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Biology in India

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The biological sciences occupy an important position in teaching as well as research activities in India. However, like every thing else in this country, there is enormous diversity, not only in the research areas pursued, but also in the pattern and contents of the various teaching programs. Given such diversity, there are no well-defined goals or policies for the nation as a whole. The present article seeks to provide some insight into the present status and future possibilities of teaching and research in various sub-disciplines of biology in India. It reflects the author's perspective and is neither comprehensive nor representative of any "national policy."

Biology teaching: present trends

Instruction in Biology/Life Sciences starts at the primary school level when the young children begin to understand the properties of living beings and their diversity. Biology constitutes a significant component of the Science curriculum and is studied by all students till the middle school level. At the secondary school level (9th and 10th standards), Biology becomes an independent subject. The process of canalisation starts at the higher secondary level (11th and 12th standards) with a largely (though not absolutely) irreversible selection of future choices. Students who desire to prepare for a career in medical practice usually select biology as one of their subjects at the higher secondary level.

Generally, those unable to enter the medical stream after school opt for admission to the B.Sc. (Bachelor of Sciences, 3 years) programme in biology-related subjects that is offered by almost all the universities in the country, either directly or through their affiliating colleges. At the B.Sc. level, subjects like Botany, Zoology, Microbiology, etc. are most common. Some universities also offer Biochemistry, Physiology, Genetics, Biotechnology, etc. at the B.Sc. level, although in most, these subjects are offered only at the M.Sc. level. Very few places treat Biology or Life Sciences as a whole at the B. Sc. level. In most cases, the students who opt for biology-related subjects at the B.Sc. level cannot study Physics or Mathematics, etc. at the same time, although Chemistry is usually allowed.

The 3-year B. Sc. degree is followed by a 2-year M.Sc. (Master of Science) course, which is an essential pre-requisite for a Ph.D. The Masters programmes are generally confined to the major sub-divisions like Botany, Zoology, Microbiology, Physiology, Biochemistry, Genetics, Biotechnology, etc. A limited number of universities also offer M.Sc. in Marine Biology, Aquaculture, Fisheries, Entomology or Biophysics, etc. A few universities offer M. Sc. in "Life Sciences" or "Biological Sciences." In some of these, the student can opt for a greater emphasis on "animal" or "plant" sciences.

Following the M.Sc., students who so desire can undertake research for a Ph.D. degree at a university department or other research institution (the research institutions cannot give their own degree and thus need to be affiliated to a university). Generally, the Ph.D. involves only research, although several places require a minimal amount of course work in addition to research.

In recent years, a number of universities have initiated integrated programs for M.Sc. or Ph.D. degrees. The integrated M.Sc. programme (5 years) starts after the higher secondary level and takes the student through to a M.Sc. degree, while the integrated Ph.D. programme (5 years) starts after the student has completed the B.Sc. After two years of course work (equivalent to M.Sc.), the next three years are devoted to Ph.D. research.

The range covered in the most commonly available courses in Botany or Zoology at B.Sc. as well as at the M.Sc. levels extends from so-called "classical" botany or zoology to "modern" biology, although considerable variations in emphasis are manifest in the syllabi of different universities. An increasing number of students in recent years have shown preference for "modern" biology and opt to study subjects like Biotechnology, Genetics, Molecular Biology, etc., rather than the traditional Botany or Zoology. The range of laboratory exercises carried out by the students varies vastly but remains limited, in a majority of cases, due to constraints in resources.

It is a general perception that a holistic teaching of biology has suffered in recent years, mostly due to the fact that "Molecular Biology" appears more highly "respected" and attractive for the future career. Furthermore, since the teaching of "classical biology" topics like taxonomy, anatomy, etc. has become increasingly "dry" and restricted to the classroom, fewer students enjoy such subjects (Lakhotia, 1991). Consequently, the quality of research in areas related to basic biology, biodiversity, etc. remains less than satisfactory. Additionally, since the university system in general fails to attract

talented "molecular biologists" due to their relatively poor infrastructure, the overall quality of academic manpower has perceptibly declined in the universities, and this is compounded by the fact that fewer of the brighter students now want to go for higher studies in the basic sciences.

Biological research in India: patterns, policies and funding

In addition to the more than 250 regular and "deemed" universities, a large number of autonomous research institutions have been established in India, mostly by governmental agencies like the Council of Scientific & Industrial Research (CSIR), the Departments of Science & Technology (DST), Biotechnology (DBT), Atomic Energy (DAE), etc. Each of these has its own specific research objectives. A number of state governments have also set up research institutes in life science related areas. The CSIR has the largest chain of national laboratories spread across the country, a good number of which are biology oriented. In recent years, several privately owned research institutions have also come into existence.

