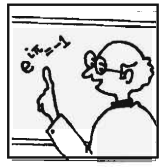
Classroom



In this section of **Resonance**, *we invite readers to pose questions likely to be raised in a classroom situation. We may suggest strategies for dealing with them, or invite responses, or both. "Classroom" is equally a forum for raising broader issues and sharing personal experiences and viewpoints on matters related to teaching and learning science.*

Teaching Biodiversity

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In a diverse country like India first hand observations of diversity of life forms could provide an interesting focus and purpose to the teaching of biology. In the process it could generate information of great relevance to monitor biodiversity in order to assess the efficacy of our conservation efforts. The endeavour of organizing such observations into a countrywide biodiversity information system could help catalyze our transition to the information age.

Introduction

That teaching of science in India could benefit greatly from a better focus and sense of purpose is indisputable. Two themes could provide such a focus for life sciences: the universally shared machinery of life at the molecular level, and the great diversity of life forms now on earth. Both themes lie at the frontiers of science, with rapidly growing understanding. Unfortunately, there is a serious limitation relating to the first theme in India today. Laboratory exercises in molecular biology demand large investments, possible for only a small minority of our teaching institutions. So teaching of life sciences with a focus on the first theme is condemned to remain bookish for the vast majority of our teachers and students. On the other hand,

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the second theme, that of biodiversity, could deal with reality easily in a megadiverse country like ours. Moreover, learning about biodiversity on the basis of first hand observations of living organisms present in the vicinity of any educational institution could be directed towards an important nationally acknowledged purpose, which is to make an inventory and monitor the country's biological resources and assess the efficacy of ongoing conservation efforts. India, with over 150 countries is committed to organize such an effort as a party to the *Convention on Biological Diversity* since February 1994. Given the magnitude of our biodiversity, 120,000 known and an estimated yet undescribed 400,000 species distributed over a wide variety of ecosystems, such a monitoring programme could only be attempted through a widespread network. The country's 6000 odd undergraduate science colleges would surely have to be a key component of this network. Teaching biology with a focus on local biodiversity in these colleges, along with agricultural universities and other institutions of higher learning and research, could then both inject greater vigour into teaching of life sciences, and generate basic valuable information for a nation wide endeavour of monitoring and conserving our precious living heritage.

Many Facets of Biology

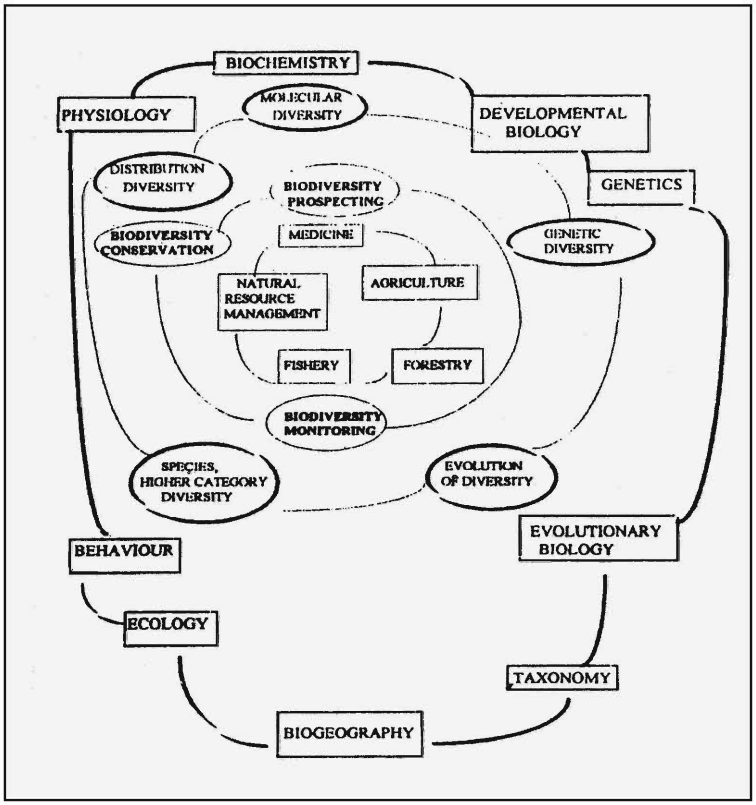
Adaptation, or fitness of design and diversity, or variety of designs are the two hallmarks of life. Adaptation, the appropriateness of the machinery of life, is the primary concern of functional biology embracing disciplines such as genetics, developmental biology, biochemistry and physiology. Of course these disciplines too are concerned with diversity. For instance, immunology, an important sub-branch of physiology, is concerned with the proliferation of antibodies to deal with a variety of foreign organisms. But diversity is at the heart of the other major branch of biology - organismic biology - embracing disciplines such as evolutionary biology, systematics, biogeography, ecology and behaviour. These basic disciplines

