CURRENT SCIENCE

P.B.No. 8001, C.V. Raman Avenue, Bangalore 560 080, India. Telephone (80) 3342310, Telex 845 2178 ACAD IN, Fax. 91-80-3346094
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Prof. S. Ramaseshan
Editor, Current Science
Distinguished Professor - Emeritus
Raman Research Institute

EDL/94

September 20, 1994

Miss Anna Mani
President
Current Science Association
C.V. Raman Avenue
Bangalore 560 080

Dear Miss Mani.

According to a decision taken at an earlier Meeting of the Working Committee of the Current Science Association my tenure as Editor of Current Science should end by December 1994 (when the tenure of the present Working Committee also ends). However, at the meeting of the Working Committee in December 1993 it was decided that my Editorship should continue up to the end of 1995. It was also suggested by the Working Committee that I should seriously search for a competent Editor who could succeed me.

I have to acknowledge the enormous help and support I have received from the Members of the Editorial Board. Most of them have come to love this journal and have worked hard for it. However their contributions, while valuable, will in no way substitute or replace the duties and responsibilities of the Editor.

I have therefore been actively looking out for some one who could be the Editor and who will be able to do a job much better than myself. In this search, I found that there are certain constraints. I explain this and the results in this long letter.

1. The editing Current Science - (because of the very nature of the journal) is different from editing most of other Academy journals. It can be strenuous as it is a fortnightly.

2. At the present juncture the organizational structure of Current Science would not permit an Editor to be outside Bangalore. Another essential criterion is that the editor must be in India most of the time - as otherwise bringing out an issue every fifteen days would be impossible.

3. It would be ideal to have a young Editor with a distinguished research career in science.

4. It is the view of many I have consulted and my own, that it may not be appropriate, at this stage, to have an editor who is professionally trained in editorial tasks but who has never been involved in scientific research.

5. Most young scientists are not willing to accept the Editorship. It is also my perception that the work of bringing an issue every fortnight would adversely affect their scientific research and career.

I was therefore very pessimistic of getting active scientists, young or old, to take up the Editorship.

However I have been extremely fortunate in persuading one of our brilliant scientists Prof. P Balaram of the Indian Institute of Science to take over the Editorship after me. Initially he was reluctant but he later felt that Current Science with its recent record was worth his putting in more effort. (Incidentally Prof. Balaram is already helping Current Science in many ways).

During my conversation with Prof. Balaram we came to the conclusion that it may be expedient if he becomes a co-Editor/joint-Editor almost immediately, (if, of course the Working Committee approves). This will permit us to meet at least twice a week and discuss the innumerable problems of publication as also plan each of the fortnightly issues. Prof. Balaram will take up the major part of the duties of the editor from December 1995. He suggested that I should continue as co-Editor for one more year at least so that he is not too overburdened with the routine part associated with bringing out the journal.

All this depends on the approval of the Working Committee of Current Science Association. It is my considered view that an eminent scientist like Prof. Balaram, joining as editor of Current Science now and later taking over the full responsibility of editor after 1995 is an opportunity that we must seize. I shall therefore be grateful if you could kindly take action to get the concurrence (or otherwise) of the Working Committee.

With my best regards,

Yours sincerely

S. Ramaseshan

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Prof. S. Ramaseshan
Editor, Current Science
Distinguished Professor - Emeritus
Raman Research Institute

EDL/94

29 October 1994

Professor N V Joshi
Centre for Ecological Sciences
Indian Institute of Science
Bangalore 560 012

Dear Professor Joshi

I am sending herewith the letter (enclosed) I wrote to Miss Anna Mani, the President of the Current Science Association which is self explanatory. The process of getting approval from the members of the Working Committee is starting. Meanwhile I would like to have your ~~idea~~ feelings about this proposal.

My idea is that in 1995 editors will be S Ramaseshan & P Balaram and for 1996 P Balaram & S Ramaseshan. After this S Ramaseshan will retire.

An immediate reply will be appreciated.

With my best regards,

Yours sincerely

S Ramaseshan

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Prof. S. Ramaseshan
Prof. P. Balaram
Editors

EB/95

June 12, 1995

Dr N.V. Joshi
Centre for Ecological Sciences
Indian Institute of Science
BANGALORE 560 012

Dear Dr Joshi:

There are several matters regarding the functioning of *Current Science* on which Prof. Ramaseshan and I would like your help, suggestions and advice.

1. When new manuscripts are sent to Members of the Editorial Board, they will be accompanied by a MS handling form on which suggested reviewers names may be indicated. In the case of Board Members in Bangalore the form may be immediately returned to the Editorial Office with recommendations of suitable referees. Manuscripts will be mailed to reviewers by the Office and when necessary returned with comments to the Board Members. In the case of Board Members outside Bangalore, two copies of the MS will be sent so that the Member may directly obtain referees reports and communicate his recommendation to the Office along with MS copy and correspondence within four weeks. If not suitable for *Current Science* the Board Member may send his recommendation within a week. This will permit rejected manuscripts to be returned quickly to authors, enabling them to resubmit elsewhere.

2. Two referees reports are sought in the case of Reviews, Research articles and Research communications. In cases where one report is inordinately delayed a decision may be made on the basis of a single report and the Board Members reading of the manuscript.

3. At least, one opinion is sought in the case of Scientific correspondence, General articles and Research news items. In the case of Research News this is often done informally and expeditously. Board Members may be particularly watchful for articles which are overly long, poorly written and repetitive.

...contd 2/-

4. A new section entitled "Research Accounts" is being started. A copy of the announcement is enclosed. We would welcome suggestions regarding prospective authors who may be invited to contribute.

5. A major concern at present is to increase the number, quality and diversity of Research communications/Articles that appear in each issue. Some scientific disciplines are extremely under-represented in the pages of the journal devoted to original research. We would deeply appreciate any help that you can give us in increasing the number of original research submissions.

6. We are also trying to reduce the time taken for completion of the review process and to shorten the period between acceptance and appearance. Several members of the Board have been particularly helpful in resolving situations where referees reports have been inordinately delayed.

7. We would like your help in increasing the number of submissions to the Research news section, particularly by identifying topics and prospective authors.

We look forward to receiving your advice and help on all matters concerning *Current Science*.

With best regards,

Yours sincerely,

P. Balaram

P. Balaram.

Research Accounts

Current Science intends to start a new feature entitled 'Research Accounts'. Articles in this category are intended to be personalised reviews of research from the authors own laboratory, based on a body of published work. The articles must provide appropriate background to the area in a concise introduction, which should also serve to place the author's work in proper perspective. A concluding section may address future trends and directions in the area. Unpublished results may be included only when absolutely essential and should be kept to a bare minimum. Articles in this category may be about 20 double spaced typed pages; A4 size (8-10 printed pages) and should include appropriate illustrations. References to the literature should not number more than about 60. Articles should address a broad readership. While most articles in this category will be solicited by the editors, unsolicited contributions will also be considered. All articles will be reviewed by two independent referees. Authors are encouraged to suggest appropriate reviewers.

Editors

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Prof. S. Ramaseshan
Prof. P. Balaram
Editors

Wednesday, 27 December 1995

Dr N.V. Joshi
Centre for Ecological Sciences
Indian Institute of Science
Bangalore 560 012

Dear Dr Joshi:

There has been a considerable reorganisation of *Current Science* over the past few years. The journal has begun to acquire a distinctive character and has a wide readership in India. During this process of change valuable inputs have been received from the Editorial Board at different points of time. The beginning of a new year appears to be an opportune moment to take stock and to seek your considered opinion on many matters related to the journal.

The improvement of the scientific content of the journal and the quality of printing/reproduction and adherence to the schedule of publication have been major matters of concern. This issue of the balance between *hard science* and *general sections* of the journal is also of relevance. The latter often attracts a wide readership and has contributed greatly to the increasing visibility of the journal.

Over the last few years there has been a conscious attempt to liberalise the expression of opinion in *Current Science*. As a consequence there have been several strongly worded letters and commentaries. Some have effectively addressed important issues and provided diverse viewpoints.

Occasionally, the correspondence columns have been used to criticise institutions, including the Indian Academy of Sciences. There have been several articles generally critical of governmental attitudes towards science and commentaries on changing perceptions about the role of science in India. While many contributions are reasoned presentations by highly regarded scientists, others are opinions by less visible individuals who may not be active scientists or persons connected with decision making.

Considerable concern has been expressed in some sections of the scientific community that the discussion of contentious issues in this journal diminishes the public image of Indian Science. There are others who feel that such open discussions are healthy and can only serve to strengthen Indian science.

While the Editors have sole responsibility for deciding the nature of published material, we would like to seek your opinion on the following points:

1. Should *Current Science* provide a broadly liberal forum for expression of diverse views on science policy and scientific institutions?

2. Should matters of scientific ethics and malpractice be squarely addressed in the pages of this journal?

3. Should disagreements on technical issues in research be permitted?

We would greatly value your opinion on these matters and also on any other issues that you would like to address. We fully appreciate the need to avoid personal attacks in the journal and have tightened editorial scrutiny of all correspondence. We believe that an enlightened editorial policy will permit *Current Science* to serve as an effective medium of communication binding India's large and disparate scientific community.

With best wishes for the New Year and with regards.

Sincerely yours

S. Ramaseshan P. Balaram

S.Ramaseshan P.Balaram

Editors

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Ref. No. GA488 2 May 1998

Dr N.V. Joshi
Centre for Ecological Sciences
Madurai Kamaraj University
MADURAI 625 021

Ref :GA488
Biodiversity, conservation and evolution of plants

by D.D. Pant

Dear Dr Joshi :

The enclosed article

Biodiversity, conservation and evolution of plants

by D.D. Pant

has been submitted for publication in the General Article section of Current Science. We would appreciate if you commented on its suitability for publication. Please send your report as early as possible, preferably within ten days.

