Biology Teaching – Urgent Need for an Integrative Approach

S. C. Lakhotia

Cytogenetics Laboratory, Department of Zoology
Banaras Hindu University, Varanasi 221 005

Biology started as a descriptive science. However, with increasing adoption of experimental approaches since the latter part of 19th century, Biology was also as much experimental by the middle of the 20th century as the "physical" sciences.

This encouraged physiologists and chemists to also inquire into the nature of life. Non-biologists like Nada Farber, Max Delbrück, E. Schrödinger, Francis Crick and others dramatically changed the nature of biological studies. These and other developments in fields of Genetics and Biochemistry catalyzed the birth and subsequent rapid development of Molecular Biology.

With an increasing number of non-biologists contributing to our understanding of "what is life", the nature of biological studies has greatly expanded not only horizontally (i.e., interfacing with other science disciplines) but also vertically (i.e., to deeper levels in biological organizations). The 20th Century witnessed most remarkable and exciting developments in biological sciences. Thanks largely to the progress in Genetics and related basic and applied areas, Biology will continue to dominate at least the first few decades of the 21st Century. The sudden drive to understand the "molecular" basis of life and the reductionist approach has helped unravel many secrets of life and this has opened newer and very powerful ways to exploit the biological wealth. Thus the excitement in Biology is not only from the basic scientific point of view but also because of the biotechnological applications.

In view of the spectacular success of the molecular approaches in Biology, Molecular Biology has become the "in" thing, which most students want to study and pursue. It may, however, be noted that molecular biology is, at best, an approach to studying the biological phenomena; it is not as well defined a sub-discipline as fields like taxonomy, anatomy, physiology, cytology, genetics and so on. Nevertheless, the all-pervasive influence and "glamour" of molecular Biology have resulted in a somewhat skewed emphasis on certain aspects of Biology at the cost of others.

Specialists concentrate in narrower and narrower areas of inquiry. As this knowledge in each of the sub-branches of Biology increased, the inter-branch communication declined. The biological organism was often not the subject of
study, individual molecules and systems gained more importance for the
researchers. This resulted in an unholy dichotomy between "Traditional"
or "Classical" and "Modern" or "Molecular" Biology. The latter places emphasis
on "biochemistry" or "molecular" reductionist approach to biological issues,
even without a reference to the organism. In the midst of such a "molecular
Biology", the disciplines that deal with whole organisms have generally been
branded as "classical" and, therefore, have often been not only ignored but
even looked down upon. The conflict between "modern" and "classical" Biology
is apparent in research programs as well as in the teaching curricula.

Conflict between "Classical" and "Modern" Biology Teaching

In terms of the curricula being followed at undergraduate and postgraduate
levels, the programs of Biology teaching in different institutions in our
country may be grouped as follows:
- Curricula where age-old things continue to be taught (teachers use
  their own "student days' notes")
- Curricula where only the "latest" is taught, ignoring the basics that are
  considered "classical" and therefore, unnecessary
- Curricula with generally updated contents and a reasonable balance
  between "classical" and "modern" subjects.

The last category is very rare.

Subjects like "Classification" (Taxonomy, Morphology, Anatomy etc.) have often
been labeled as "classical" as opposed to "modern" subjects like Molecular
Biology, Biochemistry, Genetics, Biotechnology etc. Many "modern-looking"
programs have become popular because they used to fetch better grants and
better "research". There is no denying that these new teaching programs in "modern"
Biology have been fruitful in several respects. But the over emphasis on "modern"
Biology has belittled the importance of traditional Biology departments. A
concerted effort for "classical" Biology has also sometimes become necessary in the decision-
making and influential quarters. However, it must be noted that the so-called
"classical" subjects themselves have not become important in the present context,
but it is the content and the manner of teaching of these subjects that have made
them "classical" rather than "modern". Actually, "classical" should always remain
"classical". To cite an example, taxonomy is one area that has suffered
considerably. Lack of competent taxonomists in the country is now being felt in every quarter,
especially in relation to assessment and conservation of the biological diversity
in the country. In the context of biotechnological implications and threats of
intellectual property rights, the country today is in a very disadvantageous
position. This sorry state of affairs has come to be principally due to the continued
teaching of archaic information in an uninteresting manner and to some extent
also due to a "contemporary" for taxonomy in the minds of many "modern" biologists. Appropriate integration of information available from advances in molecular genetics, developmental biology, evaluation, comparative physiology, anatomy, etc., can make the field of taxonomy as vibrant and interesting as any other. Therefore, what we need is a change in contents of the so-called "classical" subdisciplines and change in our attitude and approach to their teaching.

