4 million people are infected by this parasite and around 100,000 are blind due to *onchocerciasis*. More than 25 million hectares of fertile riverine land, particularly in Volta basin, was deserted due to the fear of this disease leading to the poverty and starvation of people. *Onchocerciasis* control program (OCP), a collective effort of international organizations under the leadership of the World Health Organization (WHO), implemented over the last 29 years, has helped in virtually eradicating this disease in many endemic countries. During the course of implementation of OCP several infrastructural facilities and trained human resources were developed, and new drugs were developed and tested in countries in the operational area. Further, by eliminating the threat of blindness and other onchocercal manifestations, OCP has opened up the way for

resettlement in fertile areas along the rivers, previously deserted through fear of the disease. Using traditional technologies and agricultural practices this new land will produce foodstuff to feed 17 million people. However, care should be taken to farm in sustainable ways and to avoid over-exploitation of the tremendous resources in river basin areas. Parasitic infections of domestic animals like dogs, chickens, horses, etc., vectored by insects reduce the efficiency of these animals and increase the maintenance and health care costs.

The positive effects of insect-nematode associations on human development include nematodes that help in biological control of insect pests of plants, vectors of animal and human diseases and invasive weeds. In fact, nematodes are the second largest selling biocontrol agents in world market. The use of nematodes in pest management helps in reducing the usage of chemical pesticides and the environmental and human health problems associated with their usage. Further, these biocontrol agents make pest management sustainable and less expensive. Control of insect vectors of human disease improves the work efficiency, reduces absenteeism from work and cost of health care, which in turn improves the productivity.

CONCLUSIONS

Insect-nematode associations, one of the most fascinating biological phenomena, have significant influence on the sustainable development of mankind. Considerable knowledge on different types of associations

and their adverse or beneficial effects on plant and animal based production systems is now available. Increased understanding of the biology and ecology of insect nematode associations using modern molecular techniques will help in identifying the key factors for mitigating the adverse effects and increasing the beneficial effects of insect-nematode associations.

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DO YOU KNOW?

- Q3. Thomas Hardy visits Ramanujan lying ill in a Sanatorium and mentions that the cab which brought him carried a number which appeared rather dull. He says what was the four digit number. Ramanujan, after a moment's thought, replied 'No my friend, it is a beautiful number; the smallest integer that can be expressed as the sum of two cubes in two different ways. What was the number ?
- Q4. How does the Indian elephant's trunk differ from that of the African elephant ?
- Q5. How often do the hour hand and the minute hand of a clock come together and what are the times ?

XENOTRANSPLANTATION : PIGS AS SOURCE OF ORGANS FOR MAN

R. K. Yadav, D. P. Mishra and B. R. Yadav *

In this age of scientific revolution, medical science has reached new heights in diagnosis and treatment, However ; there are many areas where a lot of developmental work is still required. There comes a demand of blood, tissues, and organs in crisis, even supply is always short in normal times. The scientists are looking for various sources so as to have ready supply of blood and organs. Animals, particularly pigs, are considered as potential sources. However, certain issues must be understood, biological and hormonal aspects should be humanized before the actual grafts or transplantation process. The present communication is an attempt to clarify doubts and create awareness on this emerging area in animal science in general and its medical science particularly.

INTRODUCTION

"Heart is considered 'He-art' and has always been mystic may be its affairs, repairs or replacement."

Imagine for a moment that if somebody tells you that your best friend's brother has a pig's heart, what will be your reaction? You will surely not believe him or may simply laugh it off. In medical science with the current pace of developments, it may well become a reality in the near future. The scientific innovation that will make this possible is known as "Xenotransplantation." Scientists started working on this aspect long back in the seventeenth century (Table-1). There are certain terms often used in relation to organ transplantations such as the tissue or group of cells removed from the body of one animal and

transplanted into another animal or human being is called a graft. Tissue grafts when exchanged between different parts of an individual's body, are known as autograft. Transplanting of skin from an unburnt to burnt area in plastic surgery is a typical example of autograft. Tissue transplanted between two genetically identical individuals like monozygotic twins, is known as isograft. When tissue grafts are transplanted between genetically different members of the same species it is called allograft (e.g. transplantation of liver from one individual to another). The transplantation of organs or tissues between two different species is known as xenotransplant and the process is xenotransplantation. For example if a heart is taken from a pig and transplanted into a man with a dysfunctional heart, then it is xenotransplantation. The tissues used for the purpose are called "xenograft". The scientists got renewed their interests in xenotransplantation

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Table-1 : LANDMARKS IN THE PURSUIT OF XENOTRANSPLANTATION*

Year	Activities
1682	A Russian doctor transplanted animal tissue into a noble man using the piece of skull from a dog
1800's	Frog skin was often grafted on the patients' skin in an attempt to heal burns or skin ulcers
1905	A French surgeon inserted slices of rabbit kidney into a child suffering from kidney failure.
1920	Serge Vorhoff, a French doctor, began transplanting tissues from the testicles of monkeys into elderly men
1963	Keith Reentsma, a professor of surgery, transplanted chimpanzee kidneys into 13 patients
1964	James D. Hardy at the University of Mississippi attempted for the first time to put a chimpanzee heart into a human, but it failed within 2 hours being unable to support the patient's circulation
1977	Dr. Christian Barnard attempted to use baboon and chimpanzee hearts as temporary back up pumps into patients with hearts that did not function properly after cardiac surgery.
1984	A prematurely burned baby (Baby Fae) with malformed heart received a heart from a baboon and lived for 20 days.
1992	Liver transplant from baboons to humans conducted at the University of Pittsburgh met with mixed success.
1995	Jeff Getty received immune cell from a baboon in an attempt to combat his severe AIDS, although the baboon cell died quickly his condition mysteriously appeared to improve.
1997	Clinical trials using Pig foetal nerve cells in patients with Parkinson's disease indicated some success, the injected pig cells survived in the brain of at least one person for more than 7 months.

*Currently allografts are carried out, however, xenotransplantations are not being performed or reported till clearance from the Human Rights; Commission or concerned Governments.

in the second half of the 20th century, however, success was limited (Table-2) which was further

It is an obvious fact, as experienced by scientists and doctors, that the supply of human organs

Table-2 : XENOTRANSPLANTATION DONE IN HUMAN BEINGS AND THEIR OUTCOMES*

Donor	Organ	Outcome	No of cases	Year
Chimpanzee	Kidney	9 months	12	1964
Monkey	Kidney	10 day	1	1964
Baboon	Kidney	4 1/2 days	1	1964
Baboon	Kidney	2 months	6	1964
Chimpanzee	Heart	Insufficient cardiac output	1	1964
Chimpanzee	Liver	14 days	3	1969
Baboon	Heart	Acute rejection	1	1974
Chimpanzee	Heart	4 days	1	1977
Baboon	Heart	4 weeks	1	1977

* Survival of the recipients. Subsequently researches started on immuno-regulations or suppressions, and other molecular aspects besides ethical reasons and objections.

hampered by ethical reasons. In the recent past increased demand of organs has forced scientists to venture again for xenotransplantations in the light of currently available knowledge on immunology, molecular biology and embryo biotechnology.

NEED FOR XENOTRANSPLANTATIONS

All over the world many millions of people suffer from severe ailments of heart, liver, kidney, brain or pancreas. According to United Network for Organ Sharing over 63000 patients are currently waiting for organ transplantations in USA alone. This number is steadily rising and a new name is added to the waiting list every 18 minutes. Looking at the world scenario, an estimated 120 million people are in need of organ transplantations. However, due to the acute shortage of human organ donors, most patients in need will not be offered treatment.