Yours sincerely,

for Editors

General articles discuss current trends in research in a field that will be of interest to readers outside the field; inter-disciplinary topics; science policy and administration; or some aspect of the application of science and technology to human needs or the impact of science and technology on society/ecosystem/life.

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Biodiversity, Conservation and Evolution of Plants

D.D.Pant

The present article on Biodiversity, Conservation and Evolution of Plants should be able to deal with all aspects of Botany, nay with the entire field of Biology which includes the study of diverse branches of life sciences. I must mention at the outset that people dealing with more exact sciences like physics and chemistry feel somewhat uncomfortable with Biology. A reason for this could lie in the undefinability of life. It has to be stated with all emphasis which I can muster that among all the branches of science, Biology is the only one which cannot define the object that it studies. There is no strict definition of life and even all its exact experiments are performed on dead cells or tissues.

Among the branches of biology on one side there are branches of the subject like biochemistry and biophysics which approach the more exact sciences and on the other side there are branches that are mainly descriptive and even historical. On the one hand you can experiment to confirm your conclusions and repeat the experiments for the veracity of your ideas but on the other side you can only observe, describe and classify the diversity of form and structure of the organisms you study. Compared to the diversity of chemical elements which number about 105 or more the diversity of form and structure of plants and animals is infinite and we can never make an accurate statement about the numbers of their genera and species. Indeed between the genera and species of plants and animals there are infinite

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D.D. Pant, Department of Botany, Allahabad University, Allahabad - 211 002 (INDIA)

varieties which tend to intergrade them and I can only repeat a statement which I made in 1954[1] while dealing with the classification of spores and pollen grains that it is difficult to draw boundary lines in the fine gradations of Nature and classifications are after all, all artificial.

However, underlying this biodiversity of our undefinable objective called "Life" is the process of diversification which we have been calling Evolution. This process had been going on for nearly 4000 million years from now when life arose on our earth and I must emphasize that it is still going on. You have only to look around and find for yourselves numerous examples of the process continuing among our plants and animals. Take, for example, the use of DDT and the new anti malarial drugs for the eradication of *Anopheles* mosquitoes and malarial parasites for the control of malarial fever. Very soon thereafter we came to know that the use of DDT and the new drugs had given rise to breeds of mosquitoes and malarial parasites which had become resistant to DDT and the new drugs and the threat of malaria had reappeared. To me this is clearly an example of the continuing diversification of life and shows that plant and animal taxa are in the process of continual change. We must also remember that diversity does not only increase but it also decreases. This becomes obvious from the fossil record which shows that many plants and animals have become extinct. Some of them like the dodo, of which one species *Raphus cucullatus* was living up to 1680 in Mauritius but thereafter became extinct. Another species *Raphus apterornis* lived in the Island of Reunion until the late 18th Century. This flightless bird was killed by man for food to become completely extinct[2].

Before I go further I must say that the present century has seen two great advances in science and both are concerned with the fission of the nucleus:

One of these led to the fission of the atomic nucleus by physicists which resulted in giving us atomic power. The first result of this power caused unparalleled devastation of two Japanese cities of Hiroshima and Nagasaki and I should say that we are not yet out of that devastation. A second outcome of the same fission of atomic nucleus can give us atomic power for peaceful purposes. It is claimed that this power in the long run would be able to replace our fast depleting sources of energy and irretrievable fossil fuels. But many scientists differ and have already cautioned us about the hazards of ionizing radiations of atomic wastes like Plutonium whose radioactivity takes a long time in attaining safe levels.

The second great advance was made in the field of biology and once again it involved the fission of the cell nucleus resulting in our coming to know the genetic code of the DNA molecule which is responsible for inheritance of characters from parents to the progeny. A result of this knowledge has given us the capacity to manipulate the genes in the code by what is called genetic engineering. This can give us the power to create novel forms, species or genera.

Thus far nature and natural factors were manipulating genes in what we have called aberrations or mistakes in the replication of DNA leading to mutations by factors which were mutagenic and the way they worked was largely unknown but now we are learning to manipulate the genes in the DNA molecule by deleting, introducing or displacing the genes. We may thus create new forms at will and thus enhance or retard the rate of evolution in nature and in this manner manipulate the biodiversity. Once again like the fission of the atomic nucleus it gives us immense power to create new forms. However, we must again use this power with caution and refrain from creating forms which may turn out to be like the ghost of Frankenstein.

There are additional new surprises like jumping genes and prions. The discovery of prions which seem to be self replicating proteins transferable from one individual to another has brought a Noble Prize for Stanley B. Prusiner[3], and these come in the realm of Biodiversity. In spite of these modern advances the basic need of biology remains in the study of biodiversity because therein lies the raw material whose knowledge is essential for all biological studies. The biodiversity which we study does not only extend into the three dimensions of space but in the fourth dimension of time taking us back to 4000 million years or more from now and the entire span of time from then up to date.

Studies of Pre-Cambrian rocks initiated by Barghoorn and his coworkers like Tyler[4], Schopf[5] around 1965 have given us glimpses of the earliest forms of life from these rocks. Studies of this kind have given us insights about the manner in which life originated and evolved on our planet and the possible conditions under which it arose. This work has opened new lines of research for specialists of diverse groups of plants to look back for early traces of the organisms on which they specialize.

These researches have finally shown that procaryotic organisms are older than eucaryotic ones. This has lent indirect support to the ideas about the eucaryotic cell being a permanent symbiotic association of a number of procaryotes which we call the organelles like the mitochondria, chloroplasts etc. Each one of them have their own nucleic acids which replicate independently but they live together in the nucleated cytoplasm in a mutualistic symbiotic association in every cell of the body of a multicellular organism. Imagine the repercussion of this theory which supports the conclusion that all of us have bodies containing bacterial cooperatives in each one of our cells.

Coming back to diversity of life in our present day world I have to mention that many surprise discoveries await the explorers of biodiversity who are in search of new forms of life in land, sea and air. As late as 1977 geologists of the research submarine *Alvin* discovered in a deep sea bottom warm water vent, at a depth of 3,600 metres below the ocean surface and located about 320 km south of Galapagos Islands, an ecosystem of previously unknown animals like a metre long tube worms named *Riftia pachyptila,* about 30 cm long clams called *Calyptogena magnifica* and mussels named *Bothimodiolus thermophilus* along with other animals like shrimps, crabs and fishes. The waters in the vents or cracks in the sea bottom are superheated to temperatures above 300 C under extremely high pressure and they are rich in hydrogen sulphide and contain chemosynthetic sulphur bacteria which also live inside the cells of *Riftia* worms like chloroplasts in the cells of photosynthetic plants. They also live in the cells of clams and mussels which live in water at a temperature of 20 C and provide energy to them by chemosynthesis in the darkness of the ocean floor[6]. The endosymbiotic sulphur bacteria in the cells of these dark-dwelling animals thus provide an indirect proof about the chloroplasts of green plants being endosymbionts for photosynthesing in the presence of sunlight. These examples of biodiversity from the ocean floor should thus convince you about the importance of such studies in confirming the ideas about the *Serial Endosymbiotic Theory*[7] which assumes that the eucaryotic cell is a symbiotic organism formed by procaryotes and eucaryotes on the basis of the independent self-replication of organelles from pre-existing organelles like chloroplasts, mitochondria etc in eucaryotic cells and the independent DNA and RNA of the endosymbionts and their host cells. In the place of the photosynthetic bacteria or chloroplasts

living inside the cells of green plants growing in sun light the dark dwelling deep sea animals like *Riftia* have chemosynthetic sulphur bacteria as their endosymbionts.

Barring these novel forms of life described from deep sea vents it would be well nigh impossible to mention the names of new genera which have been recognized among the lower groups of plants during the present century. Even among the higher plants which are conspicuously growing around us many new genera have been recognized during the 20th century. Even in a small group of plants like liverworts Kashyap[8] recognised quite a number of new species and endemic new genera from the Western Himalayas while our liverworts from other parts remained uninvestigated. Subsequent workers like Hattori & Inoue and others reported novel bryophytic forms like *Takakia*[9], *Marchasta*[10], *Carrpos*[11,12], *Crytothallus*[13]; *Haptomitrium*[14], *Sphaerocarpos*[15], *Pachyglossa, Chondrophyllum and Personella*[16] from Japan, Australia, New Zealand, Patagonia and the Eastern and Western Himalayas besides many new species and genera of foliose liverworts and mosses. Likewise many new pteridophytes have been recognized in the recent past in the flora of our country and elsewhere. There is thus an urgent need for their study. It would take a lot of space to mention the new genera of our present day dominant groups of seed plants included in the angiosperms which have been recognised lately but I can take up the new genera of a small group of higher plants the gymnosperms, to mention the need of the study of biodiversity of plants. Among the five major groups of living gymnosperms we knew only 9 genera among the cycads but Johnson (1959)[17] recognized a tenth genus *Lepidozamia* as distinct from *Macrozamia* and in 1987 Stevenson discovered[18] an eleventh genus *Chigua* in Columbia in northern South America. In a second group of living gymnosperms the Pinales or Coniferales, in the wider sense, we have found at least nine genera during the

20th century. Beginning with *Acmopyle* recognised by Pilger in 1903 and *Amentotaxus* recognized by him in 1916, the Taxales acquired *Austrotaxus spicata* Compton in 1922[19] and *Nothotaxus* Florin[20]. The history of the discovery of the genus *Metasequoia glyptostroboides* of the Taxodiaceae is unique. Its fossils usually mistaken for those of *Sequoia* were first recognised by Shigeru Miki in 1941[21] and the type of the genus was a fossil. But in 1948, Hu & Cheng[22], two Chinese botanists, recognized the living trees of *Metasequoia* in Southern China and after much controversy a living tree of the species became the generitype. Another genus recognized almost ten years later in 1958, again from southern and western China, is *Cathaya* of the Pinaceae[23].