The "glamor" and the supposedly better promise for future, attract brighter students to "modern" courses. Unfortunately, however, these "modern" courses have been introduced at most places without adequate training of teachers and without minimal laboratory facilities. Consequently, while the departments and faculty claim "modern", and, therefore, respectable status, the students often learn only in the "classical" ("organismic") for the "modern" ("molecular biology") biology adequately. Disappointment of students is, therefore, not unexpected. On the other hand, the traditional departments, starved of bright and eager students and of funds are in deep juice. If the teachers also lose their enthusiasm, which is an unlikely event when grants are limited and eager students are not awaiting in classrooms, such departments enter a degenerative path. Such places fail to attract bright faculty members also. The decline in reputation of many departments of Zoology, Theory of Microbiology etc. in different universities in the country, which once upon a time were considered "very strong" and leading universities, reflects this alarming situation.

Thus in the present situation, while the more "strong" departments are decaying, the new ones are, in most cases, without the basic minimal infrastructure (equipment and material facilities). This alarming critical situation needs urgent solution.

Rigid Compartmentalization Lead to Fragmented Teaching

The rigid compartmentalization in our Biology teaching programs is responsible for producing graduates with a greatly inadequate background in Physics and Computer application (fortunately, Chemistry is often, though not always, one of the subjects at the under-graduate level). Likewise, students opting for "Physical Sciences" are mostly not exposed to Biology. In addition, the apparently inviolable boundaries between the traditional Biology department (like Zoology, Microbiology etc.) and fragment or teaching of various biological themes. Thus some disciplines like genetics, Biochemistry, Virology, Evolution etc., are taught in piecemeal manner in many of these departments. As a result, the students fail to appreciate the commonality between the different biological systems.

Our system denies students from any inter-disciplinary study and learning. Likewise, nearly all of the research programs in biological sciences remain confined to narrow fields without a serious attempt to make an integrated
approach. As a consequence, such isolated endeavors do not make the desirable impact that may have been possible with an integrated approach.

Need for Integrative Biology
During the course of the past few decades, there has been an unprecedented explosion in the knowledge and understanding of biological systems; the range of biological systems has also widened, extending from populations to molecules and atoms. Therefore, it is necessary that a student of Biology today is exposed to a holistic view. To achieve this, the International Union of Biological Sciences (IUBS) has adopted a new programme called "Toward an Integrative Biology" (TIB) to restore balance between the various approaches to the study of living systems and to take advantage of the power of the field; Molecular biology, information technology, sophisticated instrumentation etc to understand life at all levels.

While "traditional" Biology employs specific approaches and techniques to study different levels of biological organization, "modern" Biology places an over-emphasis on "biochemical" or "molecular" and reductionist approach to biological studies, neglecting the organisms and their diversity. In contrast, Integrative Biology seeks both the diversity and integration of perspectives.

Integrative Biology is not a new subject or discipline but is only an approach to learn and study the diversity of biological organizations in a holistic manner. Integrative Biology may mean different things in different contexts:

- Multi-disciplinary or cross-disciplinary or trans-disciplinary approach to include incorporation of Physics, Chemistry, Engineering, Information Technology, Sociology, Economics etc.

- Use of diversity of techniques to address a question

- Hierarchical approach (from populations to individuals and from organism to molecules) to questions and techniques

As stated by Prof. M. H. Wilke (President, IUBS) "Integrative Biology provides both a philosophy and a mechanism for facilitating science at the interfaces of 'horizontally' arrayed disciplines, in both training and research".

Biology in the new millennium needs an integrative approach, an integration within the discipline (intra-Biology integration) and integration between disciplines (integration with other branches of Science). This requires not only a balance between the so-called "classical" and "molecular" Biology but also requires that students of Biology are not denied from studying Physical sciences and vice-versa. A modular system of courses that allows enough flexibility in choosing course modules as per interests and requirements is essential to produce new generations of students, teachers and researchers who can fully appreciate and take advantage of the exciting developments in Biology that are awaited in the new millennium.