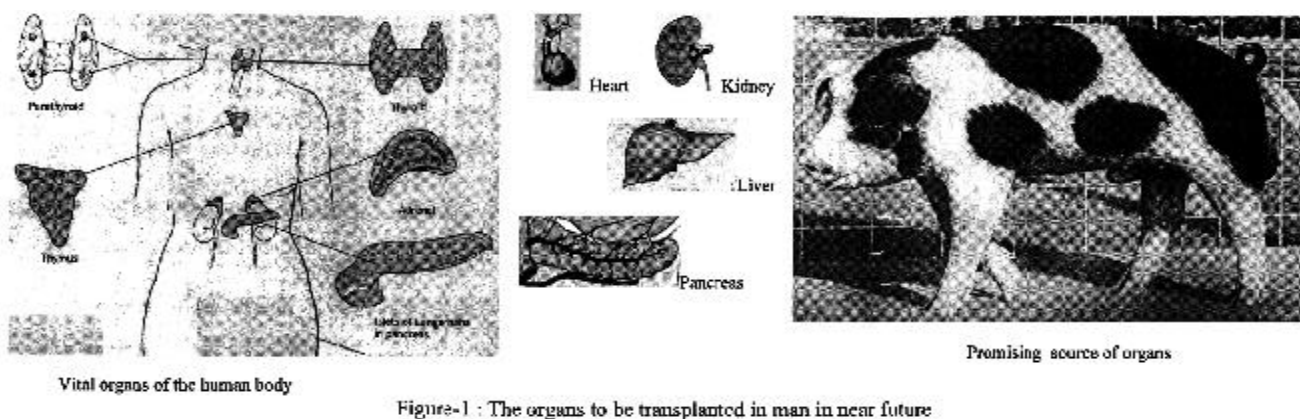
will always remain insufficient to meet the demand. It means that the animal organ donors could eventually provide the only hope of survival for many thousands of patients on transplant waiting lists (Table-3). Therefore research efforts in the recent years have been directed towards production of animal donors for xenotransplantations (Figure-1).

BARRIERS TO XENOTRANSPLANTATION

The major problem of xenotransplantations till date is attributed to graft rejection. Human body has a specialized system known as the immune system that produces antibodies. These antibodies are normally directed against infection microbes (like bacteria virus, protozoa, etc).

Table-3 : ADVANTAGES AND DISADVANTAGES OF XENOTRANSPLANTATION

Advantage	Disadvantage
Inexhaustible supply (if rapidly breeding donors with large litters are used) organs available for people currently excluded from waiting list.	Ethical objectives, animal rights and specicism
Extend the therapeutic possibilities of transplantaton eg diabetes mellitus.	Transmission of donor pathogens to human host.
Opportunity for genetic manipulation of donor organ to influence recipient rejection response.	Emergence of recombinant viral strains of unknown pathogenicity.
Planned and unhurried operations.	Transmission of human pathogen to xenograft.
Species difference in susceptibilities to disease may make xenografts useful for transplants in specific groups eg. patients with HIV or hepatitis B	Physiological incompatibilities including the potential for differential ageing of xenograft and recipient. Immunological potentially severe vascular and cellular ejection



These antibodies can also bind to the transplanted tissue or xenograft and activate special “complement” proteins in the blood, which in turn trigger the destruction of the transplanted tissue. This rejection of foreign tissue begins within minutes to hours after the surgery, destroys the blood capillaries in the transplanted organ, causing massive

hemorrhage and finally destruction of the tissue altogether. This process of rejection is known as hyperacute reaction.

Other problems involving xenotransplants are that of viral infections as incompatibility of animal tissues in human beings. During xenotransplantations there is a risk of human beings getting infected by animal tissue borne

viruses. There may also be functional incompatibilities between the xenograft and recipients' tissue as there are significant anatomical and physiological differences between animals and man. Before xenotransplantations become successful these barriers need to be bridged.

STRATEGIES TO MAKE XENOTRANSPLANTATIONS A CLINICAL REALITY

The innovations in immunology have helped in the understanding of the intricate functions of the immune system of the human body. The mechanism of foreign tissue rejection in human beings is now better understood. Therefore, various strategies have been proposed to manipulate the immune response and make xenotransplantations successful. Some of the important ones are as follows :

Use of Drugs :

In order to suppress the rejection of transplanted organs from animal donors, often immuno-suppressive drugs like cyclosporine are used for a long duration. Long-term uses of these drugs have the risks of toxicity infections and other complications. Development of drugs without these ill effects will be necessary for the success of future xenotransplantations.

Modification in the Immune System :

The bone marrow contains all the progenitor cells and is the source of all components of the blood including the components of the immune system that reacts against the animal tissue. Modification of immune system involves,

radiation therapy of the patients to suppress its immune system temporarily and transplanting bone marrow cells of animal donor. Once introduced, the donated cells spread and mature creating a modified immune system that is part donor, part recipient. The ultimate aim is to modify the patient's immune system so that it does not recognize as foreign either the donated cells or subsequently transplanted tissues from the same animal. This strategy, first used by an American doctor David H. Sachs, has shown promising results involving pigs as donor and baboon as recipient.

Immunoisolation :

In the recent past technologies have been developed where the transplant animal tissue is encased in small biodegradable capsules that can be injected under the skin or placed in the abdominal cavity with a syringe. These encapsulated membranes allow nutrients, oxygen, and certain therapeutic agents to cross it while blocking antibodies and white blood cells from reaching the graft. In this method less than a gram of encapsulated pancreatic islets cells from pigs should supply a diabetic patient with normal amounts of insulin that can save his life.

Production of Transgenic Animals

Transgenic animal contains recombinant DNA molecules in its genome through human interventions. Transgenesis is the technique that permits manipulation of gene from one organism to be introduced into the genome of another organism of the same or different species (may be close or distant or even distant genera). In the technique of transgenesis, certain genes can

be manipulated in such a way that the organs of transgenic animals when used for xenotransplantation, are not rejected by the patients immune system David J. G. White and his colleagues at the University of Cambridge introduced into the pig embryo a human gene that directs the production of human complement inhibitory protein. This transgenic pig when used as a donor will have in its blood vessels walls proteins that can prevent a human complement protein from doing damage to the graft. Production of such animals in large numbers will surely boost successful xenotransplantation.

Genetic Engineering :

The cloning of farm animals like sheep, goat, cattle and pigs has become a reality though in limited number. Scientists all over the world are working on different aspects like nuclear transfer technology, and nuclear reprogramming by gene knockout strategy. These techniques have opened up new possibilities to alter immune response, which can facilitate xenotransplantation. Gene knockout strategies are used for engineering the cells for altered gene expression. Recently, British scientists at the Roslin Institute have produced piglets for xenotransplantation using a gene knockout technique. In these piglets the gene responsible for production of the enzyme α 1-3 galactosyl transferase is knocked out or removed by genetic modifications. This gene is responsible for adding a sugar residue to cells that would be recognized as foreign by circulating antibodies in the human recipient. Antibodies recognition triggers a cascade of events that leads to hyperacute rejection.

However, once the gene for the α 1-3 galactosyl transferase is knocked out in cultured pig cells, then nuclei of cultured cells can be transferred by nuclear transfer process into the ova or eggs and subsequently these will develop into embryos and progenies. After maturity these pigs they will be sacrificed for their organ and transplanted into the human recipient which will work like any normal organ. According to PPL Therapeutic (UK based) company doing research on xenotransplantation, it is expected that the first trial evaluating transplantation of genetically modified pig organs in human patients could be under way within four years.

SOCIAL AND ETHICAL ISSUES :

At least three research firms have drawn up proposals and it is expected the first requests to provide lungs, livers, kidneys and other animal organs will be made in the year 2005. Initially, the most likely donor animals will be pigs, which have been the subject of intensive research. Britain already has a herd of pigs modified with human genes to reduce the risk rejection when their organs are transplanted into humans (Table-4). The UK Xenotransplantation Interim Regulatory Authority, was set up three years ago to monitor research and examine whether animal transplants are morally and scientifically justified. Among the most crucial issues is the risk that some of the many viruses known to be harboured by pigs, could be passed to humans. However, transplantations are to be allowed subject to safeguards. Organ recipients

Table-4 : COMPARISON OF PIGS AND PRIMATES AS ORGAN DONAR

Pigs	Primates (Chimpanzee, monkeys, baboon)
Advantages	Advantages
Breeding characteristics : sexual maturity in 9 months, gestation 3.5 month, litters of 6-16 piglets	Immunologically closely related to human being concordant.
Extensive breeding and propagation	Physical, anatomical and physiological similarities to human beings
Ethical : fewer human like qualities	Disadvantages
Disadvantages	Limited breeding in captivity, mostly wild
Immunological : distantly related to human being (discordant)	Endangered species status (Chimpanzee)
Disease transmission is higher	Disease transmission is higher than man but lesser than pigs
Physical : less similar to human beings than non-human primates. (But more similar than many other species)	Ethical : highly intelligent and social animals

would have to sign contracts accepting lifetime monitoring, banning them from donating blood or having children and agreeing never to have sex without barrier contraception to avoid passing on viruses.