With such a large network of universities and research institutions, biological research encompasses a vast range of topics in India. Research in organismic or "classical" biology is largely confined to the university system, while most of the biologically-oriented research institutions place greater emphasis on molecular biology/cell biology and biotechnology-related research. Since research in molecular biology and related fields is more finance-sensitive, the university system generally lags behind in these areas, as compared with the various research institutions, where the laboratories are generally better equipped. In most places, research work is mainly carried out by students pursuing their Ph.D. degree. The culture of post-doctoral research fellows has still to be established.

Most of the universities have little money of their own to support research. The University Grants Commission (UGC) and the Department of Science & Technology (DST) have programs whereby identified departments in different universities can get additional funding for general development and/or research in specific areas. However, in order to carry out in-depth research, the individual faculty members need to get external funding for research projects. Multiple sources of funding exist. Agencies like DST, DBT, DAE (BRNS), CSIR, UGC, DRDO, etc. all support biological research, basic as well as applied. Although different funding agencies have identified their own thrust areas for priority support (the respective websites listed in Table 1 may be visited for details), each of them continues to support a "good" research proposal in almost any area of biology. Thus the Department of Biotechnology (Govt. of India), which was created in the 1980s specifically to promote biotechnology in India, also maintains programs to support basic molecular biological research. Likewise, the Defence Research & Development Organization (DRDO, Govt. of India) also supports basic as well as applied biological research. Each funding agency has its own peer review system to screen proposals and approve the quantum of funding. Projects are generally supported for three years. In addition to individual projects, several agencies also provide more substantial grants for the establishment of major facilities, etc. Several such "national facilities" (for example, facilities for NMR, DNA and protein sequencing, confocal microscopy, micro-array analysis, etc.) have been created across the country. These facilities have worked with varying degrees of success. Private/industrial support for research is not yet substantial.

Future of biological sciences in India: challenges

Public interest in biology has greatly increased in recent years, thanks to the much discussed developments in genomics and biotechnology. Molecular biology/biotechnology and environmental studies/ecology/biodiversity have attracted the attention not only of policy makers but also of young persons and prospective biologists. India is perhaps one of the few countries that have a separate agency to promote research and applications in biotechnology, in addition to regular teaching programs in Biotechnology at the undergraduate and Master's levels. Likewise, bioinformatics has been vigorously promoted, and a number of distributed informatics service centers have been set up across the country by the DBT.

While the increased interest in molecular biology/biotechnology is visible in better quality training, research and other products, progress in the areas of environmental studies/ecology and biodiversity has not been as notable. This is due in part to the fact that good experts in these areas are no longer readily available, because of the general dislike among students, teachers and researchers for taxonomy/morphology and anatomy. As a consequence, a holistic approach to biology is missing.

An incomplete understanding of the biological system also impairs optimal realisation of the benefits of the significantly improved training and research in molecular biology/biotechnology. Biotechnology is currently taught as an independent subject even at the B.Sc. level, unfortunately also in places where neither the teachers nor the laboratories are adequately equipped for the job. Similarly, there is considerable euphoria over the great advances in genomics/proteomics, etc., but once again, in the absence of a good understanding of biology (especially genetics, cell biology and higher level biological organisation), the anticipated "quick" benefits of these technologies have often remained elusive.

As in many other countries, fewer students are now interested in teaching and research as career. Many of those who study biology-related subjects at B.Sc. and M. Sc. levels do so in the hope of entering the biotechnology industry, which is

unfortunately still not established in the country. Moreover, given the poorly equipped teachers and laboratory facilities, training of such students is, in many cases, less than satisfactory, and this adds to their frustrations. If this situation continues, the increased interest in biology may wane. To sustain this interest in biology and reap its benefits, there is an urgent need in the country to reorient the teaching programs in biology. We need a judicious mix of the "classical" and "modern" biology. At the same time it is essential to revamp higher education, specially the university system.

The general lack of interest on the part of the younger generation in a career in science is compounded by the "brain-drain." The relatively good training in molecular biology is encouraging more and more of the brighter younger scientists to "go West." Very few return to the country to undertake productive academic activities. The other type of "brain-drain" occurs within the country itself: away from the university system and toward research institutions and national laboratories. There are a variety of avoidable and unavoidable reasons for this intra-national brain drain that has already resulted in a serious decline in the quality of academia in the university system.