underlie a number of applied disciplines medicine, agriculture, forestry and fishery sciences, management of natural resources. *Figure 1* depicts the relationship between these basic and applied disciplines and the eight facets of the study of biodiversity. The latter has been distinguished into five basic disciplines study of molecular diversity, genetic diversity, diversity at species and higher taxonomic levels, evolution of diversity and distribution of diversity in space and time, and three applied disciplines - monitoring biodiversity, prospecting for biodiversity and conservation of biodiversity.

Biodiversity could become an effective focus for organising the teaching of different areas of biology.

Study of Biodiversity

As *Figure 1* shows the study of biodiversity has manifold linkages to the diverse disciplines of life sciences, the linkages being especially strong to those belonging to organismic biology. Biodiversity could therefore become an effective focus for



A course on evolution could focus on the co-evolution of figs and fig wasps, since much remains to be learnt about their biology.

organizing the teaching of the different areas of biology. This would call for appropriate changes in the syllabi for both the theory and practical components. Thus the study of molecular and genetic diversity could be incorporated into the teaching of biochemistry, molecular biology and genetics, as well as applied disciplines like immunology, plant and animal breeding.

Much more emphatically of course, the study of biodiversity could be incorporated in the teaching of organismic biology. Thus courses in taxonomy or systematic biology (e.g. fungi, angiosperms, chordates) could emphasize much more first hand observations on living mushrooms (or other fungi), legumes (or other angiosperms), birds (or other chordates) in the vicinity of the concerned educational institution, and much less dissections, destructive collection of specimens to be preserved or emphasis on organisms found elsewhere. A course on evolutionary biology could for example focus on the co-evolution of figs and fig wasps, a large number of species of both being present in India since a great deal remains to be learnt about their biology. First hand observations on these could be an exciting way of learning about evolutionary processes.

Above all, biodiversity including field observations, could be important in teaching biogeography and especially ecology. Patterns of distribution of diversity at species and higher taxonomic levels, in space and time are a key concern in the study of biodiversity which are also key areas of study in ecology and biogeography. Documentation of such patterns requires first hand observations, many of which can be conducted without expensive equipment or other infrastructural investments which is within the reach of every college in India. Such investigations could involve both short field exercises equivalent to one or few practical sessions, as well as term projects. The projects may be individual and group projects, and may involve biology as well as non-biology students. The details would depend on the extent of flexibility of curriculum in any particular college or university.

Practical Applications

Two major applications of studies in biodiversity are towards prospecting and conservation.

As *Figure 1* suggests the two major applications of studies in biodiversity are towards prospecting and conservation. There may be important additional applications in terms of pest or weed control in agriculture, or control of vectors of diseases in medicine. Monitoring of biodiversity is the basis of all these applications, which must be carried out through the agency of decentralized institutions such as undergraduate science colleges. It may then be developed as a central activity in the teaching of biology in undergraduate science colleges, as well as to a lesser degree at the M.Sc. level and in agricultural and veterinary colleges. This of course demands certain flexibility in the teaching programme, because each educational institution involved would operate in a somewhat different ecological setting and encounter a distinctive set of biological species.