CONCLUSION

In order to make xenotransplantation a routine affair in medical science, one needs to understand the molecular basis of all events related to immune rejection and suitable modifications in the events so that

the xenograft will survive in recipient successfully. The developments in molecular biology and embryo biotechnology in last two decades have opened up new possibilities in the field of xenotransplantation. There is no doubt that in near future it will be possible to produce genetically modified animal donors (sheep, goat, pig etc) in large numbers to fulfill the requirement of needy patients having various organ dysfunctions. If after 20 years somebody hears that a man has a pig heart then nobody will fall off his seat.

DO YOU KNOW?

- Q6. Are bird songs genetically inherited or passed on as oral tradition ?
- Q7. Viscosity of liquid decreases with increase in temperature. Is this also true for gases ?

VALUES AND MORAL JUDGEMENT OF ADOLESCENT GIRLS
STUDYING IN NON-MISSIONARY AND MISSIONARY SCHOOLS
IN KOLKATA

Sudakshi na Gupta*

The present day controversy regarding missionary and non-missionary education prompted the researcher to take up a comparative study which shows that adolescent girls studying in missionary schools in Kolkata score more in the democratic and power values while the non-missionary ones do so in aesthetic, hedonistic, knowledge, and health values with no difference found in the religious, social, economic and family prestige values or in moral judgement.

INTRODUCTION

A national system of education is always the reflection of a national system of ideals. One can, in fact, go further and say that education is shaped by and in turn shapes the lives of individuals and groups. The quality of a society depends on the quality of its members. Improvement of the individuals through education is thus the only means to achieve an improved type of society.¹

On achieving independence, one of the major tasks before the architects of free India was to form a strong base of education. The government took keen interest in this direction by sponsoring certain schools for the masses. Private concerns also provided financial aid to set up schools based on similar principles. The aim was to develop an accomplished citizen who would become socially productive.

Ancient Indian education evolved strictly on the foundations of Indian epistemological and philosophical traditions. The residence of the

pupil at the house of the teacher accompanied by a sense of devoted service had been a unique tradition in ancient India. Thus, the student not only imbibed the teacher's qualities through emulation, but also developed social skills as part of his duties towards the teacher. The modern concept of learning through doing as understood in the West today was the very core and essence of education in India.²

India being a country of varied religious beliefs, also has a heritage of missionary schools. 'Missionary,' as the term suggests, is used for people related with religious dealings. Many minority religious groups set up schools to teach the basics of their religion. Their aim was to emancipate man via the religious principles taught in such schools.

The beginning of the sixteenth century saw the advent of European missionaries in India. They introduced a new phase in the country and developed it appreciably. The fundamental aim of these missionaries was to propagate the Christian religion through the European mode of education. Realising that mere religious propagation was suicidal to political interests,

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the East India Company, set up in 1601, adopted a policy of religious neutrality. Eventually, in 1813, the Charter Act made Indian education an important aspect of the State's duties. This was followed by a period of political consciousness among the Indian masses. They developed a keen interest and curiosity for the English language and Western system of thought popularised by the Anglicist missionaries and economic and political benefits acquired from learning English as it was the mother tongue of the rulers.³

Though the missionaries gained a full right to carry out their work through the Act of 1833, the Government too realised their duty and the period between 1871 and 1882 saw propagation of primary education through plans and policies.

This disillusioned the Christian missionaries of their monopoly over education and spectacular success in the religious conversion of Indians through education. They withdrew from higher education and devoted their attention solely to mass education. They realised that giving education in schools was not identical with the work of propagating religion.

Today, there may not be overt differences between the missionary and non-missionary schools, but subtle differences remain. The missionary schools of today do not preach religion openly but emphasise on good living, honesty, righteousness and propound sound moral judgement among their students. The girls' schools especially aim at developing the girl into a complete woman who not only learns to deal with life situations, but is courteous, just and proficient in her work.

Women's education saw light during the later half of the nineteenth century. The impetus was gained from the influence of Western education. Many Indians realised that the condition of the Indian woman could only be uplifted through education. In spite of much opposition, Iswar Chandra Vidyasagar took the initiative to bring girls to the doors of education and set up Bethune School in 1849. The missionaries and the Company government provided able support to lay a strong foundation of women's education.⁴

In the adolescent years, the young child is open to stimulation and readily learns various avenues needed for being accepted into the adult world. This is the time when she decides to imbibe what is important to her, re-evaluates the values she inherited from her parents and society. These help the adolescent to develop adjustment skills which buffer her personality. Thus the adolescent years form an important part of growing up and learning to cope with the demands society puts on the child as she approaches adulthood. A girl in India has to not only cope with the demands of growing up but face the battle of equality, being labelled the weaker sex.

The present study attempts to compare certain values, and moral judgement of adolescent girls studying in non-missionary and missionary schools in Calcutta.

VALUES

Values are a "precipitate of behaviour." They are "established predisposition of behaviour."

They are what is attractive to a person, the essence of what she seeks in an object, a person or even herself. They operate as criteria for making judgements between alternative courses of action and directly influence the quality of the person's behaviour and decisions. People differ in their values and therefore their judgements of the same object, person or situation differ and they behave differently in the same situation.⁵ Values help in determining goal objects of an individual and her activities and behaviour during the goal-oriented task which might differ from one individual to the other.⁶

This research has made use of ten values which might exist among adolescent girls in non-missionary schools. They are as follows.

(a) Religious Value : This is defined in terms of faith in God and an attempt to understand Him

(b) Social Value : This is defined in terms of charity, kindness, love and sympathy for the people.

(c) Democratic Value : This value is characterised by respect for individuality, absence of discrimination among persons on the basis of sex, language, religion, caste, colour, race and family status.

(d) Aesthetic Value : It is characterised by appreciation of beauty, grace, symmetry and harmony in objects, persons and experiences.

(e) Economic Value : This value stands for desire for money and material gains.

(f) Knowledge Value : It stands for love of knowledge of theoretical principles of any activity.

(g) Hedonistic Value : It is defined as the concept of the desirability of loving pleasure and avoiding pain.

(h) Power Value : It is defined as the concept of desirability of ruling over others and also of leading others.

(i) Family Prestige Value : This value is the concept of desirability of such items of behaviour, roles, functions and relationships as would become one's family status.

(j) Health Value : It is the consideration for keeping the body in a fit state for carrying out one's normal duties and functions. It implies the consideration of self-preservation.

MORAL JUDGEMENT

According to Hemming,⁷ moral development is the process by which a community seeks to transfer the egocentricity of the baby into the social behaviour of the mature adult. A moral code is based on moral concepts which have been learned gradually over a long period at home and later these home-grown concepts are broadened and reinforced by learning from teachers, adults and peers. While making a moral judgement, a person is applying his/her mind to a moral problem. Moral judgement is presumably cognitive in form i.e., it is an aspect of intellectual activity.⁸

Moral judgement consists of a number of areas like, (i) immanent justice-the belief in the existence of automatic punishments which emanate from things themselves, (ii) moral realism-a belief that acts should be judged in terms of consequences, not on the basis of the motives behind the acts, (iii) a belief that punishment should be retributive vs. a belief

that punishment should be restitutive (merely restore the equilibrium destroyed by the punished act), (iv) acceptance or rejection of the ideas that more severe punishment is more efficacious and (v) choice of collective (essentially guilt by association) or of individual responsibility for punishable acts.