Some efforts have been initiated in recent years at different levels to address the above mentioned factors of limitation. There is an increased awareness of the need for an integrative approach in teaching and research in all areas of biology. With a view to initiate a wider appreciation of a holistic approach to biology, the Indian National Science Academy organised a 2-day seminar on Integrative Biology in March, 2000, with participation by scientists and technologists representing different disciplines (Lakhotia, 2000, 2001). The Indian Institute of Technology (IIT) at Kanpur, a premier institution primarily devoted to engineering and technology, has started a new Department of Biological Sciences and Bio-engineering to promote various realms of biology (and not just biotechnology). Some universities (e.g., the Banaras Hindu University) are planning to initiate new courses in Biology at the undergraduate level so that those studying Physics, Mathematics, etc. can also have the option of studying Biology. The Indian Academy of Sciences, Bangalore, has initiated an ambitious "Project Lifescape," involving a large number of teachers and students at undergraduate and post-graduate levels, to address the challenge of monitoring biodiversity for conservation, sustainable use and control. This project has already resulted in a network of collaborating biology teachers in different parts of the country. With a view to improve the quality of biology teaching across the country, the University Grants Commission (a regulatory body for higher education in the country) has recently proposed new sets of syllabi in different areas of biology for adoption by the universities, with appropriate modifications as locally required. While these are welcome signs, such efforts need to be initiated and sustained on a much wider scale.

The ordinary citizen of today is increasingly aware of the need to maintain the environment and biodiversity, of the potential benefits of biotechnology/genetic engineering, etc. There is also an increasing awareness about genetic disorders, their diagnosis and possible cure. All these concerns ensure that Biology will continue to be a major discipline for teaching and research in India in the coming decades. However, young teachers and researchers do not generally find the university system attractive enough for their careers. This has a long-term detrimental consequence. The various academic bodies and governmental agencies need to work together to tackle the socio-economic and other factors that are adversely affecting the university system. At the same time, the enthusiasm for molecular biology/biotechnology, considered as the cure-all tool for understanding life and exploiting its properties for betterment of mankind, must not be allowed to undermine the importance of other areas in biology. The rich floral and faunal diversity of the Indian sub-continent remains largely unexplored. This deficiency must be addressed with equal vigour, not only for the sake of knowledge in itself, but because comprehensive knowledge of this biodiversity is bound to provide new insights into evolution, ecology, development, etc. In addition, and perhaps more significant from the currently favoured point of view of business potential: a good knowledge of the flora and fauna is essential for a rational development of the traditional medical systems.

References

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Lakhotia, S.C., 2000. Biology today: urgent need for an integrative approach. *Current Science* **78**: 1414-1415 Lakhotia, S.C. (ed.),2001. *Integrative Biology*, Indian National Science Academy, New Delhi, India

Table 1. Web sites of major funding agencies, some research institutions and universities in India

Dept. Science & Technology (DST), Government of India, New Delhi
http://mst.nic.in/dst

The University Grants Commission (UGC), New Delhi
http://www.ugc.ac.in

Council of Scientific & Industrial Research (CSIR), New Delhi
http://www.csir.res.in

Board of Research in Nuclear Sciences (BRNS, DAE), Dept. Atomic Energy, Government of India, Mumbai

http://www.barc.ernet.in/webpages/brns/brns1.html

Dept. Biotechnology (DBT), Government of India, New Delhi
http://www.dbtindia.org

Defense Research & Development Organization (DRDO), Government of India, New Delhi
http://www.drdo.org/labs/dls/index.shtml

Indian Council of Medical Research (ICMR), New Delhi
http://icmr.nic.in

Indian National Science Academy, New Delhi
www.insa-india.org

Indian Academy of Sciences, Bangalore
http://www.ias.ac.in ; http://www.iisc.ernet.in/academy

National Institute of Oceanography, Goa
http://www.cmmacs.ernet.in/nal/icast/csir/nio.html

Wild Life Institute of India, Dehradun
http://www.wii.gov.in

Tata Memorial Centre, Mumbai
www.tatamemorialcentre.com/research.htm

International Center for Genetic Engineering & Biotechnology, New Delhi
www.icgeb.res.in

Centre for Cellular & Molecular Biology, Hyderabad
www.ccmbindia.org

Centre for Biochemical Technology, New Delhi
www.cbt.res.in

Tata Institute of Fundamental Research, Mumbai
www.tifr.res.in

National Centre for Biological Sciences, Bangalore
www.ncbs.res.in

National Centre for Cell Science, Pune
www.nccs.res.in

National Institute of Immunology, New Delhi
www.nii.res.in

Centre for DNA Fingerprinting and Diagnostics, Hyderabad
http://www.cdfd.org.in/

Bose Institute, Kolakta
www.boseinstitute.org

Indian Institute of Science, Bangalore
www.iisc.etnet.in

Department of Biological Sciences & Bioengineering, Indian Institute of Technology, Kanpur
www.iitk.ac.in/bsbe

Jawaharlal Nehru University, N. Delhi
www.jnu.ac.in

Hyderabad University, Hyderabad
www.uohyd.ernet.in

Delhi University, New Delhi
www.du.ac.in

Madurai Kamraj University, Madurai
http://www.dbtindia.nic.in/btis/dics/mku.htm

Pune University, Pune
www.unipune.ernet.in

Banaras Hindu University, Varanasi
www.bhu.ac.in

for a list of Universities in India
http://www.educationinfoindia.com