The two genera *Sequoia* and *Sequoiadendron* remained lumped together for a long time but as a result of the work of Buchholz (1939)[24] the older species *S. sempervirens* remained in the genus and the other species *S. gigantea* was assigned to a new genus, *Sequoiadendron.* A parasitic conifer previously called *Podocarpus ustus* from New Caledonia has now been assigned to a new genus *Parasitaxus ustus* (Viellard) de Laubenfels (1972)[25].

The latest additon to the list of new genera of conifers is *Wollemia nobilis* Jones, Hill & Allen (1995)[26] which becomes the third genus of the Araucariaceae. It is clearly different from *Agathis* as well as *Araucaria.*

An example of gymnospermous diversity at the specific level may be taken from the genus *Cycas.* In his monograph of Cycadales Schuster (1932)[27] recognized only eight species as valid and regarded the rest about one hundred names as varieties, forms or synonyms. In 1985 Osborne & Hendricks[28] mentioned the names of 15 species as valid but next year they added 2 more species making the total 17[29]. In 1995 Stevenson, Osborne & Hill[30] raised the

total of valid species of the genus to 52. However, the total number of valid species of the genus should be near a hundred or more out of about 150 species named by various authors.

Intimately connected with the theme of biodiversity are evolution and conservation. The biodiversity which we find around us is the result of the process of evolution which has been going on for millions of years before the present. The fossil record shows us that Tennyson's words in the *Passing of Arthur* "the old order changeth yielding place to new" are vividly true for the fossil record. During the vast stretch of time which Hutton[31] estimated from the deposition of piles of sedimentary rocks and declared "Time is to nature endless and as nothing" and added "I see no vestige of a beginning and no prospect of an end". Evolution of plant and animal life has seen many vicissitudes and in the past numerous new forms arose to replace the old ones which became extinct. In due course the new ones met the same fate.

There were in addition large scale extinctions or sudden appearances of new forms when some catastrophic change like the fall of a meteorite or other unknown factors like glaciation or sudden rise in temperatures in our unstable earth caused mass extinctions like that of the dinosaurs or the rise of the Glossopteris flora. Besides such changing or attenuating lines there were numerous other forms of life which have continued unchanged up to date or they have changed only slightly.

However, life on this planet seems to be facing an unprecedented factor and that is modern man. Equipped with his machines he is destroying forests to build his fields, roads, dams and dwellings. He is thus suddenly upsetting the balance of nature with terrific speed. This emphasizes the need for conservation of plants and animals *in situ* in what are called Sanctuaries or National Parks or *ex situ* in captivity in zoological or botanical gardens. I

must add that *in situ* conservation has the distinct advantage of allowing the animals and plants to remain in their own environment which are conducive to their proper growth and progress in evolution. On the contrary, zoological parks and botanical gardens keep them protected but the conditions which nature provides them are not available for their proper growth and further evolution. Even so we have no National Parks for the protection of our rare and slow reproducing relics of past ages like cycads and we have far too few Botanical Gardens. In China, Australia, U.S.A., South Africa and other countries practically every city has a Botanical Garden. How many Botanical Gardens are there in India and what is their rating from world standards?

In the end I must emphasize that the prime need of biological studies is teaching and research in biodiversity where exploration and protection of our plant diversity must be continued with renewed vigour. On that depends our animal diversity and ultimately our ecological balance. We need to lay special stress on exploration of our flora and fauna and survey the areas of the distribution of our plants and animals. Wherever necessary we should prepare censuses of our endangered plants and animals at regular intervals..

We have almost forgotten that the beginnings of all biological studies are made by exploration of our biological diversity and thereafter comes research on various aspects of our plant and animal wealth. While our explorers of plants and animals observe and collect them we should take special care that we do not endanger our rare species and genera by over collecting.

New Trends in Science

And now before I end this discussion I must say a few words about the new trends in Science particularly in Indian Science with special reference to the life sciences. In doing so I

must first outline the process of scientific investigation which is the study of nature and natural phenomena by observation through our eyes, ears, nose, taste and touch. In the modern age we supplement our senses by different gadgets which augment the observations of our senses. However, our observations are only the beginning of science these are followed by a process in the mind which is far more important. It classifies , and reasons out the processes under observation, draws conclusions and makes generalisations. The fall of an apple and Newton's Law of Gravitation is a fimiliar example. Thereafter these generalisations have to be tested by experiments wherever possible by artificially creating the conditions and the generalisations are now called laws or theories . The phenomena and laws thus discovered are next utilized for performing jobs or activities which are otherwise difficult to perform. Up to the discovery of the phenomena and making generalisations about it, the process is science but thereafter the skill in performing jobs with that scientific knowledge is technology although it may be difficult at times to say where science ends and where technology begins. Citing examples from the field of biology, the persons who domesticated wheat or rice plants by creating conditions for their culture under cultivation were doing science but those who repeated the cultivation for ages by improving conditions of cultivation were doing technology of agriculture but here again those who discovered better breeds in nature or bred new varieties by crossing or by other genetic processes were scientists. Taking another example from the field of medical science when Sir Ronald Ross found that bites of *Anopheles* mosquito were responsible for injecting malarial parasite in the blood stream in the human body and these thereafter multiplied in the body and caused malarial fever in man he was doing science but the doctor who prescribes quinine or other

drugs to cure malaria is only a technician but once again a doctor who discovers a new drug or a new treatment for malaria is a scientist.

And I must also mention here cases like those of James Lovelock, the author of "Gaia"[32] whose invention of electron capture detector was responsible for getting the Nobel Prize for Chemistry by others and for his being invited by NASA jet perpulsion laboratory to find out if there was life on Mars or other planets. As a result of his work he looked for a definition of life and came to the conclusion that it was a self regulating system or object. He finally concluded that there was no prospect of life anywhere else in the planets around us and that our earth itself was a living organism. The salinity of its seas, the composition of its atmosphere and the temperature of the earth have been stable throughout the ages. He called his theory "Gaia" after the name of Goddess Earth in Greek Mythology. In recent years biologists have not only started seeing the cell or the body of multicellular organisms as composite organisms but even ant, bee and termite colonies or the human society as organisms but Lovelock sees the Earth itself to be a living organism. It is a sad spectacle to find that Lovelock's theory was responsible for his exit from NASA. In our modern jargon Lovelock is holistic instead of being a reductionist. In his research laboratory at Launceston in London he has invented the microwave oven. He first discovered the long range air pollution in 1966 and pointed out that chlorofluorocarbons (CFC) and nitrous oxide are depleting the ozone layer. As a result, his holiday cottage in Western Ireland became the centre of a global monitoring net work. He continues to invent gadgets for scientific research but recently when his name was proposed for the Nobel Prize the scientists of the Nobel Committee felt that he was not a scientist but only an inventor. However, he has received the

Swedish Volvo Prize of about US $ 25000 and on the 29th October 1997 the Japanese Blue Planet Prize with a cheque of 50 million yen = more than a quarter million pounds.

Fashions in Science and change of Labels

The latest trends in Science which have come after the fission of the atomic nucleus and also that of the cell have lately started new fashions in Science which are boosted by enormous amounts of money available for these areas like atomic research, energy research, ecodevelopment microbiology or biotechnology. This tempts many of our scientists to indulge in politicking for funds and also to change their labels or signboards while they continue working in the areas of research that they were pursuing earlier. I may cite some examples to bring home to you the manner in which this is done. A scientist who is a plant physiologist gets a project of a crore of rupees to scan diverse plants for their photosynthetic capacity to fix solar energy for building carbohydrates in the plant body. The way he does it is to allow the plants to grow in the sun light for sometime, thereafter he cuts them, dries them and determines their dry weight to decide which plant is more efficient in fixing solar energy. Reports are submitted to the funding authority where they remain in the files and no one knows anything about the better fixers of solar energy or the way they can be utilized. Another scientist obtains a project on microbiology without any previous work on the subject and without the knowledge of identifying the objects he will study. Yet another scientist may continue suquashing root tip cells for counting the number and observing the form of their chromosomes but he may change his signboard from cytology to genetic engineering to draw funds available for such research.

The result of this unbalanced distribution of funds is the production of third rate work in copiously funded areas while good research in other areas is suffering. The proper

method of encouraging and funding scientific research does not lie in identifying "thrust areas" but in identifying capable and dovoted scientists of any age and giving them facilities for their work. Good science is done by capable scientists not by the labels they carry or by the costly gadgets they import. We need devotion, motivation and hard work for good science and not "brain storming". As Thomas Alva Edison has said "Genius is one per cent inspiration and ninety nine per cent perspiration". My teacher the late Professor Sahni used to define research in the same way by substituting research in place of genius. Gadgets may become important at a certain stage but the first prerequisite of good science is a devoted and capable scientific worker. The example of Sir C.V. Raman should be enough to convince you about my advice. Sir Asutosh Mookerji identified him when he was an accountant general by seeing his single minded devotion to research at the Indian Association for Advancement of Science. Sir Asutosh offered him the Palit Chair of Physics in Calcutta University and he brought the first Nobel Prize for India. On the contrary we are today busy selecting persons on caste basis, relationships and other parochial considerations and expecting good science by unbalanced distribution of research funds and by looking at the fashionable labels of the scientists and not at their capability and devotion. Of late things have deteriorated to such an extent that persons who are known to have indulged in fraudulent research or those who do not have even the basic training required for a subject are being placed in very specialized pure science institutions established by savants at the cost of their savings for the continuance of research in their fields which they feared may happen to lie unprotected outside the fashionable areas of science. In this manner square pegs are being fitted into round holes of pure science by selectors who are themselves square pegs of the same kind.