PURPOSE OF THE STUDY

Education must be wholesome in whatever form it is offered. It would seem wrong to judge one as better than the other as each has something good to offer to the young students to make them able citizens in later life. In today's condition, the missionary schools have lost most of their religious overtones, yet they uphold the most inherent principles of righteousness, virtues of being good, just and helpful human beings. In short, it emphasises on the morality of its students. These in turn not only influence but are also influenced by the personal values and individual moral judgement. The study deals with the above-mentioned areas and attempts to see how educational background, i.e., non-missionary and missionary, influence them and to what degree.

HYPOTHESES

1. There is no significant difference in the personal value (religious, social, democratic, aesthetic, economic, knowledge, hedonistic, power, family prestige, health) scores of adolescent girls studying in non-missionary and missionary schools.

2. There is no significant difference in the proportions of matured girls in the area of moral judgement (immanent justice, moral realism, retribution and expiation versus restitution and reciprocity, efficacy of severe punishment,

communicable responsibility) studying in non-missionary and missionary schools.

METHODOLOGY OF THE STUDY

In the present study, the purposive method of sampling is used. No special technique for selecting a sample was followed but the sampler's individual judgement was used.

Characteristics of the sample : The sample consisted of sixty-two adolescent girls each from non-missionary and missionary schools, all studying in Class IX, between fourteen and sixteen years of age, having the same socio-economic background and non-working mothers, all studying in the English medium.

Analysis : The technique employed was a personal administration of closed and structured questionnaires having definite, concrete and pre-ordained questions. A multiple choice of answers was given for the respondent to pick up the one she finds the most suitable.

The scores obtained by administering the questionnaires are analysed statistically. The mean scores of the two groups are found out and a testing of hypothesis is done to see if any significant difference exists between the two groups.

Tools used :

1. Personal Value questionnaire formulated by GP Sherry and Dr RP Verma (1987)⁹

2. Moral Judgement Test by Johnson, (1966-1974)¹⁰

The Personal Value Questionnaire, designed to test the 10 values mentioned above consists

of 40 questions with multiple choice items. A question consists of two parts (i) a stem and (ii) 3 items. In the stem of the question, a criterion situation for seeking the value preference was depicted. The items depicted the value for which the respondent had to express her comparative value preferences under stimulus of the criterion situation. Each item denotes one of the 10 values. The respondents were required to put a tick mark against an item that was most preferred, and a cross mark against an item that was least preferred and the third item was to be left unmarked.

The scoring was done by allowing (i) 2 for

the item with a tick mark, (ii) 0 for the item with a cross mark, (iii) 1 for the unmarked item

Reliability and validity of the test were checked by the authors.

Johnson's Moral Judgement Test consists of 20 stories illustrating 5 types of moral judgement mentioned above. Each girl scored 2 points for a mature answer, 1 for an immature response and 0 for an incoherent response was given.

For the 5 fields, the mature answers are chance, intent, restitution, less severe punishment and individual responsibility respectively.

The reliability and validity of the test were also checked by the authors.

RESULTS AND DISCUSSION

TABLE-1 : STATISTICAL INFORMATION REGARDING VALUES

Values	Groups*	Mean	Z-scores
Religious	N MG	10.5159	1.9200
	M G	11.8549	
Social	N MG	13.3730	0.0528
	M G	13.2258	
Democratic	N MG	16.3095	3.0100
	M G	17.9032	
Aesthetic	N MG	16.3095	3.9330
	M G	14.1935	
Economic	N MG	13.2143	1.2490
	M G	14.0323	
Knowledge	N MG	14.7222	2.2638
	M G	13.3870	
Hedonistic	N MG	12.0238	2.2705
	M G	10.8870	
Power	N MG	9.3254	3.6753
	M G	11.5323	
Family Prestige	N MG	10.1984	0.0502
	M G	11.5323	
Health	N MG	11.1510	4.2600
	M G	8.5484	

* MG-Missionary School Girls ; NMG-Non-missionary School Girls.

TABLE- 2 : STATISTICAL INFORMATION REGARDING MORAL JUDGEMENT

Moral Judgement	Groups*	Percentage	Z-scores
Immanent Justice	N MG	0.0317	0.561
	M G	0.0161	
Moral Realism	N MG	0.1746	1.336
	M G	0.2742	
Retribution & Expiation Vs Restitution & Punishment	N MG	0.0952	0.288
	M G	0.0806	
Efficacy of Severe Punishment	N MG	0.1111	0.032
	M G	0.1129	
Communicable Responsibility	N MG	0.0317	0.470
	M G	0.0484	

*NMG : Non-missionary School Girls, MG : Missionary School Girls.

Difference in value scores : The Scores of different values show that there is a significant difference only in the cases of democratic, aesthetic, knowledge, hedonistic, power and health

1 The democratic values i.e., respect for individuality, absence of discrimination on the basis of caste, creed, language, religion and sex are inculcated in the students of missionary schools through regular moral science lessons. This may be a reason for the girls studying in missionary schools having scored higher in democratic value.

1 The aesthetic values, i.e., appreciation of beauty, are found to be higher in the non-missionary school girls, may be because the missionary school girls are trained to appreciate other values in life more than the aesthetic ones

1 The knowledge value scores are higher for the non-missionary school girls may be because they do express their curiosity over theoretical knowledge and principles

1 The hedonistic value i.e., the desirability to love pleasure and avoid pain, is found to be lower in the missionary school girls probably of the particular training imparted to them

1 Power value, which signifies the desire to rule over and lead people is found to be appreciated more by the missionary school girls than by their sisters in the other schools. This may be because their faith and training in a generally disciplined life induce them to lead the others

1 The non-missionary school girls are found to have scored in health values, i.e., they are more conscious about their own health status, physique and its fitness than the others

Moral Judgement : No significant difference is found in the proportion of matured girls in the fields of moral judgement between the girls of non-missionary and missionary schools. The most probable reason may be that moral judgement is a cognitive process and does not depend on religious teaching, familial norms and social background

CONCLUSION

Thus, in conclusion, it may be said that the difference in the type of training imparted in schools do influence one's value in life, specially in the adolescent years, though it is difficult to say if the influence still remains once adulthood is achieved. It, however, may not be concluded which kind of training does good to the students, but a difference does exist in certain spheres.

A further study may be carried out among the middle-aged women earning at a certain level to see how their economic lives have been influenced, if at all, by their schooling background.

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SHORT COMMUNICATION

**THERE IS A HOLE IN MY BUCKY AND THERE IS A
BOAT IN MY BOTTLE****D. Balasubramanian***

My daughters used to sing a rhyme when they were in primary school that was at once linear and circular. It involved Elisa and her partner Henry. He complains “There a hole in my bucket, dear Elisa, dear Elisa”, and she suggests a solution—“Then mend it, dear Henry, dear Henry” to which he says “With what shall I mend it, dear Elisa....” and she says “With some straw, dear Henry...”. “The straw is too long”; “then cut it”; “With what?” “With a knife”; “The knife is blunt...”; “Then sharpen it..”; “With what shall I sharpen..?”; “With a stone...” ?; “With some water”. “How shall I fetch it, dear Elisa, dear Elisa, but how?” “With a bucket dear Henry, dear Henry, dear Henry with a bucket”; “But there is a hole in my bucket....!” The poem is linear since every question of Henry has a straight answer that Elisa gives and its endless refrain makes it circular.

In a chemical take-off on this rhyme, Professor Fred Wudl, of the University of California at Santa Barbara, has written a scholarly scientific paper with the title “There’s a Hole in My Bucky” (*Journal of The American Chemical Society*, July 1995, p 7003–3). He was referring to the carbon allotrope C_{60} . In this molecule, made up simply of sixty carbon atoms,

all the atoms are arranged in a compact polyhedron of 60 vertices and 32 faces, 20 of them hexagonal and 12 pentagonal. The overall shape is that of a soccer ball or a complete geodesic dome of the type made famous by the late American architect-engineer, Richard Buckminster Fuller. Thus, C_{60} is variously called soccerene, buckminsterfullerene and buckball. The 60 atoms are identical in their disposition and valencies and make a closed spherical surface, quite like a ball. No atom sticks out of the surface, and there is nothing inside the ball either. It is a hollow sphere with an internal volume that is just enough to pack a molecule of oxygen within—a nanocage as it were.

