It is also interesting to quote from a personal letter to the author from A. R. Subrahmanian, a non-resident Indian and expert in ribosomology: 'It was very striking the big reception for the Noller paper. In contrast, I recall no comments at all regarding the earlier *Proc. Natl. Acad. Sci. USA* and *Arch. Biochem. Biophys.* papers of yours which in retrospect, were seminal to this development'. This was obviously regarding the *comments of Waldrop*[7] on the paper of Noller in the issue of *Science* carrying the Noller report. No mention about *our earlier work* was made in this write up.

It may not be out of place to mention here that a ribosomal RNA-based model of translocation was suggested quite sometime ago from our laboratory[8], which is also gaining ground (for example, Gross and Jaenicke[9]). This model has been discussed in the review article 'RNA world and ribosomes' in the same issue of *Current Science*[10]. We are still working on the model and strongly feel that this will be one of the best evidences in favour of biological activity of ribosomal RNA.

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Biology research in India

Current Science (1992, **63**) has justifiably focused the attention of scientific community on the status of basic science in India. Being a biological researcher, I was particularly fascinated by G. Padmanaban's article on 'Indian biology research at cross roads'. It is true that this is an age of biological sciences where understanding life forms can contribute for betterment of mankind with the enigmatic living cells where the more one works the less he seems to understand.

I am rather disappointed that the article lays all stress on molecular biology as the frontier area of biology probably due to the specific bias of the author. True that molecular structure is the very basis of life but what about the vast area of other subjects in biology which are equally important like energy production, effluent treatment, cleaner environment which are never stressed. Present biologists seem to think that molecular biology is the thing either for getting funds or recognition by way of awards than all other branches of biology which have been relegated to the background, and look naive and out of tune to work. A kind of psychosis has been set in India that biology should involve molecular biology in some way however remotely it is related to the subject. Why should our scarce financial resources be frittered away by funding 50-odd groups to work on recombinant DNA as the author claims. We have to introspect and see the outcome of centres that are heavily funded for molecular biology by DBT and their contributions before more money is given to newer groups. What will be the real benefit our country will derive by working on the stupendous task of the human genome project? Will it ultimately help in the improvement of traits?

If we look at the biology syllabus of most universities at the postgraduate level, molecular biology and genetic engineering are included with great pride and fancy. There is no harm in making such ambitious modern topics in curricula if only there are competent teachers who understand the subject in the first place. Mostly these subjects are taught by teachers who do not have much knowledge of the subject. Then how can we expect such students to come out with background knowledge to take research work later. In most cases they have to unlearn many things which is a waste of time and effort. We can do better and be internationally competitive in biological research only if the foundation of our promising post-graduates is laid well. It is not only true of building sophisticated infrastructural facilities on a weak foundation without basic amenities like water and electricity as the author has rightly mentioned but also the human force which has to carry out the work. A lot needs to be done to tone up our education system in the area of life sciences. I have found this with great dismay and anguish at the UGC reorientation courses for university teachers held at various universities. Let us start a change from the foundation to improve biological research.

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Kamaljit S. Bawa of the University of Massachusetts, Boston, USA is known for his work on the reproductive biology of trees of the tropical forests of Central America. Of late, he has been interested in the conservation and management of biodiversity in the tropics, especially India. In this comment to Padmanaban's article on "Indian biology research at cross roads" (Curr. Sci., 1992, 63, 509–511), Bawa identifies a different pattern of hierarchy of thrust areas in biology. Arguing that Padmanaban's article is restricted to only one of the layers in such a pattern, he suggests that there are several other areas that need more thrust in India.

—Editor

Indian biology research at crossroads—Another perspective

Kamaljit S. Bawa

A critical assessment of the status of Indian science[1] has been long overdue. For a number of years, India has boasted the third highest number of scientists in the world, and until recently the government's expenditures in research and development as a percentage of GNP have steadily increased. It is thus natural to examine the impact of Indian scientists in various fields and to ascertain if science, as practiced in India, can meet the challenges of the future as well as the needs of the society, which, despite being economically disadvantaged, has so generously endowed scientific research.

Here I evaluate the assessment of Indian biology made by Padmanaban in his article, Indian biology research at cross roads[2]. In any assessment, in order to get the right answers, it is important to ask the right questions; it is my contention that Padmananban's article does not ask all the right questions. His review is confined to molecular and cellular biology. Moreover, the article does not identify factors that limit progress. Thus, it is unlikely to offer a prescription for moving the Indian biology forward, which I assume was the *raison d'être* for the collection of articles in *Current Science*. I first argue that Padmanaban's article does not fully define the central issues of biology. I then describe the fields in which Indian biologists can make unique contributions. After briefly reviewing the past and present research of Indian scientists in areas other than molecular and cellular biology, which are covered by Padmanaban, I examine factors that limit the progress of Indian biology. Finally, I examine the outlook for the future and discuss changes that will be needed for Indian science to move ahead.

Central issues

Many biologists would disagree with Padmanaban's statement that the fundamental questions in biology relate to the evolution, organization and expression of the gene. One could argue that the central problem in biology remains the origin, evolution and maintenance of organic diversity. After all, the greatest scientific revolution—the Darwinian revolution—was about the evolution of organic diversity. The evolutionary underpinnings of the diversity of life still occupy a center stage in biology and bind all biological subdisciplines. The structure and expression of the gene remains a central issue inasmuch as life on earth has a hierarchical organization. However, the gene is only one level of organization, and while for molecular biologists it might be the most important level, other levels of organization, including molecules, cells, tissues, organs, individuals, populations, species, communities, and ecosystems, also provide interesting opportunities to gain insights into the natural world. Padmanaban recognizes these opportunities when he mentions a few areas of biochemistry and cell biology. However, he overlooks whole fields of biology, such as biogeography, ecology, epidemiology, ethology, evolution, physiology, comparative morphology, systematics, toxicology, and genetics. Not only are these subdisciplines central to understanding contemporary issues in biology, but it is in some of these areas that Indian scientists have excelled in the past. Internationally, each of these subdisciplines is as vigorous as molecular biology, and some of them have been acquiring more and more importance as we come to grips with the problems of environmental degradation.

In the context of environmental degradation, few biologists would deny that conservation of biodiversity is one of the most pressing issues of our time. With the unprecedented loss of biodiversity at all levels of biological organization, the science of conservation biology has recently emerged as one of the most important and vibrant subdisciplines of biology. It is well known that tropical forests harbor one-half to two-thirds of all species that exist on earth, and that many of the contemporary extinctions are occurring in the tropics as a result of deforestation and habitat alteration. India, as Padmanaban also admits, has a rich fauna and flora. The country ranks among the top ten with respect to the number of species in many taxonomic groups of plants and animals[3]. India also has an extremely high rate of deforestation. Thus, for countries like India, conservation biology is much more central to research in biology than perhaps any other subdiscipline. Even outside India, with at least three species becoming extinct every day at the global level[4], no biologist can claim that 'the gene is still occupying the central stage' in biology.

Research issues in conservation bio-