There was a time when universities were producing good researchers and teachers in diverse branches of science but why are we not able to do so now? My answer is bad recruitment of teachers and promotions by counting years of service without looking at the performance or reputation of the candidates in teaching and research. In addition the university teachers once they get in have temptations of earning money by doing extra-curricular work like proctorial duties, admissions, examinations, arranging examinations and coaching classes etc. which are all done in the time which should go to teaching and research. These duties come to teachers by politicking which is also done at the cost of teaching and research. Unless we put a stop to these practices we cannot rejuvenate the universities and their science. Devoted research scholars, howsoever capable, cannot find suitable jobs in science departments of Universities or Institutions. Scientists in Science Institutions are produced by universities and therefore you have to stop the rot in the universities for better science anywhere in the country.

Universities themselves have gone down by the overhauling of their old liberal Acts based on those of Cambridge and Oxford while the Acts of Cambridge and Oxford have remained the same as they were four or five hundred years ago. As a result of our changed Acts, half educated persons become elected as members of the University Executive Councils for indefinite tenures to sit on judgement over university administration, standards and appointments whereas university teachers get in by rotation for a limited term of one year instead of being elected by their colleagues. The Deans of Faculties are again appointed by rotation instead of being elected by Faculty members and only two of them enter the Executive Council by rotation so that except two the remaining faculties remain unrepresented in the Council and the Deans too have a limited term of one year. Seniormost

Lecturers and seniormost Readers who fail to secure the higher ranks even by promotion become representatives of Readers and Lecturers, it is claimed to avoid electioneering. Above all Vice-Chancellors are not elected but selected by a strange Commitee which has one nominee of a political chancellor and only two others and thereafter the Chancellor has a second and final choice of appointing the Vice-Chancellor. And mind you a political Chancellor has supreme power over twenty or more universities. Unless we bring back our old Acts of Universities there is hardly any chance of improving our Universities.

In spite of the extreme paucity of avenues of employment for graduates or postgraduates in science our Universities are unable to control the mad rush for admissions in universities and colleges. The Central and State Governments started giving attention to population control when it became overdue but when it is exessively overdue no one even thinks of the control of admissions in universities and colleges. Instead their numbers have been rising year after year without quality control opening of more Universities and Colleges of higher learning where quite a large number of students enter the rolls for training as "netas" for later political life through students unions because that is the most easy course for a lucrative profession. Others join the institutions of higher learning because there is nothing else they can do in the largely elusive hope of qualifying for some employment and also because the cost of graduate and postgraduate education is easily affordable being sometimes cheaper than school education. For girl students, graduate and postgraduate education, in addition, provides a waiting room or angling interval for marriage. I think it is late but not too late and we must do something for planning our higher education particularly in science where the cost of education is relatively high. One of the methods of controlling the rush of students for higher education is to make it costly as they have done in Cambridge

and Oxford. The fees of these universities are so high that only the best students who hold government scholarships for education can enrol there or the children of those who can afford such costly education enter them. Naturally when the toppers or the students whose parents pay such high amounts for their higher education enter the universities they seldom waste their time and opportunity for learning. The lesson of this article, therefore, is make our primary education free or easily affordable but we must make our unreserved higher education, particularly in science costly and affordable only by our best and motivated students. Finally those students who choose scientific research must do so as an end in intself and not as a means to some other end.

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Ref :H136
Cell population growth during the formation of the chick eye lens

by Mahendra S. Sonawane et. al.

Dear Dr Joshi :

The enclosed paper has been submitted to Current Science. We would appreciate if you, or a competent colleague of yours, reviewed the paper and let us know if it merits publication.

Since Current Science is an interdisciplinary journal, papers reporting novel ideas or results of broad general interest will be given priority.

We will be obliged if you could return the paper with your comments as soon as possible, preferably within ten days.

Yours sincerely,

C S Ramakrishnan

for Editors

Cell Population Growth during the Formation of the Chick Eye Lens

by

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Pp 1-12, 2 Figures and 1 Table

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Abstract: The eye lens, a radialy symmetrical and autonomously growing organ, contains dividing cells in the epithelium while fibre cells do not divide. Between 7-15 days of chick embryogenesis, the annular pad extending from the peripheral epithelium is formed which acts as a reservoir of proto-differentiated fibres that are then transferred to the fibre area. Around the optical axis, a wave of apoptosis is generated in terminally differentiated fibre cell nuclei. We have determined cell numbers in the epithelium, the annular pad and fibre compartments and the data fit a logistic model the best, indicating a saturating growth. The growth rates for various lens compartments change with time.

Introduction

The evaginating optic vesicle comes in contact with the head ectoderm and induces the lens placode[1] that invaginates to form the lens vesicle[2]. The primitive lens contains prospective lens fibres in the inner hemisphere and prospective epithelium in the outer hemisphere[3,4] and becomes an autonomously growing organ. The prospective fibre cells stop dividing[4], enter a G_{01} phase[5] and synthesise lens crystallins[6-8]. The prospective epithelium contains dividing cells[4]. Progressively, the peripheral epithelial cells establish a distinct germinative zone[9,10] beyond which a reservoir, the annular pad, of non-dividing proto-differentiated fibres appears. These cells also contain fibre-specific δ crystallins[8] and are transferred to the fibre area throughout the life span[5,10]. The lens offers the best model for programmed cell death or apoptosis as elongated terminally differentiated primary fibre cells, located along and around the optical axis, exhibit a temporally and spatially specific pattern of nuclear pycnosis and loss[5]. The apoptotic lens cell nuclei lose DNA *in situ*[5],

undergo DNA strand scission[11] liberating free 3'OH ends detected as initiators *in situ* for calf thymus terminal dexxynucleotidyl transferase[12-15]. In both native[16, 17] and 2-D [native and denaturing] agarose gels it was shown[18] that fibre nuclear DNA breaks down and forms a DNA ladder respecting the polynucleosomal structure of chromatin, and lose the histone H-1[17, 19]. The fibre cell bodies devoid of nuclei and packed with crystallins, pile around the optical axis. Throughout the life span the lens cell population grows wherein the epithelial cell progeny contributes to both epithelial and fibre cell populations; the latter via the transfer compartment or the annular pad.

Earlier modelling[20] revealed that, between 2½ and 12 day development, both epithelial and fibre cell populations grow exponentially and the establishment of the lens cell lineage is not a clonal event. Recently, a geometrical model, based on shape changes and lens volume growth, has been published[21] but it is inadequate to describe the cell population growth dynamics of the lens. We now estimate cell population sizes in various lens compartments and fit these to 4 different growth models. We show that the logistic growth model fits best for the data on 50 lenses distributed over the entire embryonic period and 15 days after hatching.

Materials and Methods

Fifty chicken lenses of 3-20 days embryogenesis and 15 days after hatching were dissected in Tyrode, fixed in Carnoy, embedded in paraffin and serially sectioned (5μ thick) along the plane perpendicular to the equator and parallel to the optical axis[20]. Sections were stained in Mayer's hemalum and mounted in Permount or Eukitt.

To estimate cell numbers, we have divided the lens in 5 major compartments. (i) The central epithelium, (ii) the peripheral epithelium, (iii) the annular pad (AP) with

proto-differentiated fibbers, (iv) NFB harbouring the differentiating nucleated fibre cells, and (v) PYC with fibres showing pycnotic nuclei[5] in phases I and II. The geometrical co-ordinates of the region containing non-nucleated fibres (NNC) is measured but cell numbers cannot be. The top one-third annular pad also contains dividing cells and the bottom third contains elongated proto-differentiated fibres, AP was subdivided into the outer (OAP), middle (MAP) and inner (IAP) annular pad. Number of cells in the central and peripheral epithelium, AP, NFB and PYC were counted and corrected using Abercrombie's formula[23] as described[20].

The Lens System

Until 5th day of embryogenesis, the entire epithelial cap contains dividing cells. After 7 days, the annular pad is progressively formed at the outer rim of peripheral epithelium and the dividing cell population becomes restricted to a germinative zone common to the peripheral epithelium and the top [or outer third] of the annular pad[10] or OAP. Thereafter, central epithelial cells exhibit decreasing proliferative activity and become non-dividing[10] but maintain the division potential[22]. Along the lens equator, the annular pad joins fibre cells where elongated and proto-differentiated IAP cells, present as a single row, turn around their long axis by 90^0 and become confluent with cortical lens fibres. The middle third pad (MAP) is a pseudo-stratified region between the IAP and OAP. In the lens fibre area, only nucleated fibres (NFB) are seen till 8^{th} day of development, and, then, those along the optical axis, begin to exhibit nuclear pycnosis and this region is termed as PYC. The pycnosis starts at the centre and spreads as a wave radialy outwards[5]. By 13 days, all cell nuclei close to the optical axis are pycnotic and this zone, after 15 days,

becomes non-nucleated, as nuclei are lost, *in situ*[5]. Thus, from the 15th day, we discern three different fibre regions, namely, the nucleated fibres (NFB) in the cortex and bow, fibres with pycnotic nuclei (PYC), and non-nucleated (NNC) fibres (Fig 1).

Cell counts

The geometric co-ordinates of all compartments of the radialy symmetrical lens were measured as before[20]. Chick lens cells are mono-nucleate and the nuclear counts represent cell numbers in each compartment. Assuming that the sections are compressed on a horizontal plane parallel to the equatorial plane, the total cell number in each compartment of the lens are estimated as described[10, 20]. However, this method does not allow us to estimate the number of non-nucleated cells.