Since its discovery, buckball has excited the imagination of chemists, physicists, material scientists and popular science writers. It is remarkably robust under a variety of conditions, a fact that has made some suggest that it might exist in interstellar space (This point is lent some credence by the presence of specific spectral lines that are attributable uniquely to buckyball). Its electronic structure has made physicists suggest that it can be modified suitably so as to enable it to conduct electricity with practically no resistance, that is, as a superconductor. Accordingly, chemists are attempting to “dope” or “contaminate” it with measured amounts of metals and similar substances, so as to prod it to be an efficient superconductor. Then, again, with the explosive

* L. V. Prasad Eye Institute, Road No. 2, Banjara Hills, Hyderabad-500034. email : dbala@ubly, itph.net Article published earlier in the Hindu. Reproduced with permission.

interest in recent times on nanometer-dimension assemblies called nanomaterials, chemists are attempting to manipulate the buckyball in various ways, such as making a string of them to produce a molecular pearl necklace as it were, or to open it up to insert guest atoms and molecules within. Some of these “supramolecular systems” are expected to have application in diverse areas such as complexation, catalysis, protection of unstable species and so on. The organic chemist is excited about the possibility of synthesizing it, building it carbon atom by carbon atom; this would offer him not only a sense of achievement and fulfillment (as Mount Everest did to Sir Edmund Hillary: “I want to climb it because it is there”!), but would also let him hone his tools for other difficult synthetic tasks. Thus, each discipline has its own reasons to visit the buckyball.

The synthesis of fullerene is remarkably simple, much to the chagrin of some of my organic chemist friends. You take some graphite and vapourize it at high temperature; extract the resultant mixture with organic solvents and separate the buckball. Along with it, one also isolates its close relative, C_{70} , C_{88} and even a trace of C_{240} . By now the procedure, originally proposed by Kroto, Smalley, Krotschener and others, is routine enough that buckyball is available in the market; a gram of it costs \$ 1870, while a gram of diamond (5 carats) sells for \$ 5000. The latest allotrope of carbon, polycarbyne, called a neotrope, is arguably the most expensive; it is yet to be priced, let alone marketed (graphite is very cheap at \$20 a kilogram).

C_{60} is the simplest hollow-cage structure encountered so far in chemistry and therefore becomes the candidate molecule to put things in

or to encapsulate guest molecules within. The volume is big enough to accommodate an oxygen molecule but how do you put the guest in? There are two strategies to do so. One is to take the guest substance and build the host ball around it, and the other is to puncture a hole in the ball and insert the guest through the hole.

The first method seems to have worked, unwittingly, in the hands of Richard Smalley, a guru in the buckyball game. His team found that when they vapourized graphite using a laser as the heating source, they could make pure C_{60} . When the graphite was mixed with a bit of lanthanum oxide and laser vapourized, the result was buckyballs, some of which contained lanthanum atoms inside. The yields were poor, perhaps no more than one buckyball in a thousand had the metal nestling inside, but surprisingly, there were occasionally as many as three La atoms inside a ball! Smalley suggests the symbol @ to designate the nestling in. Thus, what they saw were $La@C_{60}$ and $3La@C_{60}$. Also, when a boron/graphite composite rod or boron/potassium (KCl)/graphite composite were laser vapourized at 1200°, they could get $K@C_{60}$ and even a ball of the type $C_{59}B$, wherein a boron atom replaces a carbon in the fullerene structure itself; this also hosted a potassium atom as $K@C_{59}B$. This startling set of results led them to write; “How do you fill the void? Just do it in an oven at 1200°C”. Then, in 1993, Dr Martin Saunders of Yale found that when an electric arc is passed between graphite electrodes in an atmosphere of helium gas, they could make minute amounts of $He@C_{60}$. When neon was used as the gas they got $Ne@C_{60}$. Heating these led to the gas escaping not leaking through the walls but through a temporary “window”, opened by the breakage of a carbon-carbon bond which joins up after the guest is let out.

These are examples of the *a priori* method, which involves extreme conditions at which many organic molecules will break apart. One needs alternate methods of introducing the guest inside bucky. Wudl, in his recent paper mentioned above, has taken the *a posteriori* approach of making the ball first and then puncturing a hole in it so that the guest can be slipped in. To this end, he and his associates M Prato, Q Li, V Lucchini and J C Hummelen first reacted C_{60} with azides to make azafulleroid or $C_{60}NX$ where the football was slightly expanded with one nitrogen atom sandwiched as the sixty first atom between two adjacent carbon atoms on the surface, sticking out as a slight bulge or a bubble. (The X is a “protecting group” that fills up the third valency of the nitrogen). When this bucky-bubble is illuminated in the presence of oxygen, the bubble burst at the two adjacent carbon atoms to produce a hole sufficient in size for the penetration of a helium atom—“There is a Hole in My Bucky!”

The Wudl paper is a landmark result since it might finally enable chemists to prepare fullerene-encapsulated materials. What one needs to do now is to puncture bigger holes, through which substances of large size can be slipped in. (Close on the heels of this paper comes another, from a group in Sussex, England, termed “Holey Fullerenes!”, where the authors have taken C_{70} and made a eleven-atom hole in it). One might want to close up the hole after the guest is introduced in some instances, so that it does not fall out and get lost.

An alternative is to use the “boat in the bottle” approach. I call it so, after the arcane hobby that some patient individuals pursue which, at the first glance, is a parabox. The

ship or the boat just about fits the wide sides of the bottle but the puzzle is how did the boat slip in through the narrow neck of the bottle! The trick, it may be let out, is to build the boat model outside the bottle, roll the whole thing into a tube, wrap it with some thread and shove it through the neck of bottle. Once it is inside, you pull the wrapping thread to unfurl the boat in its full glory inside the bottle. I am sure chemists will exploit this boat in the bottle strategy—make the guest molecule outside, fold it into a conformation or shape that can be slipped in through the hole in the bucky, and change the temperature, pressure or other relevant conditions so as to unfurl the guest molecule to its desired shape.

Dr. E. D. Jemmis, the brilliant, young organic chemist from the University of Hyderabad, has thought up a completely different approach; he builds the bottle around the boat! The bottle chosen is a diamond-like 12-faced arrangement of boron (B_{12}), and the carbons are added five at a time in a ring, attached to each of the boron. The resulting box within a box or onion-peel arrangement is called a stuffed fullerene. He and his student, B Kiran further say that the whole thing can even be made entirely of boron, with no carbon at all, as $B_{12}@B_{12}@B_{60}$ —a box in a box in a box!

Discussions with Dr. J. Dhar of INSA also suggested the possibility of using buckyballs not as cages but as flower vases. In this arrangement, the guest-like flower would be fixed by its stem in the vase and yet be able to offer a face that can act as a catalytic surface. If we can string many such bucky-vases together in a chain or on a solid surface, we might have an efficient and easily recycled “buckycats”.

KNOW THY INSTITUTIONS



NATIONAL CENTRE FOR ANTARCTIC AND OCEAN RESEARCH, GOA

THE INSTITUTE

The Department of Ocean Development (DOD) was created in July, 1981 to function as a nodal department for organizing, coordinating and promoting ocean development activities in the Country, in line with the Ocean Policy Statement. National Centre for Antarctic and Ocean Research (NCAOR) is a Research and Development Institution established on 25th May, 1998 as an autonomous Institute of the DOD.

MISSION MANDATE

To plan, promote, coordinate and execute the entire gamut of Polar Science and Logistic

activities of the country in order to ensure a perceptible and influential presence of India in Antarctica and uphold our interests in the global framework of nations in the Southern Continent and the surrounding oceans.

AIMS AND OBJECTIVES

- 1 Undertake, aid, promote, guide and co-ordinate scientific research in the fields of polar science (Antarctic & Arctic) and Southern Ocean Oceanography.
- 1 Serve as a nodal agency responsible for the overall coordination and implementation of the Indian Antarctic Programme.