It is therefore essential to arrive at a set of microbial, plant and animal species that will be monitored on the basis of certain standardized survey methods throughout the country. This set of species may be as large as 5000-6000 for the country as a whole. This would ensure that students of any given educational institution encounter a few hundred of these species. The set should be selected so as to focus on species of special significance, that are common, widespread and more easily accessible for investigation. The Indian Academy of Sciences has in November 1996 initiated a project termed *Lifescape* to select such a species set, generate material to help in their reliable identification, and arrive at a standard set of ecological survey methods appropriate to particular taxa.

The species thus being monitored must be placed in their appropriate ecological setting. This calls for a standardized inventory of ecological habitats and resource material to enable students and teachers to identify the set of habitats they would investigate in the course of biodiversity monitoring. These habitats would best be defined on the spatial scale of a hectare, since this is the scale for which remote

Undergraduate students could generate comparable data that could feed into a countrywide system of biodiversity monitoring.

sensing satellites provide good information. Habitats on this scale are defined in terms of vegetation structure, and may be termed 'earthscape elements' in the terminology of the newly emerging discipline of Landscape Ecology. Lifescape project also aims to come up with a system of classification of earthscape elements appropriate for India, and provide their descriptions and keys to their identification. This would provide an excellent opportunity to introduce science students to the exciting new discipline of remote sensing. Finally, a third objective of the Lifescape is to recommend a set of standard ecological survey methods appropriate to particular taxonomic groups and ecological habitats.

Information System

This basic resource material would permit undergraduate biology students, and others, to generate comparable, standardized data that could feed into a countrywide system of biodiversity monitoring. This information must be scrutinized, validated and properly organized. Scientifically more sophisticated organizations such as Botanical and Zoological Surveys and University departments would have to play an important role at this stage. The data must then be computerized and incorporated in a nationwide synthesis of such information. This could be done by some Universities, State Councils of Science and Technology or Centres of the Natural Resource Data Management System of the Department of Science and Technology. Involving biology students and teachers in such an effort would introduce them to computerized data bases, and the emerging discipline of informatics. It may also generate welcome interaction with students and teachers of computer science. This would be an excellent way to help catalyze our country moving into the new information age.

Ongoing Experiments

The ideas presented above have been developed over a three year

period through interaction with a network of some 20 undergraduate colleges and NGO's in Maharashtra, Karnataka, Tamilnadu and Kerala. This has been a fascinating experience, given the high level of motivation amongst the students and teachers working in this network. This preliminary experiment involved activities undertaken entirely on a voluntary basis as extracurricular activities.

To take this further obviously requires acceptance of at least some elements of the programme as a part of the regular curriculum which is relatively easy in autonomous colleges. Two colleges involved in the Western Ghats Biodiversity Network, the Madura and American College from Madurai are autonomous and have taken the lead in making this transition. They are being joined in this experiment by eight other autonomous colleges from Tamilnadu. It is hoped that we can then build on the experience of these colleges to bring in appropriate changes in curricula of other Universities with normal affiliating colleges as well. Such possibilities are being explored in several other states as well. Thus in Bihar a group of college teachers have been active in extracurricular activities similar to the Western Ghats Biodiversity Network through an organization called Nature Conservation Society based in Ranchi. In Madhya Pradesh Ekalavya, an NGO, has made pioneering contributions to science education at school level. Active volunteers of Ekalavya include many college biology teachers. Project Lifescape hopes to work with such groups throughout the country to explore these exciting possibilities of revitalizing teaching of biology while generating information of value to conserving and sustainably using our nation's rich living heritage. A project like this can only hope to succeed as a network of motivated volunteers and the Indian Academy of Sciences would like to call on all interested biology students and teachers and other nature lovers to write to us if they wish to be involved. This issue includes a special tear sheet which may be used for this purpose.

Suggested Reading

- M Gadgil. Inventorying, monitoring and conserving India's biological diversity. *Current Science.* Vol.66. No.6. pp.401-406. 25 March, 1994.
- M Gadgil. Documenting diversity : An experiment. *Current Science.* Vol.70. No.1. pp.36-44. 10 January, 1996.
- M Gadgil. Deploying student power to monitor India's lifescape *Current Science.* Vol. 71. No.9. pp.688-697. 10 November, 1996.