Data analyses

Cell numbers were plotted against the lens age and the distributions were analysed using linear regression, power function, exponential function and logistic growth function[24, 25]. The linear regression formula, $Y = mX + C$, enables estimation of the rate of increment from the slope m and allows direct comparison of growth rates of different compartments. The power function, $Y = a\,(X)^{2ß}$ used previously[20] to analyse the growth of lens epithelium and lens fibres and estimates the fractional inputs or the growth fraction (ß) in the system whereas a gives the cell population size when the lens is induced. The logistic growth function $Y = [(A1-A2)/(1+(X \div X0)^{ø})] + A2$ was also applied to the data. The fits would signify that the population first grows rapidly but then the growth slows down due to a decreased rate of proliferation, cell migration/transfer, and/or cell death, and that the population attains a steady state equilibrium. In this equation, A1 and A2 are the initial and final cell

numbers, while X0 is the time when 50% saturation level is attained. The Runs test[25] was applied to data examined for all growth models using the Microcal Origin Version 3.5.

Results and Discussion

The total lens cell number was estimated by adding those determined for each compartment. Data were plotted against time (Fig.2) and fitted to a linear regression, power function and the logistic growth function, While all fits were statistically significant ($P<0.005$), only logistic fit is found to be significant when Runs test is applied. Runs test assesses for the random distribution of data points along the fitted line or curve. In any case, each function among the three allows estimation of different growth parameters and these are shown in the Table I.

Early modelling studies[20] have revealed that induction and establishment of the lens cell lineage is not a clonal event, and both lens epithelium and fibres grow exponentially up to 12th day of embryonic development,. However, the cell division rate of the epithelium is greater than the growth rate of fibres and the annular pad is established as a reservoir. We have now analysed the growth of epithelium (EPI), the annular pad AP (OAP+MAP+IAP), and the fibre (NFB+PYC) compartments up to 15th day of after hatching. Both EPI and OAP harbour dividing cells, or those with division potential, and we have analysed the growth of the resultant DIV (EPI+OAP) compartment. The MAP and IAP form the reservoir (RES) of proto-differentiated fibres.

Although the correlation coefficients and 'P' values for linear regression are excellent due to the large data set, the linear function does not fit well the data

(Fig.2) beyond 12 days as the dividing lens cell fraction decreases exponentially with time[10] and the input in the system decreases progressively. Furthermore, with Runs test[25] the fits are not significant. Nevertheless, using this model we find that both AP and NFB grow fast whereas EPI exhibits the slowest growth rate (Table I). In contrast, the growth rate is higher when EPI and OAP are pooled (DIV), while the fraction containing MAP and IAP (RES) appears to grow slower (Table I). Thus, OAP grows much faster than the rest of AP compartments.

Beyond 12th day of development, the exponential function does not fit the present data (results not shown). The power function enables estimation of growth fractions of each compartment and, again, we find (Table 1) that DIV has the largest growth fraction of 0.7 while in EPI alone it is 0.48. This is consistent with earlier studies[10] that, after 8 days, dividing cells become progressively restricted to the peripheral epithelium and OAP to form the germinative zone. From the increment in the fibre region we conclude that the rate of fibre differentiation is less than in OAP. This is probably why the progeny of DIV, positioned towards the fibre area, accumulates and causes the formation and growth together of MAP and IAP (RES) harbouring proto-differentiated fibres. The estimates of the presumptive cell population sizes of various lens compartments at the time of lens induction derived from the power function vastly exceed the cell number observed at that time so that this method is not applicable for the long-term lens data. Furthermore, the fits are not significant when Runs test was applied.

The lens growth is best described by the logistic growth function (Fig. 2, Table 1). Furthermore, the Runs test[24] for a random distribution of data point around the

curve fitted best the logistic growth curves alone for all lens compartments. Thus, the growth rates of different lens compartment are constantly changing from the initial exponential to a slower progression during the later part of development. This fits with earlier observations[10] that the dividing cell number increases till 8 days and decreases thereafter.

During the development and ageing, the lens grows due to two distinct growth phenomena. Growth due to cell division is restricted to the DIV compartment while fibre cell population size grows due to a transfer of non-dividing cells from the annular pad. In contrast, the growth of the intermediate MAP + IAP (RES) appears to saturate the earliest (Table I) and then controls the transfer rate to the fibre area. Due to the radial symmetry of the lens, there is no reason to visualise an active transfer or migration of annular pad cells to the fibre area[10]. We agree that elongated IAP cells can remain at their original location and integrate with the fibre by changing their orientation by 90°. The question of inter-compartment transfer can be settled by applying modelling tools to lenses subjected to ^{3}H-TdR pulse-chase. The present analysis (Table 1) suggests that the fibre cell population reaches 50% saturation level fastest at 15 days which, we feel, is an artefact due to the absence of data on cell numbers in NNC. In any case, To estimate transfer rates, we must determine the number of non-nucleated cells by novel modelling methods and the work is continuing in this direction.

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Table I

Growth parameters of developing chick lens

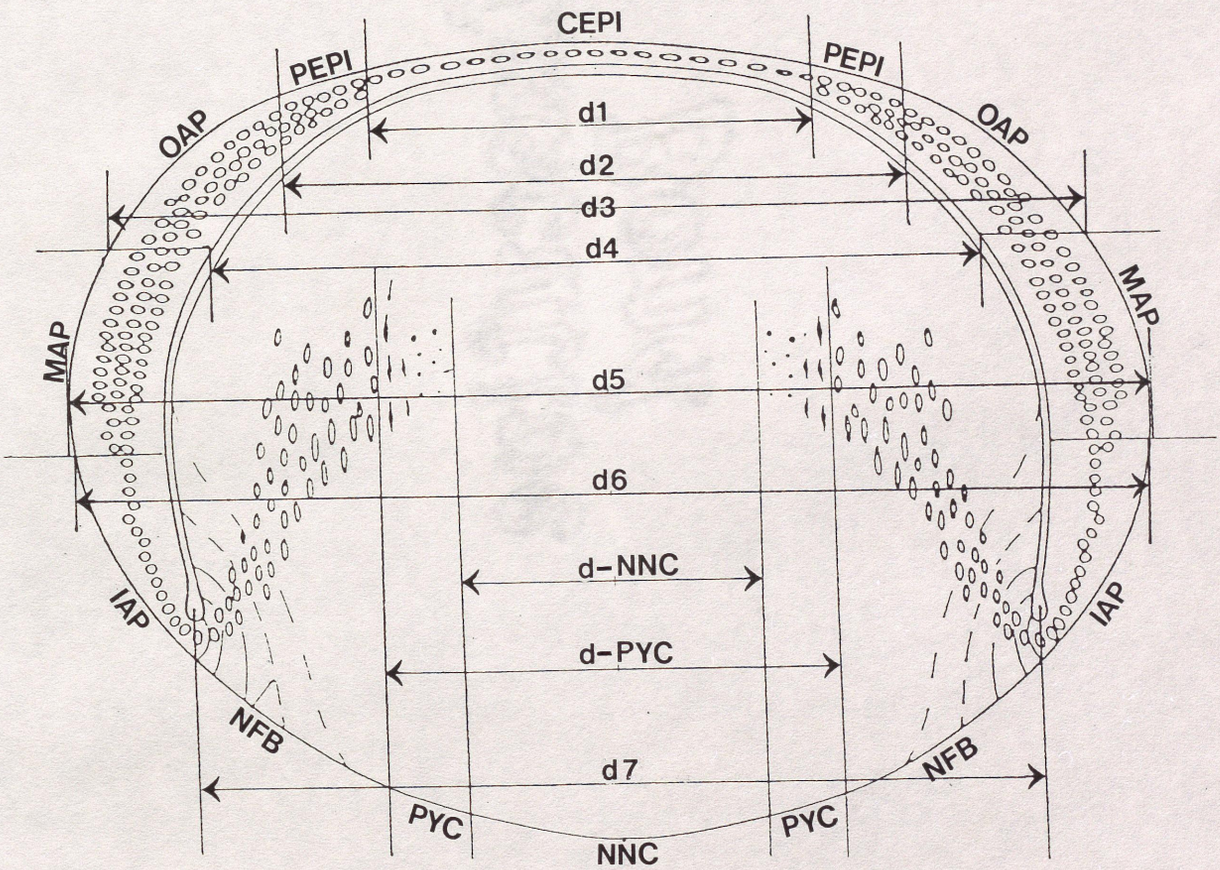
	Linear Regression	Power Function		Logistic growth function	
Lens Compartments	Growth rate No. Cells per day **	Growth fraction (β)	Cell Number at the time of induction **	Saturating cell population size	Lens age [days] at 50% saturation level
Entire Lens	1.965×10^4	0.503	2.28×10^4	7.8×10^5	19
Epithelium (EPI)	1.59×10^3	0.48	2.7×10^3	5.7×10^4	17
Annular Pad (AP)	9.66×10^3	0.6	7.31×10^3	6.7×10^5	38
DIV (EPI+OAP)	6.6×10^3	0.7	2.75×10^3	3×10^5	25
RES (MAP+IAP)	4.6×10^3	0.46	5.51×10^3	1.8×10^5	17
Fibre region (NFB + PYC) *	8.42×10^3	0.49	1.34×10^4	2.6×10^5	14

* Based on cell numbers excluding those for NNC, i.e. after the loss of cell nuclei
** Data fits are not significant by Runs Test

Figure Legends

Figure 1. As Schematic drawing of a 17 day-old chick lens section showing lens compartments: CEPI, central epithelium; PEPI, peripheral epithelium; OAP, outer annular pad; MAP, middle annular pad; IAP, inner annular pad; NFB, nucleated fibre region; PYC, fibres with pycnotic nuclei; NNC, non-nucleated fibres. Vertical lines show the inner and outer boundaries of lens compartment. Horizontal lines, d1-d7 represent the inner and outer diameters of CEPI, PEPI, OAP, MAP, IAP and NFB. d-PYC and d-NNC are diameters of PYC and NNC compartments, which appear after 8 days and 14 days, respectively, of chick embryogenesis. After 14^{th} days d-NNC is subtracted from d-PYC to get the actual radii of PYC zone.