- 1 Establish and maintain research base in Antarctica and provide all operational and logistical support.
- 1 Encourage cooperative research both at National and International levels, especially in the frontier areas of science, which are emerging and have application potentials.
- 1 Devise, formulate and initiate programmes of strategic importance in the realm of polar science, which will create a knowledge base for future commercial and scientific interests of India in Antarctic, Arctic and Southern Oceans.
- 1 Effectively interact and liaison with Scientific Committee on Antarctic Research (SCAR), Council of Managers of National Antarctic Logistics and Operations (SCALOP), and other international bodies in order to keep the Indian Antarctic Programme at par with international scenario and ensure a perceptible presence of India in the global framework of nations in Antarctica.
- 1 Establish a singular research laboratory setup with such facilities which are of specialized nature or otherwise not easily accessible elsewhere. Some of these are: deep drilling technology, low temperature ultra-clean laboratories for the preservation and analysis of ice cores, instrument facilities like mass spectrometer (MS) and ICP-MS for isotopic and trace metal analysis, microcosm laboratory for biological investigations, remote sensing tools and techniques for application of advanced satellite technology for studies of the polar regions.

- 1 Develop predictive models for dynamic processes controlled and driven by Antarctica and the surrounding oceans.
- 1 Coordinate, address and monitor all environmental issues arising out of the Environmental Protocol to the Antarctic Treaty.
- 1 Develop a complete database inventory and repository for Antarctic and Arctic science and logistics including establishing a Polar Museum and Library.
- 1 Create a complete warehousing facility and inventory of entire Antarctic Logistics and procurements.
- 1 Provide a fertile platform to generate specialized human resource capabilities for polar science and logistics through training, fellowships, awards, workshops, Publication, exchange of scientists etc. both at National and International levels.
- 1 Cruise planning and management of the Oceanographic Research Vessels engaged by the Department of Ocean Development and NCAOR.
- 1 Take up scientific and technological projects of the Department of Ocean Development as and when entrusted.

INFRASTRUCTURE

To implement the mandate as well as to ensure the efficient functioning of the Institute, NCAOR has been organised into different scientific, Technical and Management Divisions/Sections, as follows:

- 1 National Antarctic Programme comprising the divisions of Antarctic Science and Expedition Logistics.

- 1 Scientific wing comprising the Research and Development Group.
- 1 The Legal Continental Shelf Programme.
- 1 Ocean Survey and Services Group.
- 1 Programme Planning and Evaluation Division
- 1 National Antarctic Data Centre and Information Services
- 1 Paleoclimatic Research Division-Antarctic Ice Core Laboratory.
- 1 Polar Remote Sensing Division.
- 1 Polar Environment & Ecology Division.
- 1 Southern Ocean Oceanography Division.
- 1 Management services, comprising the Administrative, Establishment, Finance and Purchase and Store Sections.

LEGAL CONTINENTAL SHELF PROGRAMME PRO-

The Indian Legal Continental Shelf (LCS) Programme, the implementation of which has been entrusted to NCAOR by the Department of Ocean Development, is a multi-institutional and multi-crore national endeavor that seeks to establish the outer limits of the country's legal continental shelf (LCS) beyond the 200-nautical mile limit of the Exclusive Economic Zone (EEZ), in accordance with the certain guidelines of the 1982 United Nations Convention on the Law of the Sea. Under the provisions of this convention, coastal nations with demonstrable legal continental shelves beyond their EEZ are required to submit their claims along with the requisite scientific and technical data to an International Commission on

the limits of the Continental Shelf (CLCS) by a stipulated deadline. The CLCS in turn will consider the data submitted and make recommendations in accordance with the UN provisions.

Underpinning India's endeavors at laying claims to an extended legal continental shelf will be a comprehensive marine geophysical work plan comprising deep-penetration multi-channel seismic reflection, refraction, magnetic and gravity surveys covering over 24,000 km² in parts of the Arabian Sea and the Bay of Bengal. Considering the extensive and invaluable geophysical data envisaged to be collected in the course of these surveys deploying state-of-the-art equipment, NCAOR has designed the work plan in such a way that the data collected will not only define and substantiate the country's legal shelf claims, but would also form the cornerstone for India's future research programmes in the offshore realm.

The entire work is being carried out under the direct supervision of NCAOR along with active participation of scientists from several front-ranking National Organizations and Institutes such as the National Geophysical Research Institute (NGRI), the Directorate General of Hydrocarbons (DGH), the National Institute of Oceanography (NIO), the Geological Survey of India (GSI), National Hydrographic Office (NHO), etc. The post-processing of data, its interpretation, synthesis, documentation and related scientific support for the programme would be provided by a core group of Indian Scientists from NCAOR, NGRI, DGH and the NIO under the direct management of NCAOR and the Department of Ocean Development.

OCEANOGRAPHIC RESEARCH VESSEL
(ORV) SAGAR KANYA

A multi disciplinary ship was built in Germany under the joint efforts of Indian and German Partners within the framework of Indo-German Economic Cooperation. Commissioned in the year 1983, the vessel is a versatile ocean observing platform equipped with technologically advanced scientific equipment and related facilities.

The vessel is capable of carrying out Geoscientific, Meteorological, Biological, Physical and Chemical Oceanographic Research as major disciplines. It is stabilized and capable of operating under all weather conditions including during monsoons. The Ship is provided with all facilities to perform its tasks with the greatest possible efficiency and world wide voyages upto 10,000 sea miles lasting 45 days and reaching upto 50 degree south latitude.

The Oceanographic Research Vessel Sagar Kanya has been providing a platform to the Indian Scientific Community for conducting field experiments in atmospheric and oceanographic sciences. The vessel has also been effectively used for other DOD programmes such as National Data Buoy and Ocean Thermal Energy Conversion (OTEC) executed by NIOT. The ship has been used in BOBMEX and ARMEX programmes on Indian Climate Variability (ICLIVAR) launched jointly by DST, ISRO and

DOD, OCEANSAT data from Multichannel Scanning Microwave Radiometer (MSMR) and Ocean Colour Monitor (OCM) has been validated with data collected from the ORV Sagar Kanya. So far ORV Sagar Kanya has completed more than 170 cruises.

POLAR REMOTE SENSING

Remote Sensing is the science of deriving information about an object from measurements made at a distance without physically coming in contact with the object.

Although remote sensing was simply referred in 1960's as observations and measurement of distant objects, it has since then taken discipline dependent meanings, in the Environmental Sciences of Geography, Geology, Meteorology, Agriculture and Oceanography. It usually refers to the use of Electro-Magnetic Radiation (EMR) Sensors to record the images of the environment, which can be interpreted to yield useful information. India's OCEANSAT-I, MSMR data is being analysed jointly with SAC, Ahmedabad to study sea-ice extent and its seasonal / interannual variability.

For further information, please write to :
National Centre for Antarctic and Ocean Research. Headland Sada, Vasco-da-Gama, Goa-403804, phNo. 91 (0832) 2520863 to 2520865, 2520867. Fax : 91 (0832) 2520893. email : info@ncaor.org; website: www.ncaor.org

BOOK REVIEWS

THE ENIGMA OF CONSCIOUSNESS

A. Bhattacharya, Published by Firma KLM Pvt.
Ltd, 257 B B B Ganguly Street, Kolkata-700012,
Price 950/-

The Enigma of Consciousness by Al ok Bhattacharyya is aimed at an international audience and ambitiously designed to be a comprehensive study on consciousness in a compact form which is felt to be a great desideratum. It is an interdisciplinary work drawing on resources in philosophy, experimental psychology, neuroscience, cognitive psychology, artificial intelligence, evolutionary biology, palaeontology, archaeology, quantum physics and the science of complexity, and chronicles the thoughts of the world's greatest minds on one of the most profound mysteries confronting humanity since the times of the Upanishads and Plato.

The essence of the book has been to chart the course of scientific reasoning in various disciplines in the past few decades in search of an explanation of consciousness, hitherto considered an exclusive preserve of philosophers and psychologists, and in the process it brings into focus the essential features of all the major contemporary theories of consciousness, keeping the general reader's curiosity about the central issues connected with the topic in view. The author also undertakes a critical appraisal, pointing out the gaps in the explanatory framework of these theories with the inescapable incursions of some deep philosophical issues.

His object is to show where exactly we stand at the beginning of this millennium in solving the riddle of consciousness. The author argues that it is as misleading to expect that a complete neurobiological explanation or an explanation based on cognitive science for the phenomenon of consciousness is possible as it is to expect that a solution of the mystery surrounding it lies in resolving the tangle involving quantum mechanics, an enigmatic aspect of the physical world, and classical physics. Treat consciousness as an emerging and creative property of the complex brain processes *en route* biological evolution or as something constructed out of social and cultural practices of the human species and linguistic in origin is equally unsatisfactory, he contends. The author also explores the depths of religious and mystical experiences, parapsychological phenomena, defocalisation of consciousness practised by shamans across cultures and the limits of scientific knowledge, and admits that some edges of human experience are still beyond the reach of the instrument of science and that there is no way we can determine the validity of all kinds of experience. But, in the same breath, he asserts that man's insatiable spirit of inquiry will never allow him to rest content unquestioningly in a conjured up divine bliss and the belief harboured by men of religion that consciousness is a gift from the high. He holds that scientific understanding in spite of its many imperfections, is the best option available to us in our effort to comprehend this universe and its relation with our conscious mind.

The author thinks that the origin of consciousness is perhaps the deepest of all the

three origin mysteries, the other two mysteries being the origin of the universe and the origin of life. Unification is the strongest slogan of science, he says. Einstein discovered the space-time continuum. The matter-life continuum is now almost a sure-fire to the scientists. But how can we establish the matter-life-consciousness continuum, the author asks. Science, no doubt, faces this challenge with all the resources at its disposal, but a breakthrough is not yet in sight. In the author's view, notwithstanding the remarkable success in recent years in development of molecular biology, neuroscience along with brain imaging techniques, artificial intelligence and some adventurous ideas backed by quantum physics, what remains to be explained about the working of the brain far outstrips what had really been explained, and we have a long way to traverse before we can claim that the code of consciousness has been cracked. But the scientific search for the origin of consciousness in the last few decades, he maintains, has not been entirely in vain, as we have now at least a deeper insight into the nature of consciousness and a better understanding of the gaps in our knowledge of this elusive and yet most prized possession of

mankind. The future can only tell us if the brain of *Homo sapiens* exactly evolved to a level enabling us to know how consciousness originated. It also remains to be seen if the more difficult questions of human self-consciousness in forms where we transcend our biological origin, such as our appreciation of beauty, our pure and disinterested altruism, and our relentless search for the truth for its own sake can be genuinely tackled by neuroscience, genetics and cognitive science at the peak of their success or by any major paradigm shift in science. Meanwhile, the ontological battle on consciousness, the author foresees, will continue.

The book is primarily meant for non-specialist general readers; but, at the same time, it is expected to be an important source-book for students and researchers working in this field. It has been written in an intimate style without much use of the pre-fabricated jargons that often tend to confound the common readers. It is hoped that the book will set one thinking in new ways about who we are and what the world around us is all about.

Prof. S. K. Mukherjee
Kolkata

Conferences / Meetings / Symposia

Date	Topic	Contact
10-12 June 2005	7 th World Congress on Environment Management, Palampur	WCEM Secretariat World Environment Foundation M 64 Greater Kailash II New Delhi 110048 (Email : iod@vsnl.com)
14-17 June 2005	2 nd International Symposium on Sweet Potato and Cassava Kuala Lumpur	Dr. Tan Swee Lian MARDI Rice & Industrial Crop Research Centre P O Box 12301 50774 Kuala Lumpur, Malaysia (Email : sltan@mardi.my.web)
27-30 September 2005	Analysing Risk : Science, Assessment and Management, Boston	Harvard School of Public Health, Centre for Continuing Professional Education, 677 Huntington Avenue, CCPE- Department A, Boston MA 02115- 6093, USA (Email : contedu@hsph.harvard.edu)
29 November- 2 December 2005	Third International Conference on Plants & Environmental pollution, Lucknow	Dr. R. D. Tripathi National Botanical Research Institute Lucknow-226001, India. (Email : isebnbrillko@satyam.net.in)
13-15 October 2005	10 th World Congress on Advances in Oncology & 8 th International Symposium on Molecular Medicine, Crete	Prof D A Spandidos 1, S Merkouri Street Athens 11635 Greece (Email : spandidos@spandidos.gr)

5-7 December,
2005

Second International
Conference on Parthenium
Management, Bangalore

Dr. T. K. Prabhakara Setty
Director of Research
University of Agricultural
Sciences, GKVK Campus
Bangalore 560 065
(E-mail - p_setty@rediffmail.com)

15-20 December
2005

International Chemical
Congress of Pacific Basin
Societies, Honolulu Hawaii

Secretariat
1-5 Kanda Surugadai,
Chiyokku,
Tokyo 101-8307, Japan

March 25-26,
2006

National Conference on Computing
and Mathematical Modeling
Gandhi gram

Dr. K. Thangavel,
Department of Mathematics
Gandhi gram Rural Institute
Deemed University,
Gandhi gram-624 302, Tamilnadu.
(Email : ktel@rediffmail.com)

ANSWERS TO 'DO YOU KNOW?'

- A1. In 1759 the fruit with this name was introduced in Newzealand and it became known as the Kiwi fruit. That is the universal name now
- A2. 64 percent in veins, 20 percent in arteries, 9 percent in the lungs and 7 percent in brain
- A3. 1729.
- A4. The Indian elephant has a single finger like portrusium at the tip of the trunk whereas the African elephant has two.
- A5. Why don't you find this out for yourself.
- A6. Oral tradition. A bird raised in isolation without any contact with other members of the species can only twitter nonsense.
- A7. No, with increase in temperature there are more molecular collisions in the gas phase and viscosity increases

S & T ACROSS THE WORLD**VASCULAR GENE DELIVERY**

Vascular transplants, a frequently used method to treat some diseases, suffer from a high failure rate, resulting in a significant unmet treatment need. In this connection, Genetronics' technology may help prevent rejection or obstruction of newly implanted vessels and increasing the number of long-lasting vascular transplants. Genetronics has shown in numerous pre-clinical studies that electroporation, a method free of the unwanted side effects associated with viral gene delivery technologies, can effectively facilitate intracellular delivery and dramatically improve uptake of such genes.

Genetronics Biomedical Corporation is a late stage biomedical company focused on building an oncology franchise based on its proprietary electroporation therapy. The therapy targets a significant unmet clinical need: the selective killing of cancer cells and local ablation of solid tumors while preserving healthy tissue. The company is moving its lead product, the MedPulser(R) Electroporation Therapy System, through pre-marketing studies for head and neck cancer in Europe, where it has CE Mark accreditation, and a US Phase III pivotal study for recurrent head and neck cancer. Merck, Chiron, the US Navy, Vical and other partners are also employing Genetronics' electroporation technology, which enhances local delivery of drugs and DNA, in their developments of novel DNA vaccines and gene therapies.

(Biospace.com, Aug 31, 2004)

ELECTRONIC EYE FOR BLIND

An electronic 'eye' developed by scientists in Japan will allow blind people to cross busy roads in total safety for the first time. This research is published in the journal "Measurement Science and Technology", published by the UK's Institute of Physics. Tadayoshi Shiroyama and Mohammad Uddin, from the Kyoto Institute of Technology, have developed a system that is able to detect the existence of a pedestrian crossing in front of a blind person using a single camera. When combined with two other techniques the authors have produced for measuring the width of the road and the colour of traffic lights, a single camera can give blind all the information they need to cross a road in safety, says the report. The camera would be mounted at eye level, and be connected to a tiny computer. It will relay information using a voice speech system and give commands and information through a small speaker placed near the ear.

(PTI Science Service, Dec 1-15, 2004)

E CO HOMES

EcoHomes assesses buildings against a range of environmental issues with credits awarded for good environmental performance—the more credits achieved, the better the final rating. Its success lies in the fact that it provides the marketplace with a balanced approach to sustainable development, looking at both the design and operation.

Recently a new credit, rewarding the use of zero-emission energy sources, has been added

to BRE's EcoHomes scheme as part of its 2005 update. It encourages the use of locally generated renewable energy sources, such as solar photovoltaics and wind turbines, to supply at least 10% of a development's heating and electricity. This will not only lead to reduced emissions of greenhouse gases and other pollutants, but will also help to conserve fossil fuels and develop a market for renewable technologies.