Figure 2: Cell numbers of entire lens and lens compartments are plotted against time (days) and fitted to linear regression (A1 to A6), a power function (B1 to B6) and Logistic growth function (C1 to C6). All fits are statistically significant ($P<0.005$). To note that the best fits are for logistic growth function A6, B6 and C6 offer the best comparison and only C1 to C6 are significant by Runs test.


CEPI
PEPI
PEPI
OAP
OAP
d1
d2
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d4
MAP
MAP
d5
d6
d-NNC
d-PYC
IAP
IAP
NFB
NFB
d7
PYC
PYC
NNC

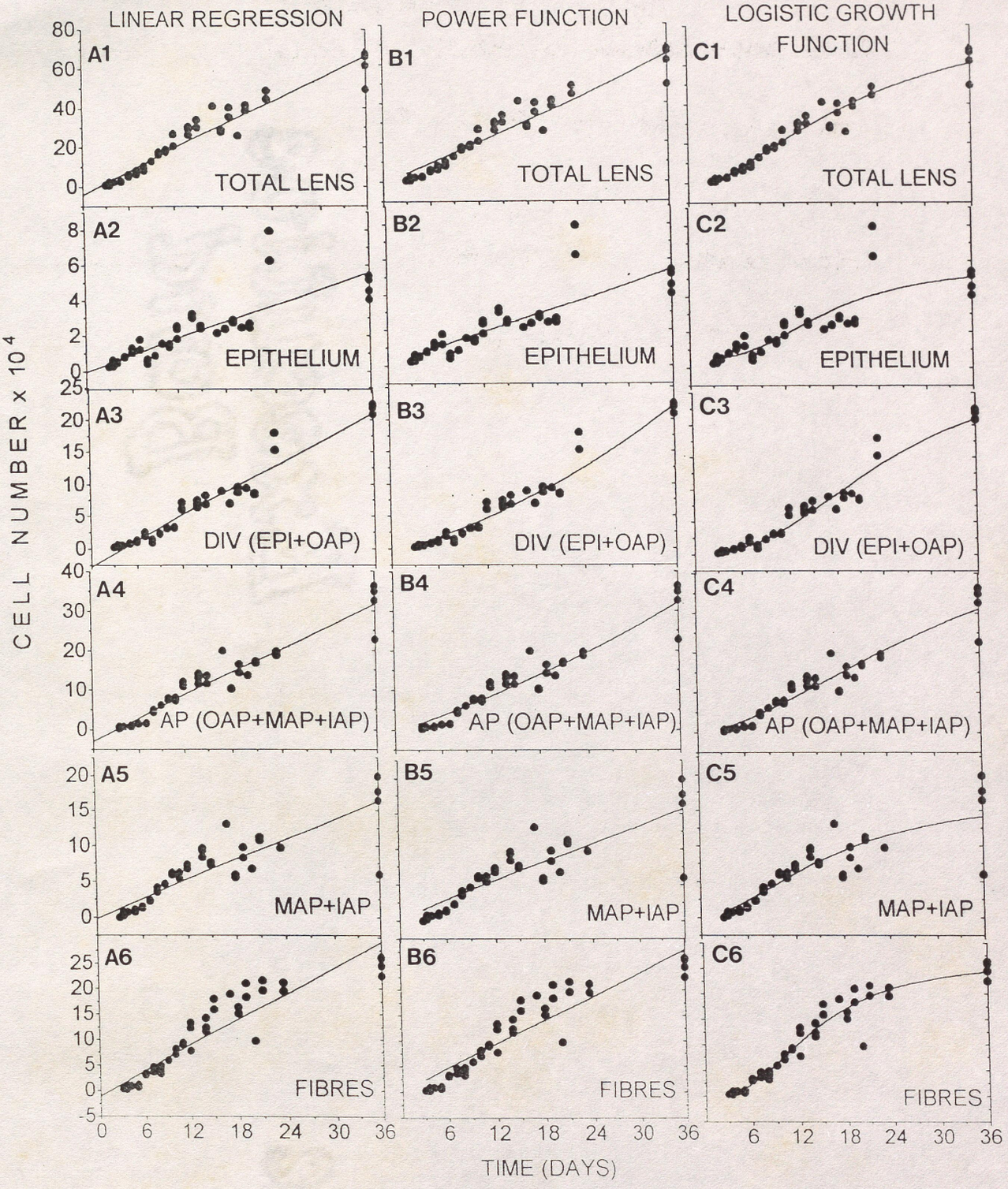
#136

FIG. 1, ↑ Top. (with lettering)
SINGLE COLUMN WIDTH

Cell population Growth during the Formation of the Chick Eye lens

by

Mahendra S. SONAWANE, A.M. THERWATH and Sohan P. MODAK.


LINEAR REGRESSION
POWER FUNCTION
LOGISTIC GROWTH FUNCTION
A1
B1
C1
TOTAL LENS
A2
B2
C2
EPITHELIUM
A3
B3
C3
DIV (EPI+OAP)
A4
B4
C4
AP (OAP+MAP+IAP)
A5
B5
C5
MAP+IAP
A6
B6
C6
FIBRES
CELL NUMBER x 10^4
TIME (DAYS)

H136

FIG 2. ↑ Top (with lettering)
DOUBLE COLOUMN WIDTH

Cell Population Growth during the Formation of the Chick Eye Lens.

by.

Mahendra S. SONAWANE, A.M. THERWATH and

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18 July 1999

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Towards the Dharma of ecology

by T.N. Khoshoo

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Towards the Dharma of ecology

by T.N. Khoshoo

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TOWARDS THE DHARMA OF ECOLOGY

T N Khoshoo

Ecology: A Moral Issue

The word *Dharma* enjoys universal acceptance having been included in all the standard English dictionaries. Now it is as much an english word as it is a sanskrit word. It is derived from the sanskrit root *dri* which means to "uphold, sustain and support". In simple language it means to "hold together the different aspects and qualities of a being". Associated with it is also righteousness, morality and duty. In short, it embodies all that is universally and eternally true. Without dharma nothing can make sense. Therefore, it is a part of the very nature of every thinking human being about all situations and problems including ecology that confront humanity at large. Dharma is, therefore, enshrined in any orderly life, society and environment. Implicit in it is that human beings have to control themselves so that their actions do not endanger the ecology which surrounds them, and on which they depend for sustenance all the time. Also implicit in dharma is that one should not inflict on surroundings and other living beings anything which is disagreeable to one's ownself. Therefore, there is a deep interconnectedness between dharma, ecology and environment that surround all forms of life all the time. In view of this, it is not surprising that ecology and environment are fast becoming moral issues and a moral responsibility of the human race which has the capability to think and foresee about the end-result of human actions. *Prakrati* (nature) and *Purush* (human being) are two major elements recognised in the scriptures, which, if antagonistic, can bring doom and gloom to Mother Earth.

Nature more often does not degrade environment because there is an inherent underlying balance in nature. If natural cataclysmic changes happen, there follows environmental degradation. Left to nature, there starts a process of ecological rehabilitation and reconstruction of the deteriorated habitats, and, more often, a new ecological regime sets in, which may even bring *status quo ante* in course of time, or even a new balanced ecological state. There is, therefore, tremendous resilence in Nature, because of the inherent capacity to reconstruct and rehabilitate. Nature is also not static, because there is in it an

inherent capacity to change, refine and update. Those of us who visit natural habitats see these phenomena occurring all the time.

On the other hand, market forces, more often than not, depend on short-term gains and profits. These are oblivious of the responsibility of setting right the damage created by their short-sighted policies. Regrettably, at present making profits is the dharma of industry, but losses regarding generation of wastes/pollution is governmental and societal responsibility. Even at the individual level, eating food every day is a personal matter, but disposal of wastes therefrom is societal and/or governmental problem. Environment is the source of all raw materials which everyone is out to grab, but environment is also the sink for all wastes. A question arises as to how moral are such attitudes? Therefore, benefits and costs must become part of all environmentalism.

The world is not united on the question of sustainability of the Earth system including a concern about growing human numbers. However, most scientists are worried about the shape of things to come. They advocate understanding the basic questions scientifically and evolve technologies to combat the impeding dangers. Earth being a finite entity, does not grow in size. Thus there is a need to combat realistically the problem of increasing human numbers, and their wants and desires, and qualitative and quantitative dwindling of resources and above all the very health of the Earth system.

The basic question is, can we raise the carrying capacity of the Earth system to cope with demands of *one* species (*Homo sapiens*) which happens to be the pinnacle of organic evolution! Using technological innovations, this species having spoiled the Mother Earth, no doubt has also the technical capability to stop endangering the health of the Earth system! This sounds paradoxical, but is nevertheless true.

The above are some inconvenient but real-life questions for which we have to find solutions: sooner the better. Here then is a combined challenge for scientists, technologists, economists, sociologists, and those who deal with ethics of resource use. The basic question arises as to what will confer sustainability! Some thinkers (including this author) have attempted to answer this, but there is need for a more concerted attention of an expert group so that a necessary policy frame-work can be drawn for this purpose.

To save our planet with all its living and non-living manifestations and to ensure the diversity that has been its strength, there is an urgent need to adopt a Code, which may be called *The Dharma of Ecology*. Without following dharma nothing can make sense. Human being is a thinking species, therefore, dharma has to be part of its very nature including the ecology that surrounds it. Although this word is a oriental coinage, it is universal in approach and application. It is connected with human conduct and is enshrined in all religions of the world in one form or another (Khoshoo, unpublished). The important point is that all living and non-living resources in the life-support system are held in an intricate balance and have a value. These resources are to be held in trust. Thus human action should not inflict on other species (including other human beings) anything that is disaggreeable to one's ownself including the surroundings of a particular individual be it plant, animal or microorganism.

Some Basic Principles

Following are some basic principles underlying the dharma of ecology:

- Protecting and augmenting the regenerability of life-support system. This has to be accomplished by rationalized husbanding of all resources. Among other things, this would involve nurturing and protecting renewable resources; conserving non-renewable ones together with prolonging their life by recycling and reuse; avoiding waste; and benefiting from the economy of scale;
- Fair sharing of the resources, and means and products of development between and within nations of the world. This would reduce the disparity in resource-use, leading to a significant reduction in resource-use in the developed countries and increase in resource-use with little or no environmental degradation in the developing countries;
- Promoting awareness regarding the hidden social, economic and environmental costs of consumerism and overuse of resources with particular reference to its impact on the developing countries;
- Adopting willingly sustainability as a way of life by encouraging *frugality,* i.e. getting more from less, and *fraternity,* i.e. getting it in association with others;

- Meeting genuine societal needs and legitimate aspirations of the people by blending economic and environmental imperatives so as to alleviate poverty; and
- Halting and then reversing the overuse of resources and armament build-up for ensuring sustainable environment, peace and security.

We need a firm commitment to the dharma of ecology at the individual level, because a society or a government is only an extension of an individual. The common threats to the long-range ecological security will bring nations of the world together. The earth as a whole is also a Civilization Reserve not only for humankind but also for all the living beings: be it plants, animals or microorganisms. Therefore, as citizens of the world, the human race must rise above the local and national ideologies and narrow economic systems, and owe allegiance to the life-support-system as a whole.

Global Family

Never before, there has been a greater need for application of the concept of Global Family (*Vasudaivakutumbakam*) as is today. Environmental crises facing the world are actually an outward manifestation of an inner crisis in mind and spirit of human beings. Environment can no longer be treated as bits and pieces and dealing only with wildlife, ecodegredation, pollution and the likes of these. In the larger context, environment encompasses the whole well-being of all life on our planet. In the developing countries, poverty is the biggest polluter, a statement made by the late Indira Gandhi. Poverty degrades environment and thereby accelerates the pace of poverty in the developing countries. Their dire need is a survival strategy. On the contrary in the developed world, it is the prosperity and unlimited greed, which cause environmental degradation. Even though the developing countries harbour over 84% of the people, their contribution to ecodegradation and pollution is far less than that by 16% of the people in the developed countries, who consume nearly 80% of the world's resources.

If history of human being is traced eversince its origin in Africa, it is clear that, from the environmental and socio-economic points of view, there were three major societal epochs discernable: the Hunter-Gatherer Societies,

followed by Agricultural Societies and the more recent Industrial Societies. We may now examine the broad contours of each of these.

Hunter and Gatherer Societies

The human being has been a hunter-gatherer for 99% of its time span. It is only during the last ten to twelve thousand years that it has taken to agriculturization and industrialization. During the hunting-gathering stage, the human being was largely nomadic, and acted as one of the species in the concerned ecosystems. The environmental impact was strictly local and small, and due to the natural process of eco-repair, ultimately there was little or no damage. Hunter-gatherers have performed the biggest trial-and-error experiment for the humanity as a whole. The latter has to be ever-grateful to the former.

Agricultural Societies

The early agricultural societies domesticated livestock for food, clothing and for carrying loads. They also began selecting and cultivating plants as food in 12 centers of origin and domestication in the world, one of which is in India. Except for some microorganisms, humankind has not added to the list, and has been using the same animals and plants that were selected and domesticated by its primitive ancestors. However, with the invention of the plough and the wheel, agricultural societies were involved increasingly in clearing forests for cultivating crops, raising livestock and making dwellings. With rather assured food supply, population began to increase and food supply had to keep pace with it. Thus arose the need for irrigation network. With the enhanced rate of deforestation leading to enhanced rate of siltation, there was clogging of the irrigation systems. Since, by now, population had begun to increase and agriculture had extended considerably, there was need for labour both for agricultural and desilting operations. This gave birth to a landed class who owned land, and a landless slave or labour class who put in hard work. The small and localized environmental impacts gave way to larger impacts with forest clearances for agricultural purposes and grasslands for domesticated cattle. The human being still depended on its muscle power and that of the domesticated animals.

Next came the *Agriculture-based Urban Societies,* which led to further increase in population. Moreover, while some villages produced food, the larger villages grew into towns and cities. In the latter case, people depended for food produced in the villages. In their spare time in cities, people took to small industries like tool-making, weaving, pottery, hand-made goods, etc. Six such contemporary civilizations appeared on the earth; these were: Nile Valley, Babylonian, Greek and Roman, Indus Valley, Huang Ho Valley, and Mayan and Aztec. While these civilizations contributed materially to literature, art, music, science etc., there were two classes in each: the *haves,* who constituted a small section but had large assets and were powerful; and the *have nots*, who were a large section, with little or no assets; and they were powerless and were involved in producing food and doing all the dirty work and rendering services all the time. Earlier, fights between groups took place for possession of more and more livestock, but now fights began about the ownership of land. This led to the springing of leaders with armies of followers who controlled large areas. Wars began to be fought for possession and control of land and ecological assets. There was scant respect for environmental assets like water, forests and land which were poorly managed and overgrazed, resulting in soil erosion, blockage of irrigation systems and increased number of slaves to clear the silt. The cities had a lot of waste generated by people leading to infectious diseases and parasitic attacks. Habitats began to be altered beyond their carrying capacity, and, for the first time, there was significant ecodegredation. In this process, some empires became weak and wars became frequent. All this resulted in further degradation of environment. Such ecological, economic and social reasons led to the collapse of the six civilizations enumerated above.

Industrial societies

Starting from England, in the Western Europe was born the Industrial Revolution, with many inventions involving coal-based steam engine systems followed by the internal combustion engines. Thereafter, horse carriages and wind-powered ships were replaced by engines using fossil fuels. This was the period of European expansionism into Asia, Africa and the Americas. In this process the indigenous peoples were either largely annihilated or subjugated.

Even agriculture now began to be based on coal and oil in place of human and animal energy. Production increased and there was migration of former farmers to towns and cities. They now took jobs in mechanized factories. With the two world wars, fought in the 20th Century, many inventions were made in the area of science and technology. After the wars, these led to mass production of useful products at affordable prices and a "high" standard of living with higher GNP per capita. With the application of modern science and technology there have been major gains in the yield potential of the domesticates. There also was improved life expectancy, better living conditions, education and old age security.

The environmental impacts of the industrialized societies were tremendous, be it agriculture, industry, mining etc. All these led to degradation of land, forests, water, biodiversity and air through the release of noxious chemicals and cutting down of forests. Most cities became twin cities, the mega-component with all the facilities, and the slum-component where ecological refugees live. Most cities in the world are still stuck with such a situation. There also developed the regional problems of acidification and global build-up of carbon dioxide and depletion of ozone.

In fact industrialization has been a mixed blessing. There was considerable economic growth with per capita increase in GNP and overall standard of living. However, all this progress and benefits have been at tremendous environmental costs. Furthermore, for some time past, lifestyles in the developed countries have also affected the resource base in the developing countries. The classical cases are that in return for food and financial aid by the developed to the developing countries, the latter destroyed their forests by supplying timber, growing cash crops and producing cheap meat for the consumption in the developed world. In this regard the well known case is the *Hamburger Connection* where Norman Meyers showed that 40% of the forest cover in Central America has been destroyed for making pasture land available so as to supply beef at cheap rates to North America. The present-day cost of beef does not reflect the *true cost* of its production because huge environmental costs are not added to it. This example stirred the conscience of the whole world. The developing countries also use obsolete and dirty technology supplied by the developed countries, thus degrading the

environment further. In return for financial aid, some developing countries have even offered sites for burying and dumping noxious wastes. All such aids are in fact *concealed compulsions* and, in practice, amount to acts that threaten the ecological security of the poor developing countries.

Thus, in the developed countries the causes of eco-degradation and pollution are their prosperity and greed, while in the developing countries the causes are poverty and need. In the latter case, it is matter of a survival. The most profound aspect of the industrial era has been the arrogance of humankind to consider itself the most superior organism in the biosphere, and a growing feeling that everything is subordinate to human needs, and a feeling of being a co-creator.

The world today is divided into two camps. About 26 developed countries are mostly located in temperate regions of the world, while over 107 developing ones are mostly in the tropical, subtropical and hot temperate belt. The 16% population in the former consumes nearly 80% of the world's resources. The underlying feeling of undue exploitation of resources by the developed countries exists in the developing countries. This causes tensions and friction. However, in the recent years, the developed countries, confined mostly to the temperate regions, have realized the criticality of tropics and subtropics for their own survival and well-being. This has led to a trend to swap the debts of the countries in the tropics, for conservation of tropical forests. It is indeed a healthy sign, because environmental inter-connectedness and interdependence between the rich and the poor nations is becoming increasingly clear. No nation however rich or poor is safe if its environment deteriorates significantly.

Environmental problems are thus the result of interaction between complex and poorly understood social, economic, technological and political factors. However, it is also clear that although developing countries suffer from problems of over population and lack of resources, the net quantum of eco-degredation and pollution in their case is far less than the less-populated developed countries. Furthermore, pollution in the developing countries is mostly biodegradable, while that in the developed countries is mostly non-degradable.