The scheme strives to achieve this in a cost effective and practical way, ensuring market appeal and giving individual buildings recognition where they perform well.

(BRE-Jan 3, 2005)

SMART CLOTHING

A new type of 'smart' clothing capable of adapting itself to changing temperatures to keep the wearer comfortable, is being developed by two universities, namely the University of Bath and the London College of Fashion. They are using nature as a guide to develop the materials which will use the latest in micro technology to produce material which will let in air to cool a wearer when it is hot and shut out air when it is cold. This is similar to a system used by pine cones to open up and emit seeds.

The smart garments will consist of a top layer of tiny spikes of water-absorbent material, possibly wool, each only 1/200th of a millimetre wide. When the wearer of the clothing gets hot and sweats, the tiny spikes in the material will react to the moisture and automatically open up, so that air from the outside can get through the material to cool the wearer. When the wearer stops sweating, the spikes will close down again to stop air getting in. The lower layer will be of

material that is not porous so that rain can never get through from the outside, whether the spikes are open or closed.

Innovation is going to lead to a fundamental change in clothing. The material could have a wide variety of applications and could be used for coats, hats, gloves, shirts, trousers, dresses and skirts.

(EurekAlert, Oct 14, 2004)

DEVICE INDICATING WEAR OF BRAKE LININGS

A patent originated in Sweden and titled as "A device for indicating wear of brake linings in a vehicle brake" has been completely accepted by Indian Patent Office on October 23, 2004. Patent No 194342 is invented by Mats-Ekeröth-Sweden and is assigned to Haldex AB, of Box 501, 26124 Landskrona, Sweden. Invention is briefly described below.

"A device for indicating wear of brake lining in a vehicle brake, actuated via an automatic brake lever with a built-in brake adjuster; the lever being intended for transmitting brake force from a brake cylinder and being mounted on a brake actuating camshaft characterized in that a coded disc, on its surface being divided into a number of equally large circle sectors, has at least one coded path, shaped as a circle segment, with equally long magnetic areas in each sector; the magnetic areas being of different lengths in the different lengths in the different coded paths, and that a hall-element is provided in a cover adjacent the coded disc for sensing each coded path, the coded disc and said cover being rotationally arranged in relation to each other.

(The Gazette of India, Oct 23, 2004)

LIBRARY SERVICE

The Indian Science Congress Association

14, Dr. Bireesh Guha Street, Kolkata-700 017

The library of the Indian Science Congress Association subscribes the following Indian and Foreign journals. List of these journals are given below :

India

Current Science
Down to Earth
Food & Nutrition World
Indian Journal of Experimental Biology
Indian Journal of Biochemistry and
Biophysics
Indian Journal of Marine Sciences
Pramana
PII Science Service
Science Reporter

Foreign

Ambio
American Scientist
Endeavour
Interdisciplinary Science Reviews
International Studies in the Philosophy of
Science
Journal of Environmental Planning and
Management
Nature
Natural History
New Scientists
Policy Studies
Science
Science & Society
Social Choice and Welfare
Technology Analysis & Strategic Management
Tropical Science

In addition to those subscribed above, the following journals/newsletters are also received by the Library in exchange of the Association's journal "Everyman's Science" :

Chemecology
CSIR News
DRDO News
Environmental Awareness
Environmental Health Perspectives
Gana Darpan
Gyan Bigyan
IASSI News
INSA News
ICSSR Newsletter
Indian Journal of Physics
Indian Spices

JIMA
Journal of Forensic Sciences
Natural History (Bombay)
S & T Post
Science & Culture
Spices India
University News
WMD Bulletin
WISTA

The Library is open to all category of members of the Association as well as school, college and university teachers on all weekdays (except Saturday, Sunday and holidays) from 10.00 a.m. to 5.30 p.m.

AUTHORS INDEX

EVERYMAN'S SCIENCE VOL. XXXIX NOS 1–6, 2004–2005

- Annandale, T.N. Presidential Address : Evolution Convergent and Divergent No. 1. p. 5.
- Bala Subramanian, D. Who Can See Well Under Water? Mken! No. 1. p. 54. Genes that Control Food Preferences. No. 3. p. 187. A Doctor's DNA Dilemma. No. 4. p. 257. Alus are Rare-A genetic Oxymoron No. 5. p. 324. There is a Hole in my Bucky and There is a Boat in my Bottle No. 6. p. 398.
- Bhattacharya, A. Biological Significance of Gaia Hypothesis and its Different Spectra. No. 5. p. 315.
- Bhattacharya, P.K. The Multidisciplinary Approach and the Paraphyly in the Phylogenetic Classification of Land Plants (Embryophytes No. 1. p. 46.
- Bhattacharya, s Role of Arthropods in Medical Science. No. 1. p. 35.
- Bose, J.C. Presidential Address : The Unity of Life. No. 4. p. 206.
- Chakraborty, P. Understanding Nanomaterials. No. 3 & 4. p. 168 & 248.
- Choudhury, P. The Tale of a Neglected Mathematician, His Works and Beyond. No. 6. p. 361.
- Das, S. Inventory Management in Reverse Logistics No. 1. p. 30.
- Das, A.K. Science in Storytelling No. 4. p. 236.
- Das, D.K. DNA Chips : The Reshaping Technology of Molecular Body No. 5. p. 301.
- Devi, Y.P. Effect of Therapeutic Food Supplementation on the Nutritional Status of Pre School Children. No. 3. p. 160.
- Dubey, S.K. Biodynamic Farming in India, No. 2. p. 100.
- Forester, M.O. Presidential Address : On Experimental Training No. 2. p. 72.
- Gupta, R.K. Organic Vegetables in Nutrition and Health Security No. 2. p. 105.
- Gupta, S. Values and Moral Judgment of Adolescent Girls Studying in Non-Missionary and Missionary Schools. No. 6. p. 391.
- Hisamudin Phytoplasm The Plant Parasitic Molluscs No. 6. p. 371.
- Howard, A. Presidential Address : Agriculture and Science. No. 3. p. 128.
- Jose, K.P. Post harvest Processing of Spices. No. 4. p. 230.
- Joshi, U.C. Unique Properties of Water. No. 3. p. 147.
- Kalia, V.C. Environmental Genomics : A Novel Approach for Searching Microbes. No. 1. p. 43.
- Kaur, P. Probiotics : A Beneficial Health Option. No. 4. p. 224.
- Krupanidhi, S. Designer Genes. No. 5. p. 304.
- Mishra, A. Fish in Human Welfare. No. 2. p. 111.
- Mishra, P. Methane in it's Hydrate Form-A Wonderful Future Energy Source. No. 2. p. 84.
- Nautiyal, C.M. Variation of Temperature and Other Climatic Parameters During the Late Quaternary Period. No. 3. p. 151.
- Pal, H.R. Theories of Intelligence. No. 3. p. 181.
- Raman, C.V. Presidential Address : On Raman Effect. No. 6. p. 350.
- Ray, H.S. Benchmarking Exercise in Public Funded R&D Organisations. No. 5. p. 309.
- Roy, S.K. Explosion that Creates Materials. No. 3. p. 140.
- Sanwal, V.K. Intelligence Revisited. No. 1. p. 26.
- Saravanan. T. Plant Growth Promoting Rhizobacteria in Plant Disease Management : An overview. No. 6. p. 357.
- Sharma, R.K. Green Chemistry : A Present Day Need for Sustainable Future. No. 2. p. 93.
- Simonsen, J.L. Presidential Address : On Chemistry of Natural Products. No. 5. p. 286.
- Singh, D. Forensic Entomology : Use of Insects in Crime Investigation No. 5. p. 321.
- Somaskhar. N. Role of Insect-Nematode Associations in Sustainable Development. No. 6. p. 376.
- Thapliyal, P.C. An Overview of Luminescent Pigments. No. 2. p. 88.
- Yadav, R.K. Xenotransplantation : Pigs as Source of Organ for Man No. 6. p. 384.



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