Ecological Ethics

In the coming years it is certain that ecological ethics will get added importance. In this connection Table 1 summarizes the basic perceptions of the major religions of the world about ecology. The Western religions have looked at the relationship between humankind and Nature with arrogance and an underlying co-creator attitude. The result has been *conflict* with Nature. On the other hand, the Eastern religions have viewed environment and Nature with reverence and an underlying partnership, leading to *harmony* with Nature. Most orientalists start their day with prayers to Nature and the bounties it offers. The two components *Prakrati* (Nature) and *Purush* (humankind) are partners which must work harmoniously.

Table 1. RELIGIONS AND NATURE

<table>
<tr><th>WESTERN</th><th>EASTERN</th></tr>
<tr><td>JUDEO-CHRISTIANITY
Humankind the sovereign; monarch, or the supreme ruler</td><td>HINDUISM
Humankind a constitutional partner</td></tr>
<tr><td rowspan="2">ISLAM
Humankind the: ruler exercising authority</td><td>BUDDHISM and
JAINISM
Humankind an integral partner</td></tr>
<tr><td>SIKHISM</td></tr>
<tr><td>ZOROSTRIANISM
Humankind paternalistic</td><td>TAOISM
Humankind an equal partner</td></tr>
<tr><th colspan="2">STATE OF MIND AND SPIRIT</th></tr>
<tr><td>- Arrogance
- Co-creatorship
- Conflict</td><td>- Reverence
- Partnership
- Harmony</td></tr>
</table>

A lot of useful literature is now emanating from western world about the ethics of resource use because, more than the east, west has realized that their present day pattern of development is not sustainable. They are eager to hear the views of orientalists about the environment, because this subject has been a part of ethos of the latter from time immemorial.

Connected with the subject of ecological ethics is the fact that humanrace has had a common origin (in East Africa) and also a common past. Then there followed divergence, and human being colonized all the continents

because it has been the first intelligent, inquisitive and thinking animal (Fig. 1). In due course of time, there followed population explosion, multiplication of needs, undue demands on and progressive destruction of components of earth system (namely: atmo-, hydro-, litho- and biosphere including biodiversity). The net result has been that the Earth system as a whole became progressively endangered: some of its parts more than the other parts.

There then began a global realization about the impeding dangers associated with serious environmental deterioration. Then came the Stockholm Conference (1972), followed by the Rio Conference (1992), and plethora of other conferences. In this process, the humanity as a whole jumped from the *Common Origin* to the concept of *Common Future* (Fig. 1). There has been talk of globality of environment, and connectivity between local and global environments. Yet there are no worthwhile global or regional strategies or even national strategies for achieving sustainability. Therefore, while *Common Origin is a* fact, *Common Future* is still a myth (Fig. 1). Some years ago, M S Swaminathan raised a very pertinent question: How can there be a common future without a common present? The latter is still an open question and an enigma! Should not humanity do something tangible about it! This is a moot question which needs to be addressed to very seriously.

The only way left is that human race has not only to work out solutions to local problems, but also has to rise above the local issues and think about the repurcussions of these at national, regional and global levels. Furthermore, it has to work over-time to give all such strategies a practical shape. It is indeed a two-way traffic. Understanding the dynamics of this two-way traffic will actually lead us towards real sustainability in development.

Future possibilities

The future holds three possibilities. First is the evolution of *Super Industrial Societies* with ever-increasing economic growth through the use of high technology. It would support a higher population growth and a higher standard of living. This would be a society of *Technological Optimists.* However, it is bound to lead to ecodegredation and pollution much beyond the carrying capacity of the Earth System. Thus, here human beings would be working *against* nature.

The second possibility is a New Brand of the *Hunter-Gatherer Society*, which may come up as a result of a global nuclear and space war. As a result of such a war, the human race is likely to be annihilated, except for only scattered groups, which either escape the exposure to radioactivity or are somewhat tolerant to atomic radiation. Agricultural technology will be poor, and once again the situation would revert to where it began; the human being will become *a part of nature.* There may be good chance for natural ecological repair for any small and local damage to the environment.

The third possibility is the evolution of *Sustainable Societies.* These would lead to a decline in the population in the developing countries with rational resource use and minimum waste. Materials would be recycled and reused, and determined efforts would be made to conserve the life-support systems and to help in their regeneration. There would be opportunities for ecological repair for any damage that may be caused. The sustainable societies would be based on the need and not on greed, and stress on comfort and not on luxury. The basic philosophy should be to blend environmental and economic imperatives into a connected whole. Such societies will owe allegiance to the life-support system, and not go by their narrow loyalties to the economic systems. The human being in these circumstances would be *working with* nature.

Apostles of Ecological Dharma

Regrettably during the 20th Century, the human race has seen more tormenters (atleast four) but only one benefactor (Mahatma Gandhi). In recent times, two Indians who, in every sense, preached and practised the Dharma of Ecology are: Mahatma Gandhi and Mother Teresa. The former was Indian by birth but the latter was by her voluntary adoption. In fact, both belonged to the whole humanity. Ranga, the famous Indian cartoonist, caught their simplicity and elegance (Figures 2 and 3) in his famous cartoons. The two belonged to different faiths but followed identical paths and reached similar conclusions: to care for the poor, the dispossessed and the destitute or, as M S Swaminathan has said in a different context: *reaching the hitherto unreached.* Thus, sheer simplicity is all that these two great souls wore. Here, then are ideals for the whole humanity in sustainability.

The lessons one draws from the past experience are loud and clear and there is considerable realization about the following:

- Earth is a finite system, both in resources and in its carrying capacity;
- Future economic growth cannot be sustainable if it is at the expense of long-range ecological security;
- Environmental insecurity ultimately leads to economic, social and political insecurity;
- Sustainable development for intra- and intergenerational human well-being has now to be an integral part of the future composite world culture; and
- Sustainability in development is a global concept and every living being, as a member of the World Family (*Vasudaivakutumbakam*), has a role to play.

There is an urgent need to translate these lessons into reality through the *Dharma of Ecology*. While we must understand scientific and technical complexities of nature, we must not do so with arrogance of *conquering* nature, but *working in close harmony* with it. We must develop a good measure of reverence for nature for the vast bounties it provides. In this connection, we must also learn from the tribal societies, which have developed an approach of harmony with nature. This can still be seen in the interiors of the Andaman and Nicobar Islands and Amazonian forests.

If there is any one thing that is going to bring nations of the world together, it is the *common threat* to our long-range ecological security. Therefore, before we talk of common future, there is need for common concerns, approaches, strategies and actions for our *common present*. Thus, for our sustainable future, we have to move towards globality on the one hand so as to correct the follies particularly of the industrial countries; and. on the other hand, we need to meet common global threats. There is need to develop a culture/ethics/code for Ecological Dharma at all levels starting from the individual up to a country or region and the entire Globe so as to practise the cult of sustainability in development. It is only then that we will have a situation as put by Rene Dubos: "*think globally but act locally*".

A basic question arises: Are we moving towards a sustainable society? This indeed is a major challenge as also an opportunity before the entire human

race. In India, if we go on the way we have been so far, on 1st January 2001, like today, centuries will continue to co-exist. We will continue to have a subsistence India of a large number of poor and dispossessed toilers and plodders who live in medieval times, and an affluent India of a small number of people who are jet-set and wealthy. The latter may be poised to enter the 21st Century with a bang. How soon we take even the preliminary steps to bridge the vast gap between the large but powerless subsistence and the small but powerful affluent India, will actually determine whether we can make it to a sustainable society, where we have environmental harmony, economic efficiency, resource conservation, gender equality, equity with social justice, and local self-reliance.

Conclusions

Among the important findings of this century is that Earth is the only planet in our planetary system that supports life as we know. It is our only home. Furthermore, the 20th Century has been a century of discovery and of considerable environmental destruction, but a question arises whether the next Century will be one of continued and rapid environmental destruction, or of environmental reconstruction! Humankind has to make-up its mind about becoming more humane and less selfish. The biggest question facing human race in the next century is how much is *enough* for a simple, need-based, austere and comfortable life style! This has become obligatory for all of us, because history teaches us that ecological deterioration directly leads to economic decline, which in turn is followed by social disintegration. We need to draw lessons from decline of once flourishing civilizations in the medieval times, and avoid disrespect for nature at all costs.

We need to conserve not only the natural heritage, but also the intellectual heritage created and crafted by the human beings for the good and the well-being of humanity at large. In the natural heritage is included the Mother Earth itself with all the biomes, ecosystems and populations of all living species (including the human being). In the intellectual heritage is included all that has been crafted and created by human genius for the good, the benefit and the well-being of humanity at large. It would also include human

settlements, science and technology, art, literature, music and dance, handicrafts, myths and what not.

The civil society needs to make a commitment so as to make innovations in development possible and thus ensure a better life for the generations to follow and help in sharing and caring. Thus, conservation does not include only environment and its components but equally so our history, culture, science, technology, religion and philosophy. Herein lies a dual responsibility for each one of us: one for the biosphere and the other for humanity and all life forms on a collective basis. In short, there is need to guarantee a healthy Earth by itself, and the life on earth in all its manifestations.

To conclude, sustainability is not only a scientific, technological, social, and economic issue, it has also moral and an ethical dimensions. Determined efforts have to be made to avoid crossing the line (The *Laxman Rekha*) dividing sustainability and unsustainability. To achieve this, there appears to be a greater need for a unique "technology" for our own "inner" development so that misuse of resources and creation of unsustainability is avoided. To the present author, these are some of the basic and *dharmic* responsibilities of humanity as a whole.

Acknowledgements: The author is grateful to Dr R K Pachauri for providing facilities, and to Mr Ranga for permitting the use of the two cartoons illustrating this paper.

Fig. 1 Transition from Common Origin to Common Future

Fig. 2 Mahatma Gandhi

Fig. 3 Mother Terasa

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